


# GEOCHEMICAL EVALUATION OF THE BASAL CAMBRIAN SYSTEM

## Plains $CO_2$ Reduction (PCOR) Partnership Phase III
## Task 16 – Deliverable D89

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# GEOCHEMICAL EVALUATION OF THE BASAL CAMBRIAN SYSTEM

## EXECUTIVE SUMMARY

A binational effort between the United States and Canada is under way to characterize the lowermost aquifer system in the Williston and Alberta Basins of the northern Great Plains prairie region of North America in the United States and Canada. This 3-year project, begun in 2011, is being conducted with the goal of determining the potential for geologic storage of carbon dioxide ($CO_2$) in rock formations of the 1.34 million-$km^2$ Cambro-Ordovician saline system (COSS).

The focus of this report is to evaluate and discuss geochemical modeling and laboratory studies performed by the Energy & Environmental Research Center to determine potential chemical reactions between $CO_2$, brine, and rock on the portion of the COSS that occurs in North Dakota, Montana, and South Dakota. Although the modeling and laboratory activities were conducted independently, the results of the two different activities were compared to each other to establish a greater understanding of the validity and applicability of the modeling and laboratory approaches.

The geochemical modeling study was performed using publicly available PHREEQC software and databases. Rock samples, mineralogy, and water analysis data for both the sandstone injection target and the shale cap rock were also obtained from publicly available sources. The laboratory-based exposure tests entailed exposure of various COSS rock samples to $CO_2$ for 28 days at formation pressure and temperature.

The results of the geochemical modeling were consistent with existing literature, and suggested that because most of the COSS comprises quartz-rich sandstone, much of the rock matrix will be nonreactive. Reactions can, however, occur with secondary components (clays, carbonates, micas, K-feldspar) that can be contained within the sandstone and the heterogeneous mixed lithology zones between the primary sand layers. The geochemical modeling study predicted that a geochemical effect from the interaction of $CO_2$ with the COSS minerals and formation water was the dissolution of calcite and concurrent formation of dolomite. The source of $Mg^{2+}$ for this reaction was either from $Mg^{2+}$ contained within secondary formation minerals, such as illite, phlogopite, celadonite, and clinochlore, or from $Mg^{2+}$ in the formation water. The modeling calculations also indicated a potential reaction of the $CO_2$ with illite and K-feldspar in the formation. The K-feldspar was predicted to decompose into quartz, clay, and carbonates, thus trapping the $CO_2$ in a mineral form.

The results of the laboratory experiments generally compared favorably with the modeling portion of the study. The analytical data generated from the exposed samples show a variable mix of concentrations of K-feldspar and a general trend of decreases in illite. Illite and K-feldspar behaviors were generally in agreement with the geochemical modeling results. The most significant reactions occurred between $CO_2$ and dolomite/calcite and glauconite in the sandstone. Glauconite contained within samples completely dissolved and decomposed during the exposure experiments. The decomposition of glauconite will form siderite and quartz as well as some ions that will remain in solution. This phenomenon in glauconite-rich areas may increase local permeability as well as provide a mineral-trapping mechanism for $CO_2$. Samples of shale that were exposed to $CO_2$ showed no change in morphology or chemistry, with the exception of halite precipitation. The formation of halite that was seen is most likely an artifact of the samples being dried (not rinsed) after exposure to $CO_2$ and brine solutions.

The modeling calculations and laboratory experiments both suggest that $CO_2$ interactions with the COSS mineral phases (reservoir and cap rock) are not detrimental to $CO_2$ storage. Large areal changes in porosity and permeability are not anticipated from the interactions of $CO_2$ with the COSS. Minerals within the COSS that did react with $CO_2$ are typically found in lower concentrations in the quartz-dominated sandstone or within the low-porosity cap rock. Any reactions with the cap rock are not likely to penetrate past the $CO_2$–cap rock interface because of low porosity/permeability. Variations in formation water chemistry, mineral content, and porosity in the COSS can result in large variations in the amount of $CO_2$ that can be trapped. These variations occur both geographically between different areas of the COSS and vertically at each location.

Additional focused efforts are needed on both the modeling and rock–$CO_2$ exposure fronts to better understand the potential effects of $CO_2$ storage in the COSS. With respect to future modeling efforts, additional data are necessary for more robust calculations to address the effects of pressure, kinetics, and concentrated brines in the COSS. Laboratory-based $CO_2$ exposure experiments could be improved by implementing more advanced sampling methodologies for highly heterogeneous rocks to ensure that observed differences in chemistry are accurate. Heterogeneity in the rock samples provides for challenging interpretation of results when minute changes in chemistry are observed. Improvements to the $CO_2$ exposure methodology to allow for better detection of minute mineralogical changes within the rock fabric will greatly aid in the refinement of this experimental process.

# GEOCHEMICAL EVALUATION OF THE BASAL CAMBRIAN SYSTEM

## INTRODUCTION

A binational effort between the United States and Canada is under way to characterize the lowermost saline system in the Williston and Alberta Basins of the northern Great Plains–Prairie region of North America in the United States and Canada. This 3-year project is being conducted with the goal of determining the geologic storage potential of carbon dioxide ($CO_2$) in rock formations of the 1.34-million-$km^2$ (0.52-million-$mile^2$) Cambro-Ordovician saline system (COSS). To date, no other studies have attempted to characterize the storage potential of large, deep saline systems that span the U.S.–Canada international border. This multiprovince/multistate, multiorganizational, and multidisciplinary project is led on the U.S. side by the Energy & Environmental Research Center (EERC) through the Plains $CO_2$ Reduction (PCOR) Partnership and on the Canadian side by Alberta Innovates – Technology Futures (AITF). The project objectives are to characterize this saline aquifer system in the northern Great Plains–Prairie region of North America and to evaluate its storage potential and geochemical suitability for $CO_2$ storage.

At the base of the sedimentary succession in the Williston and Alberta Basins of the northern Great Plains–Prairie region of North America is a saline system composed of variable lithology which includes clastic and carbonate facies deposited across a range of environments. This system lies directly on top of igneous and metamorphic basement rocks and is largely contained beneath sealing formations that include shales and tight carbonates. These Middle Cambrian- to Lower Silurian-aged rocks extend from west-central Alberta into Saskatchewan, southwestern Manitoba, and then south into Montana, North Dakota, and South Dakota. These formations form an extensive saline system that is generally devoid of significant hydrocarbon resources. In the area overlain by the COSS, there are 43 large $CO_2$ sources that each emit more than 0.75 Mt $CO_2$/year. While $CO_2$ is increasingly being recognized as a commodity, especially for enhanced oil recovery, if the emissions from all of these sources were to be geologically stored in the COSS, several questions would have to be addressed: What is the storage resource of the system? How many years of $CO_2$ emissions will the system be capable of storing? What will the fate and effects of the stored $CO_2$ be? What are the potential interactions/reactions between the reservoir rock and $CO_2$? The research activities being conducted by the EERC and AITF and their associated results will provide previously unavailable insight to address those questions.

The information contained within this report will provide some insight into the fourth question above. First, a literature survey of the $CO_2$-trapping mechanism, past work, and expected $CO_2$–rock reactions–interactions both from an experimental approach and a modeling approach will be presented followed by a characterization of the study area used for this work and the approach/methodology. Lastly, results from geochemical modeling calculations and $CO_2$–rock exposure experiments will be presented.

### Literature Review – $CO_2$-Trapping Mechanisms

In order to understand the geochemical effects of $CO_2$ injection, it is necessary to review the mechanism by which $CO_2$ is trapped or contained in underground sequestration. The $CO_2$ injected into deep saline formations can be contained through physical trapping and chemical trapping (Gunter and others, 2004). During physical trapping, $CO_2$ retains its physical and chemical structure while contained by stratigraphic, structural, and capillary traps. Chemical trapping includes solubility, ionic, and mineral trapping whereby $CO_2$ changes its physical and chemical structure. Solubility trapping involves acid-generating reactions (Kaszuba and Janecky, 2009) as $CO_2$ dissolves in formation water to form carbonic acid ($H_2CO_3$[aq]) (Equation 1). As shown by Equations 2 and 3, carbonic acid may further dissociate into either the bicarbonate ion ($HCO_3^-$[aq]) or the carbonate ion ($CO_3^{2-}$[aq]), respectively.

$$CO_2(g) + H_2O(l) \leftrightarrow H_2CO_3(aq) \quad \text{[Eq. 1]}$$

$$H_2CO_3(aq) \leftrightarrow HCO_3^-(aq) + H^+ \quad \text{[Eq. 2]}$$

$$HCO_3^-(aq) \leftrightarrow CO_3^{2-}(aq) + H^+ \quad \text{[Eq. 3]}$$

For example, the interaction of $HCO_3^-$(aq) with alkaline aluminosilicate minerals may result in the formation of dissolved alkali carbonates and bicarbonates, thereby enhancing solubility trapping. During mineral trapping, $CO_2$ reacts directly or indirectly with minerals in the aquifer rocks and those dissolved in formation water, causing selective dissolution and precipitation of rock-forming minerals. $CO_2$ also reacts directly or indirectly with organic matter in the geologic formation, leading to the solubilization of organic matter. Mineral trapping is preferred because it may immobilize $CO_2$ for long timescales. In the short term, hydrodynamic trapping (Bachu and others, 1994) may be the most important mechanism for retaining $CO_2$. Hydrodynamic trapping occurs when the $CO_2$ is captured as a gas or supercritical fluid in a deep regional-scale formation with hydrogeologic conditions such that the residence or travel time to reach the surface is on the order of thousands to millions of years. The laboratory and modeling activities described in this report were designed and executed to examine the potential effects of the various chemical-trapping mechanisms on large-scale $CO_2$ storage in the COSS.

### Literature Review – Experimental Investigations of $CO_2$–Brine–Reservoir Rock Interactions

Geologic systems are typically heterogeneous with respect to both mineralogical composition and fluid chemistry. $CO_2$–water–rock interactions are also complex and thus not easily simulated numerically. Because of these attributes, the interactions are highly reservoir-

specific and are difficult to generalize. Empirical information on $CO_2$–brine–reservoir rock interactions is generally indirect and mostly based on gas or fluid samples recovered from observation wells. For example, Raistrick and others (2009) monitored the brines produced during $CO_2$ injection into a carbonate formation for enhanced oil recovery in the Weyburn oil field in Canada. Raistrick and others (2009) detected increases in $Ca^{2+}$, $Mg^{2+}$, $K^+$, $SO_4^{2-}$, $HCO_3^-$, and $CO_2$ concentrations probably because of the dissolution of calcite ($CaCO_3$), dolomite ($CaMg[CO_3]_2$), and K-feldspars ($[K,Na]AlSi_3O_8$). In addition to field data, laboratory experiments at simulated reservoir pressure and temperature (P–T) conditions enabled the generation of empirical data specifically for the reservoir being evaluated.

Sayegh and others (1990) injected 5 wt% NaCl brine saturated with $CO_2$ at 13.8 MPa (2000 psi) and 45°C (113°F) into sandstone cores from the Pembina Cardium reservoir in Alberta, Canada. That study observed a reduction in core permeability because of the dissolution of calcite and siderite and migration of fine mineral grains that were originally cemented to the rock by carbonates.

Bertier and others (2006) performed 18 experiments at 15 MPa (2175 psi) and 80°C (176°F) on $CO_2$–simulated brine–Westphalian and Buntsandstein (Campine Basin, Belgium) sandstone mixtures. They detected the dissolution and reprecipitation of carbonate minerals. Reactions with aluminosilicates also occurred, but they were less prominent.

Wigand and others (2008) treated a sample of Bunter Sandstone Formation rock from Europe and simulated brine (1 M NaCl) solution at 30 MPa (4350 psi) confining pressure, 15 MPa (2175 psi) pore fluid pressure, and 60°C (140°F) while supercritical $CO_2$ was injected at a pressure gradient of 1–2 MPa (145–290 psi) for 1496 h (62.3 days). The fluid pH decreased from a median value of 6 to 5 after saturation with supercritical $CO_2$. Most of the major (e.g., Ca, Mg, Fe, and Mn) and trace element (e.g., Sr, Ba, and Pb) concentrations in the sandstone increased after the treatment. Scanning electron microscopy (SEM) analyses indicated the dissolution of dolomite cement, K-feldspar, and albite and the formation of montmorillonite. Berg and Banwart (2000) also determined that $CO_2$ accelerates feldspar dissolution.

Mohamed and others (2012) injected Berea sandstone cores with supercritical $CO_2$ at P–T conditions of 8.96 MPa (1300 psi) and 21° to 121°C (70°–250°F) and a flow rate of 5 $cm^3$/min. Core permeabilities were reduced by 35% to 55% after $CO_2$ injections. Core permeabilities were reduced much greater at 93° and 121°C (199° and 250°F) relative to 70°C (158°F). Permeabilities decreased because of the dissolution and reprecipitation of carbonate minerals and/or the migration of clay particles that were originally cemented on sand particles by carbonates.

Alemu and others (2011) reacted carbonate-rich and clay-rich cap rock shale samples, cored from a proposed underground storage site on the island of Svalbard, Norway, with a mixture of 1 M NaCl solution and ±$CO_2$ at 11 MPa (1595 psi) at a water:rock ratio of 20:1 and temperatures ranging from 80 to 250°C (176°–482°F) for 1–5 weeks. Fluid analyses indicated that Ca, Mg, Fe, K, Al, and Si increased in all experiments. Release rates of Fe and Si were more pronounced in solutions reacted with $CO_2$ and brine than with $CO_2$-free brine. Lower temperature (80°C, 176°F) $CO_2$–brine reactions released much more Fe and Si than higher

temperature (150°–250°C, 302°–482°F) reactions. The carbonate-rich shale was most reactive at 250°C as evidenced (through SEM and x-ray diffraction [XRD] analyses) by the dissolution of plagioclase and clays (illite and chlorite), dissolution and reprecipitation of carbonates, and the formation of smectite. The clay-rich shale reacted with $CO_2$, and the brine did not undergo significant mineralogical alteration. Recently, Li and others (2012) reviewed the literature pertaining to $CO_2$–brine–cap rock interactions and discovered reactions to be minimal. Although some reactions do take place with the cap rock, they are limited to the $CO_2$–rock interface and do not permeate into the seal.

Fischer and others (2011) and Wandrey and others (2011) exposed water-filled Stuttgart Formation sandstone core samples, from the reservoir horizon for the $CO_2$SINK project in Ketzin, Germany, to simulated reservoir P–T conditions of 5.5 MPa (798 psi) and 40°C (104°F). After 15, 21, and 24 months of $CO_2$ exposure, rock and fluid samples were analyzed to evaluate geochemical, mineralogical, and petrophysical characteristics. Fluid chemical and mineralogical analysis results were consistent with the dissolution of plagioclase, K-feldspar, and anhydrite. Initially, the dissolution of minerals increased porosity as observed with nuclear magnetic resonance measurements and mercury injections. After 24 months of incubation, porosities and inorganic fluid component concentrations declined and albite precipitated, consistent with secondary mineral formation.

The empirical results summarized herein have some practical implications. Reactions between acidic $CO_2$-rich fluids and shale cap rock have been observed but appear to be very minimal. Mineral dissolution of reservoir rock components and subsequent reprecipitation can decrease reservoir permeability. Conversely, mineral dissolution near the injection site could enhance porosity and permeability, thus facilitating $CO_2$ injection. Mineral trapping, i.e., precipitation of carbonates, can be a significant part of a reservoir's overall storage capacity and ensure $CO_2$ storage over geologically significant time frames. Based on the literature review, no major unexpected consequences of $CO_2$ injection have been observed with experiments involving $CO_2$, brine and reservoir rocks. Presented in Table 1 are some possible reactions that explain the dissolution and precipitation observations summarized heretofore.

**Table 1. Potential Reactions Between Sandstone Minerals and $CO_2$**

| Mineral | Reaction | Reference |
|---|---|---|
| Calcite | $CaCO_3 + CO_2 + H_2O \leftrightarrow Ca^{2+} + 2HCO_3^-$ | Wellman and others, 2003 |
| Dolomite | $CaMg(CO_3)_2 + 2CO_2 + 2H_2O \leftrightarrow Ca^{2+} + Mg^{2+} + 4HCO_3^-$ | Wellman and others, 2003 |
| Kaolinite | $Al_2Si_2O_5(OH)_4 + 6H^+ \leftrightarrow 2Al^{3+} + 2H_4SiO_4 + H_2O$ | Li and others, 2005 |
| K-Feldspar | $2KAlSi_3O_8 + CO_2 + 2H_2O + Ca^{2+} \rightarrow 2K^+ + 4SiO_2 + CaCO_3 + Al_2Si_2O_5(OH)_4$ | Pauwels and others, 2007 |
| Clinochlore | $(Mg_5,Al)(Al,Si_3)O_{10}(OH)_8 + 10H^+ \rightarrow 5Mg^{2+} + 2Al(OH)_3 + 3H_4SiO_4$ | Mito and others, 2008 |
| Chamosite | $(Fe_5,Al)(Al,Si_3)O_{10}(OH)_8 + 10H^+ \rightarrow 5Fe^{2+} + 2Al(OH)_3 + 3H_4SiO_4$ | Mito and others, 2008 |

## Literature Review – Geochemical Modeling of $CO_2$–Brine–Reservoir Sandstone Interactions

Reactive transport models are commonly used to evaluate the efficiency of $CO_2$ capture and storage. Mineral dissolution and formation reactions are modeled thermodynamically and kinetically. Differences in thermodynamic equilibria and kinetic modeling results are caused by differences in the geochemical model codes, thermodynamic and kinetic databases, selection of the ion activity model, temperature correction of equilibrium constants, $CO_2$ fugacity calculation, and selection of primary and secondary minerals or solid solutions (Dethlefsen and others, 2011, 2012). Gaus and others (2008) provide an overview of geochemical and solute transport modeling for $CO_2$ storage purposes, highlighting its data requirements and gaps.

Gunter and others (1997) modeled long-term $CO_2$ storage in a glauconitic sandstone formation located at a depth of 1500 m (4920 ft) in the Alberta Basin, Canada. Previous experiments (105°C, [221°F] and 9 MPa, [1305 psi] $CO_2$ for a month) to evaluate the $CO_2$ mineral-trapping capacity of the sandstone were challenged probably because of kinetic limitations. The experiments indicated, however, an increase in alkalinity as a result of the $CO_2$–formation water–reservoir rock interactions. Gunter and others (1997) predicted substantial trapping of $CO_2$ via the formation of siderite ($FeCO_3$), calcite ($CaCO_3$), and aqueous bicarbonate ions ($HCO_3^-$ [aq]) over a 6- to 40-year time frame. Perkins and Gunter (1995) extrapolated Gunter and others (1997) modeling results to the field, i.e., glauconitic sandstone aquifer at 54°C (129°F) and a proposed $CO_2$ injection pressure of 26 MPa (3770 psi), and concluded that the $CO_2$–mineral-trapping reactions would take hundreds of years to complete after the formation water had equilibrated. From a hydrogeological perspective, the $CO_2$-trapping time is relatively short as the fluid residence times in deep low-permeability formations similar to those in the Alberta Basin are measured in the tens of thousands to hundreds of thousands of years. However, the time frame for the operational life of a power plant is measured in tens of decades, not centuries, so the work by Perkins and Gunter (1995) suggests that mineral trapping would not likely be a significant trapping mechanism during the injection period of a carbon capture and storage (CCS) project.

Xu and others (2003) developed a geochemical model for evaluating long-term $CO_2$ storage in arenaceous sandstone formations because alteration of the predominantly aluminosilicate host minerals was very slow and not amenable to laboratory experimentation under deep formation conditions. They performed numerical simulations for an ubiquitous Gulf Coast sediment under natural and $CO_2$ injection conditions. Their model predicated that $CO_2$ trapping would occur through the formation of secondary carbonate minerals such as calcite ($CaCO_3$), dolomite ($CaMg[CO_3]_2$), siderite ($FeCO_3$), and dawsonite ($NaAlCO_3[OH]_2$). The $CO_2$–mineral-trapping capability after 10,000 years was predicted to be comparable to $CO_2$ dissolution in pore waters (2–5 kg $CO_2$ per cubic meter of formation). The addition of secondary carbonates to the modeled system probably decreased porosity and permeability.

Cantucci and others (2009) geochemically modeled the enhanced oil recovery project at Weyburn in Saskatchewan, Canada, where $CO_2$ is being injected to increase the recovery of oil from the shallow marine carbonates of the Midale Beds. The conclusions of Cantucci and others (2009) were threefold: 1) the calculated preinjection chemical composition of the Midale Beds brine was consistent with the chemical compositions of the waters collected in 2000 (baseline

survey), 2) main reservoir reactions ($CO_2$ and carbonate dissolution) occur within the first year of simulation, and 3) temporal evolution of the fluid chemical compositions in the Weyburn reservoir suggests that $CO_2$ can safely be stored by solubility (as $CO_2$[aq]) and mineral trapping via dawsonite precipitation).

Talman and others (2012) recently modeled the effects of long-term $CO_2$ storage in the COSS of the Prairie Region in Canada using the geochemical simulation code PHREEQC. They focused on the equilibrium conditions in the reservoir formation, cap rock, and well cement both pre- and post-$CO_2$ injection. Their results suggested that the amount of gaseous $CO_2$ which can potentially be stored by chemical trapping in the Basal Aquifer is negligible because of the low reactivity of the aquifer solids, primarily quartz (>80 wt%), and the high salinity of the formation water. Minor amounts of several carbonate minerals were predicted to form as the result of interactions among injected $CO_2$ (as a supercritical fluid), brine, and reservoir rocks. Talman and others (2012) considered two scenarios to simulate the reactions induced in the cap rock by $CO_2$ injection. The first considered the reaction between the original pre-$CO_2$ injection formation water and cap rock minerals and the second assumed the water migrating through the cap rock was in equilibrium with the formation mineralogy and a free $CO_2$ phase. In both scenarios, the general tendency was to transform chemically complex clay minerals into the structurally and chemically simpler kaolinite clay. The $CO_2$-rich waters, however, were much more reactive toward the cap rock than the original formation water. The reaction zones in both scenarios were predicted to be small in comparison to the cap rock thickness.

Many of the same reactions observed in the experimental studies previously mentioned have been predicted in the theoretical simulations. The main reactions are dissolution and deposition of carbonate-bearing species (dolostone, calcite) and $CO_2$ interactions with K-feldspar and clays. Any interaction predicted between $CO_2$ and the cap rock is minimal. One species of specific interest, because of its prominence in the COSS is sandstone that is enriched with glauconite (bright green, Fe-rich mica). The importance of glauconite in $CO_2$ sequestration is discussed further in the following section.

### Role of Glauconite in $CO_2$ Trapping

Understanding the potential interactions between $CO_2$ and glauconite is important for this study because the sandstones of the Deadwood Formation in the U.S. portion of the COSS are known to contain significant amounts of glauconite in some areas. Equilibrium modeling by Zerai and others (2006) demonstrated that glauconite dissolution and subsequent siderite precipitation are important for mineral trapping of $CO_2$ as represented by the equation:

$$KFe_3AlSi_3O_{10}(OH)_2 + 7CO_2 + H_2O \leftrightarrow 3FeCO_3 + 3SiO_2 + K^+ + 4HCO_3^- + Al^{3+} \quad \text{[Eq. 4]}$$

Numerical simulations of geologic $CO_2$ storage by Xu and others (2004) indicated that the precipitation of ankerite and siderite is sensitive to the rate of $Fe^{3+}$ reduction in mineral precursors such as glauconite. Xu and others (2004) calculated that glauconite alteration could potentially sequester as much as 61.97 kg of $CO_2$ per $m^3$ (1.75 lb/$ft^3$) of glauconite, assuming complete alteration. This potential glauconite-trapping capacity is predicted to be larger than the solubility trapping of 7–10 kg per $m^3$ (0.2–0.3 lb/$ft^3$) of medium. Xu and others (2004) predicted that the glauconite in a glauconitic sandstone completely dissolves relatively rapidly, in about

20 ka (kiloannums), at a $CO_2$ pressure of 26 MPa (3770 psi), pH of ≈5, and Eh of ≈0.1 V. Fernandez-Bastero and others (2005, 2008) determined the kinetics of glauconite dissolution in the pH range 2–10 at 25°C. Glauconite is more stable at neutral or slightly alkaline pH values. Under acidic conditions, glauconite is slightly more soluble than the other silicate minerals ubiquitously present in marine sediments. Glauconite dissolution is a two-stage process involving a structural disordering that results in microstrain and a reduction in the crystal size domains within the tetrahedral and octahedral layers causing the release of interlayer cations. The dissolution process produces an amorphous silica residue that reduces the reactive surface, thus inhibiting dissolution advancement. With these potential phenomena in mind, the EERC activities did take care to ensure that the role glauconite might play in $CO_2$ storage in the COSS was examined.

## GEOLOGIC SETTING OF THE STUDY AREA

Deep sedimentary rock formations saturated with saltwater (also known as saline formations) are viable targets for secure, long-term storage of large volumes of $CO_2$. Deep saline formations generally occur in geologic settings known as sedimentary basins, which are depressions in the Earth's crust filled with thick sequences of sedimentary rocks such as sandstone, shale, and limestone. Within central North America, the COSS is a viable candidate for geologic $CO_2$ sequestration given its depth, highly saline formation water (i.e., salinity is above the regulatory threshold of 10,000 ppm total dissolved solids for underground sources of drinking water), and proximity to several large-scale sources of $CO_2$ emissions. This saline system is composed of Middle Cambrian to Lower Ordovician rocks that overlie the crystalline Precambrian basement in the Williston and Alberta Basins. The Canadian portion of the COSS is largely sandstone; however, the U.S. portion is more heterogeneous and includes shales and carbonates. The COSS is overlain by a primary cap rock (Ice Box Formation) composed mostly of shales with some carbonates and evaporates higher up in the stratigraphic sequence. This saline system attains depths of >3.1 mi (>5000 m) near the Rocky Mountain thrust and fold belt in the Alberta Basin and 1.9 mi (3000 m) at the center of the Williston Basin. As shown in Figure 1, the COSS extends from north of Edmonton in Alberta, Canada, to South Dakota in the United States, covering a combined area of ≈509,000 sq mi (≈1.3 million $km^2$). The COSS covers ≈195,814 sq mi (≈507,155 $km^2$) and ≈313,285 sq mi (≈811,345 $km^2$) in the United States and Canada, respectively.

Water salinity in the COSS increases with depth attaining total dissolved solids (TDS) values of >350,000 mg/L in both Williston and Alberta Basins (Talman and others, 2012). Figure 2 contains a map describing the lithology of the Deadwood Formation within the COSS system. More information and petrographic analysis of rocks from the COSS system can be found in Appendix A.

The effective geologic storage of $CO_2$ requires a scientific understanding of the interactions among injected $CO_2$ (as a supercritical fluid), brine, and reservoir and cap rocks. These interactions can potentially change the mineralogical and chemical compositions and petrophysical characteristics of the reservoir and cap rocks.

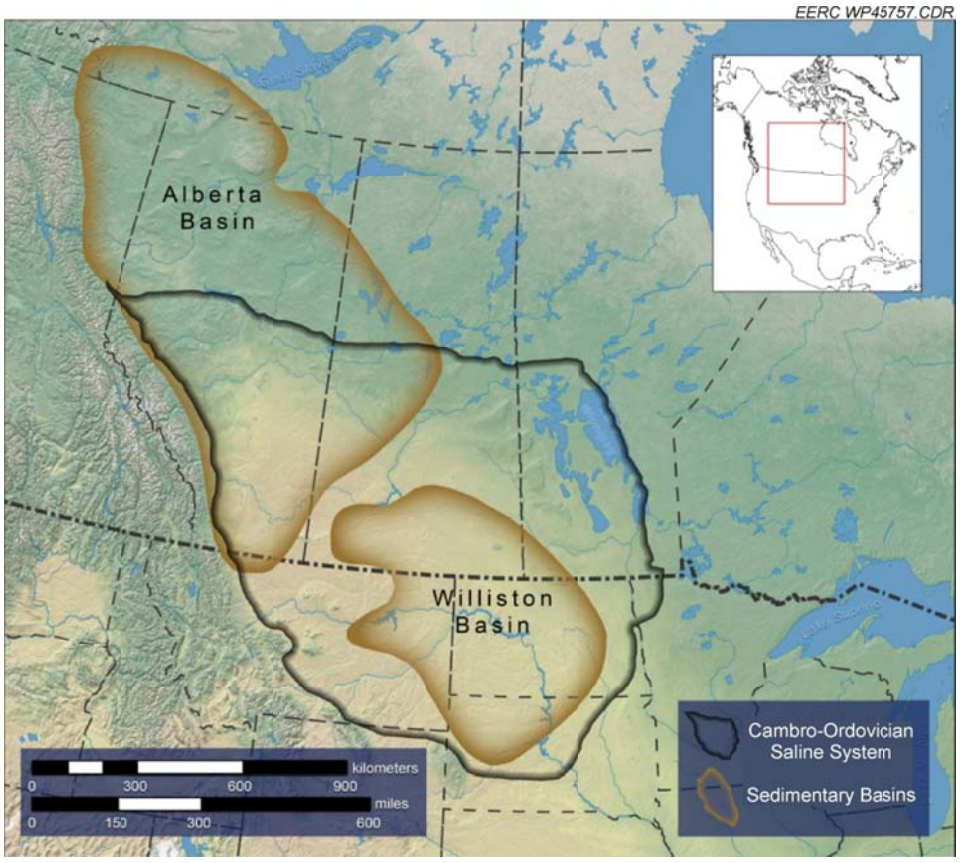



Figure 1. Areal extent of the COSS in the northern Great Plains region of the United States and the Prairie region of Canada.

**Study Approach**

To better understand the storage capacity and geochemical suitability of the COSS as a target for $CO_2$ sequestration, the EERC conducted a two-pronged approach. A portion of the effort involved geochemically modeling the effects of long-term $CO_2$ storage in the system. To complement this effort, the EERC performed independent $CO_2$, rock, and brine exposure experiments. The $CO_2$ exposure experiments were conducted with a focus on actual reservoir rock, pressures, temperatures, and brine concentrations. The two approaches remained independent of each other until the data were ready for comparisons. Several of the rock and brine analyses were used in both the modeling and $CO_2$ exposure studies which lends to direct comparisons of each independent method. Following are descriptions of the modeling effort and results followed by the $CO_2$ exposure methods and results.

The rock core and water analysis data were associated with wells located on the U.S. side of the COSS, more specifically from the Dakotas and Montana. Well locations used for both the core and brine samples for the modeling and $CO_2$ exposure experiments can be found in Figure 3. More specifics on each well and location can be found in the applicable section.

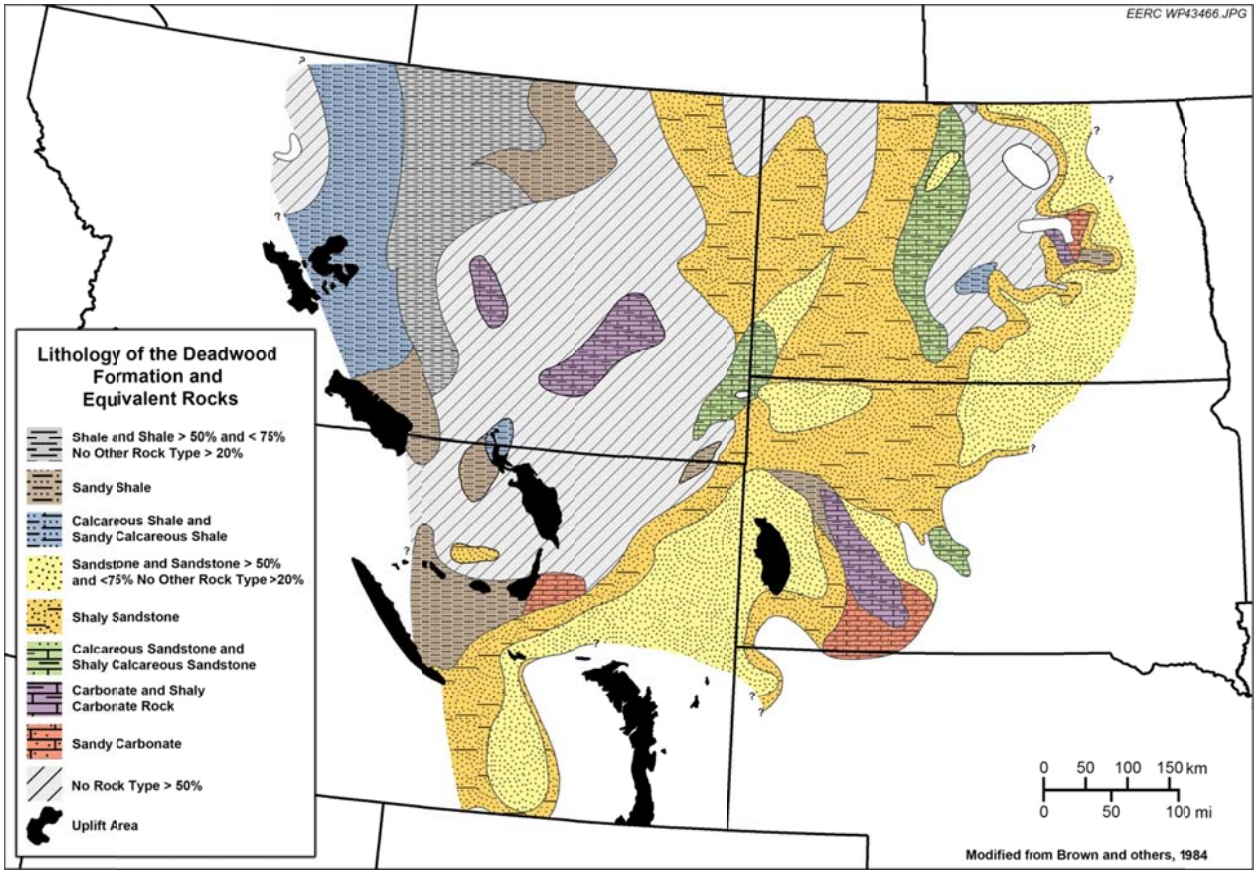



Figure 2. Lithology (facies) distribution map of the Deadwood Formation as interpreted by Brown and others (1984).

## GEOCHEMICAL MODELING

### Methods

Geochemical modeling calculations were performed on selected rock formations within the COSS system. More specifically, intervals within the Deadwood Formation (dominantly sandstone with a mix of shale and carbonate rock) and the Icebox Formation (a shale cap rock) were selected. Core and brine data were collected from several sources for the calculations.

#### *Data Sources*

Formation water analyses were obtained from public sources. Specifically, data were obtained from:

- North Dakota Industrial Commission (NDIC) Department of Mineral Resources Oil and Gas Division well files. https://www.dmr.nd.gov/oilgas/.

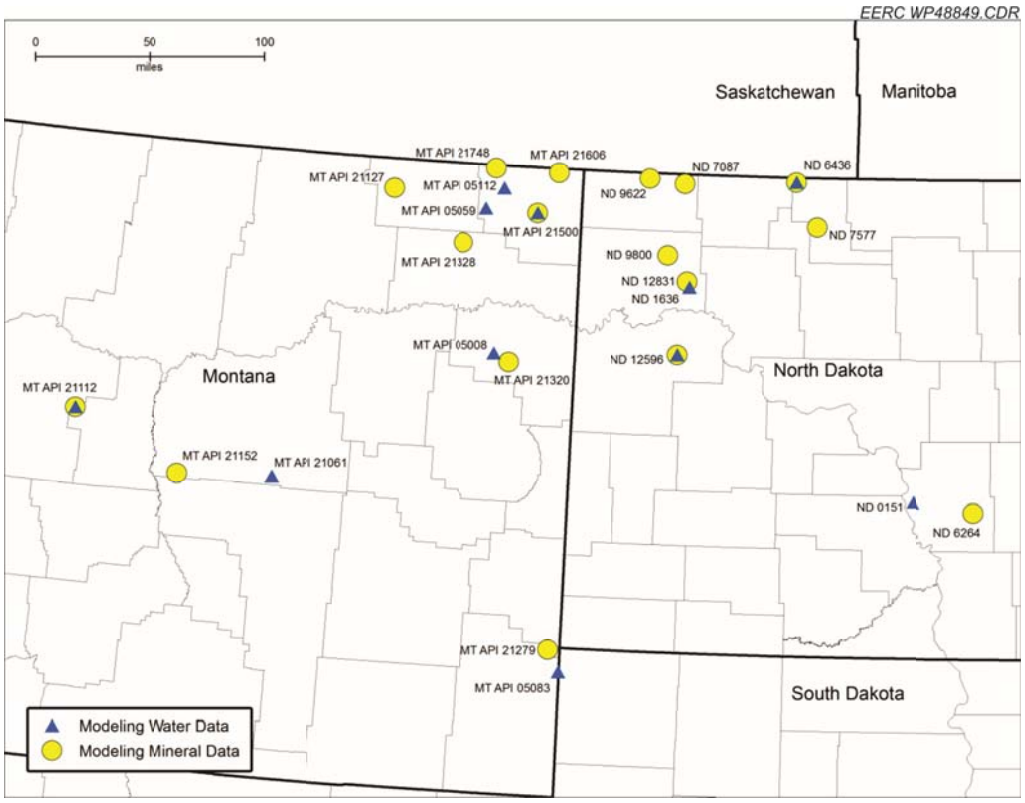



Figure 3. Map of sample locations for modeling and $CO_2$ exposure experiments.

- North Dakota State Water Commission ground and surface water data archive http://www.swc.state.nd.us/4dlink9/4dcgi/redirect/index.html.

- U.S. Geological Survey Produced Waters Database archive. http://energy.cr.usgs.gov/prov/prodwat/data2.htm.

*Water Analysis Data*

Twenty-eight wells with formation water analyses for the U.S. area of the COSS were found. Their names and locations are given in Appendix B. Normally, analysis values were provided for bicarbonate ($HCO_3^-$), calcium ($Ca^{2+}$), chloride ($Cl^-$), magnesium ($Mg^{2+}$), potassium ($K^+$), and sulfate ($SO_4^{2-}$) and for pH. Analysis from well files typically included density and the temperature at which the density was determined. The well files may also include analysis values for other ions, such as $Fe^{2+}$. Density was not provided for data in the USGS database. In the case of analyses for which the density was not available, the density was estimated from a linear regression of density versus total dissolved solids from water analyses for which density was available. A plot of these data and the regression equation can be found in Appendix B. The temperatures for these estimated densities were assumed to be 15.6°C (60°F).

*In Situ Temperature and Pressure Data*

Formation temperatures were obtained from the well files, if available. The USGS data set did not provide formation temperatures. Unavailable temperatures were estimated from corrected borehole temperatures. The formation pressure was taken to be the initial shut-in pressure of the drillstem test (DST) associated with the water sample. For wells where this pressure was not available, the formation pressure was estimated from the vertical depth using the formula pressure in psi = 0.44 × depth in feet.

*Well-Naming Convention, Formation Water Chemistry, Mineralogy, and Zone Determination*

The wells identified for use in this portion of the study were distributed throughout North Dakota and Montana. The unique identification number given by the state of North Dakota was used for wells in North Dakota. Wells located in Montana were referred to by the well-specific identification number located in the American Petroleum Institute (API) naming convention. For example, a well with API No. 25-033-21152-0000 was referred to in this report as MT API 21152.

Thirty wells had well log data that could be used to determine mineralogy in the COSS. A limited number also had these data for the overlying cap rock. The mineralogical data were derived through multimineral petrophysical analysis using the Qunati.Elem module in Schlumberger's Techlog program. The actual mineralogical data are presented in Appendix B.

Four wells had both formation water chemistry data and mineral data. Another thirteen wells were judged to be near enough (within 100 km, 64 miles) to the nearest well with water data to use these water data for the well. The distribution of the wells is illustrated in Figure 3.

Through the process of multimineral petrophysical analysis, mineralogic distribution through the thickness of the saline system was resolved to 0.5- to 1-foot (0.15- to 0.30-meter) intervals. As would be expected, there are substantial variations of mineral composition within both the COSS and the cap rock. Ideally, modeling calculations would have been performed for each interval value to provide the highest resolution; however, this would have required much more time and resources than were available for this effort. Instead, the mineral data for each well were divided into a number of zones based on predominant mineral composition and calculations performed on the average mineral composition of each zone. A calculation was also performed using the average mineral composition for the entire well mineral data set. The selection of the zones was made empirically from well logs showing the major mineral components. Please note that the zone numbers are not the same for each well. For example, Zone 1 determined for any given single well has no relation to any other Zone 1 determined for any other specific well.

*Chemical Equilibrium Between Formation Water, Minerals, and $CO_2$*

The publically available USGS program PHREEQC (http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc/) (Parkhurst and Appelo, 1999) was used for calculations of interactions between formation water, minerals, and $CO_2$. The program version used is

PHREEQC Interactive 2.18.3.5570, released August 16, 2011. It implements PHREEQC Version 2.18.3.

The program calculates the aqueous species concentrations and activities, the saturation index of minerals, and fugacity of gas-phase species. It should be noted that PHREEQC does not account for pressure. To account for $CO_2$ interactions at high pressure, the method of Talman was followed (Talman and others, 2012) where a pseudo $CO_2$ solid phase is defined and the equilibrium constant for the reaction $CO_2 + H_2O \rightarrow H^+ + HCO_3^-$ adjusted to provide the concentrations of $H^+$ and $HCO_3^-$ for a given $CO_2$ pressure.

*Thermodynamic Databases*

Pitzer equations are important for understanding the behavior of ions dissolved in natural waters. The ideal thermodynamic database to use for calculations involving concentrated brines is a Pitzer database. As such, similar thermodynamic calculations with the Canadian portion of the COSS used the PHREEQC-compatible Pitzer thermodynamic database data0.ypf.clean.edit_nocomments.dat. This database was originally developed by Sandia National Laboratories for the U.S. Department of Energy (DOE) Yucca Mountain Project as the YPF database. It was rewritten to be compatible with PHREEQC by the Nuclear Waste Management Organization of Canada; however, there is no publicly available version of this database, and thus it could not be used for the EERC's COSS modeling effect.

The Pitzer database included in PHREEQC does not include oxidation and reduction reactions for species, which are important for calculations involving $CO_2$. Additionally it lacks thermodynamic data for many of the common mineral species, including quartz, Mg-beidellite, Na-beidellite, K-feldspar, Mg-montmorillonite, Na-montmorillonite, kaolinite, and illite and, therefore, could not be used for these calculations.

A second database included in PHREEQC is llnc.dat. This database uses the Debye–Hückel activity model and is not optimal for use with concentrated brines. However, it does contain an extensive database and handles oxidation–reduction reactions. In the absence of a more suitable Pitzer database, by default the llnl.dat database was used for the calculations. It is recognized that this database may not be applicable to concentrated brines (>0.01 M solutions).

*Mineral Composition*

The mineral composition provided by the well data includes the following minerals: biotite, calcite, chlorite, dolomite, glauconite, illite, potassium feldspar (K-feldspar), kaolinite, muscovite, pyrite, quartz, anatase, microcline, sanidine, mica, smectite, and ankerite. Biotite, chlorite, glauconite, anatase, mica, smectite, and ankorite are not present in the llnl.dat database. However, the database does include minerals that have chemical compositions and mineralogic properties that are similar to those which are missing, thus allowing for substitutions. Thus phlogopite was substituted for biotite, clinochlore for chlorite, celadonite for glauconite, rutile for anatase, muscovite for mica, illite for smectite, and dolomite for ankerite.

Since "shale" is not a discrete mineral, a mineral composition consisting of the average of two Icebox shale samples as determined by XRD was used to replace the percentage of shale in

the PHREEQC calculations. The actual chemistry used to represent the shale mineralogy and the chemistry of other minerals can be found in Appendix B.

After the mineral substitutions were made, the mole fractions of each mineral were calculated along with the fractional density. The weighted density of all of the minerals along with the effective porosity was used to determine the minerals (in moles) in contact with 1 kg of formation water.

*Calculation Procedure*

The PHREEQC calculations follow the method of Talman and others (2012). The input script for one of the wells can be found in Appendix B. It should be noted that a number of the steps were not used by the EERC in the calculation; however, they have been left in the script (with the text commented out [preceded by a "#" character]) to illustrate differences in calculations from those of Talman. Some of the steps were not used because of differences in rock/water chemistry and information available in the databases.

*Postprocessing of the Calculation Results*

The behavior of the clays (celadonite, clinochlore, illite, K-feldspar, maximum microline, and sanidine) in a portion of the calculations precluded a direct assessment of the interaction of $CO_2$ with the mineral phases. Instead, the differences between the final products with and without $CO_2$ present are used to estimate the interaction of $CO_2$ with the formation water and mineral phases.

**Results of PHREEQC Modeling Calculations**

The challenges encountered with the PHREEQC calculations for the interaction of $CO_2$ with the formation water and the COSS minerals should be kept in mind. However, even with the following challenges, PHREEQC remains a valuable tool for evaluating geochemical interactions between rock and $CO_2$:

- The llnl.dat database was formulated for dilute solutions and is being extrapolated to strong brines.

- Substitutions were made for several of the mineral species in the mineral data sets to similar minerals which were in the llnl.dat database. The specific chemistry may not be identical to variations present in the COSS.

- The calculated depletion of some of the clays in the calculations suggests that the thermodynamic values of these species may not correct. To account for the behavior of these clays, the differences between the calculated products with and without $CO_2$ present are being compared.

- The effect of pressure is being simulated using a $CO_2$ pseudo solid phase because the model does not have information for the behavior of supercritical $CO_2$.

The ND 6436 well is taken as an example of the calculation results. A brief summary of all of the calculations performed follows ND 6436. Detailed results for the other wells are given in Appendix B.

Tables containing the average mineral compositions for the seven COSS zones and four cap rock zones that were identified for this specific well can be found in Appendix B. The zones were identified from mud log data with the TechLog program. The identification of a zone was the result of a concentration of certain mineral phases in each specific well location. Some locations contained much variability and, therefore, had as many as 11 zones identified in the COSS. It should be noted that the zone numbers are unique to each well's geology and do not correspond to zones identified within other wells. Figure 4 shows the zones' mineral composition and porosity as a function of depth for the COSS portion of the well. The corresponding Figure 5 shows the same information for the cap rock.

A table containing all of the formation water chemistry can be found in Appendix B. Calculated $CO_2$ uptake data and water chemistry for the ND 6436 well where differences were noted with and without $CO_2$ injection are presented in Table 2.

Introduction of $CO_2$ results in a decrease in the formation water pH and a concurrent increase in the pE (reduction potential). There is an expected increase in the solution carbon because of the introduction of $CO_2$. Solution water calcium concentration decreases because of precipitation of dolomite, and there is an increase in the solution magnesium concentration. It is felt that the increased magnesium concentration in solution may be an artifact of the lack of a mineral pathway in the database to precipitate it as a carbonate. Note that the inclusion of magnesite as a mineral species seemed to give unrealistically high $CO_2$ uptake due to precipitation. Dissolved $CO_2$ in the formation water is approximately 0.8 moles/kg water (37.8 g/kg water). This appears reasonable compared to the solubility of $CO_2$ in pure water at formation pressures. Other major contributors to $CO_2$ held in solution are $HCO_3^-$, $MgHCO_3^+$ and $NaHCO_3$.

The major contribution to $CO_2$ uptake by the COSS is predicted to be the precipitation of dolomite. The precipitation is resulting from the calcium in the formation water and the magnesium being released by the (thermodynamically unavoidable) dissolution of illite and K-feldspar. In other wells containing calcite, the calcite is predicted to dissolve and dolomite form preferentially.

The uptake of $CO_2$ on the basis of unit volume varies considerably for the zones identified in this well (Appendix B). Zone 2 has the highest total uptake of $CO_2$, although other zones have a higher uptake by mineral reactions. This appears to be a consequence of the higher porosity of Zone 2 in this particular well. The extent of mineral reactions, i.e., precipitation of carbonates, also varies considerably. Zone 1 has almost equal amounts of solution and mineral $CO_2$ (fraction mineral $CO_2 = 0.450$), while Zone 7 has very little mineral $CO_2$ (fraction mineral $CO_2 = 0.054$).

It should be noted that the sum of the uptake of $CO_2$ for the seven COSS zones in well ND 6436 is somewhat more than the average of the entire column. This appears to be the result of both variations in porosity as well as specific mineral–$CO_2$ interactions in the individual zones.

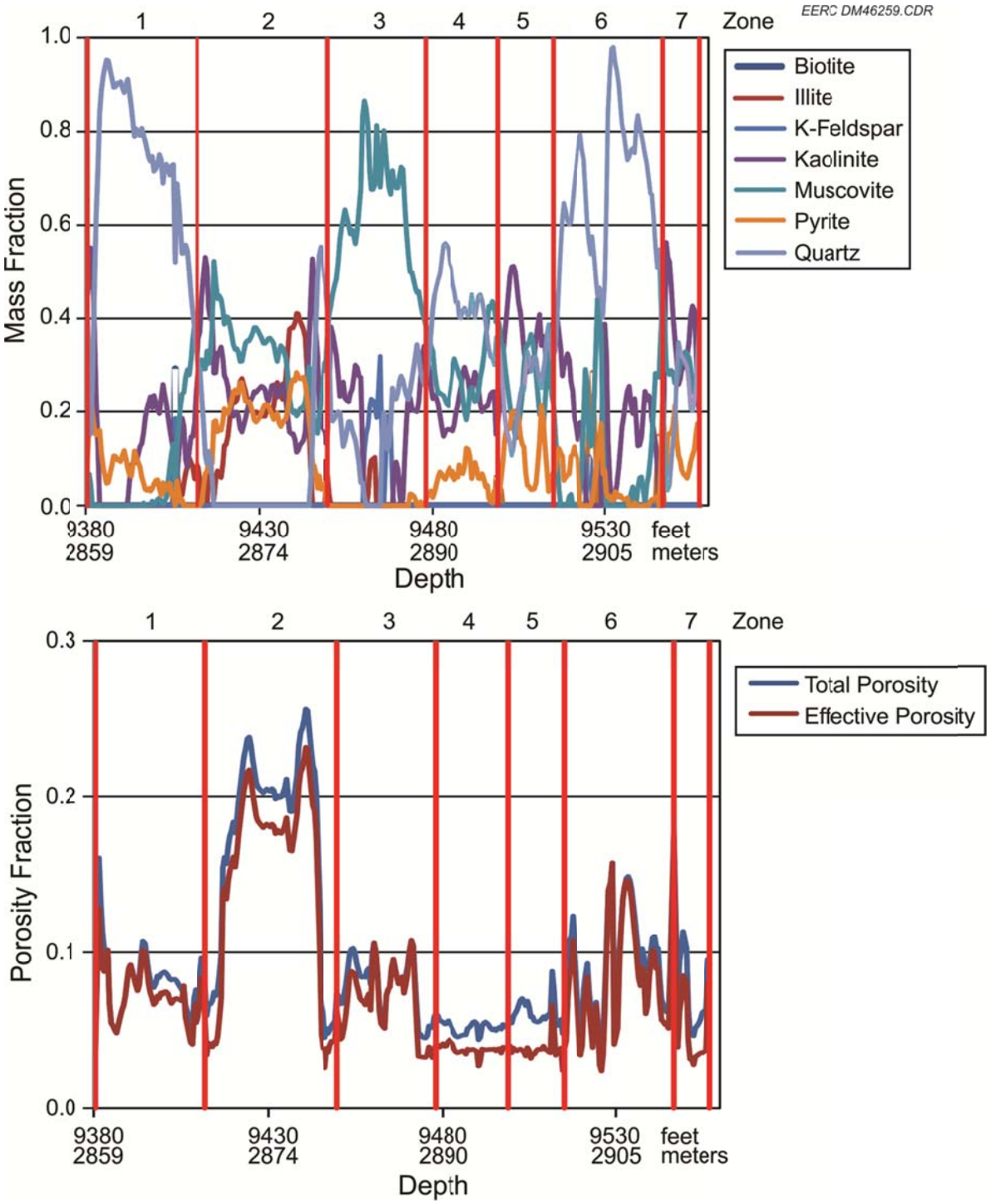



Figure 4. ND 6436 mineral composition and porosity as a function of depth.

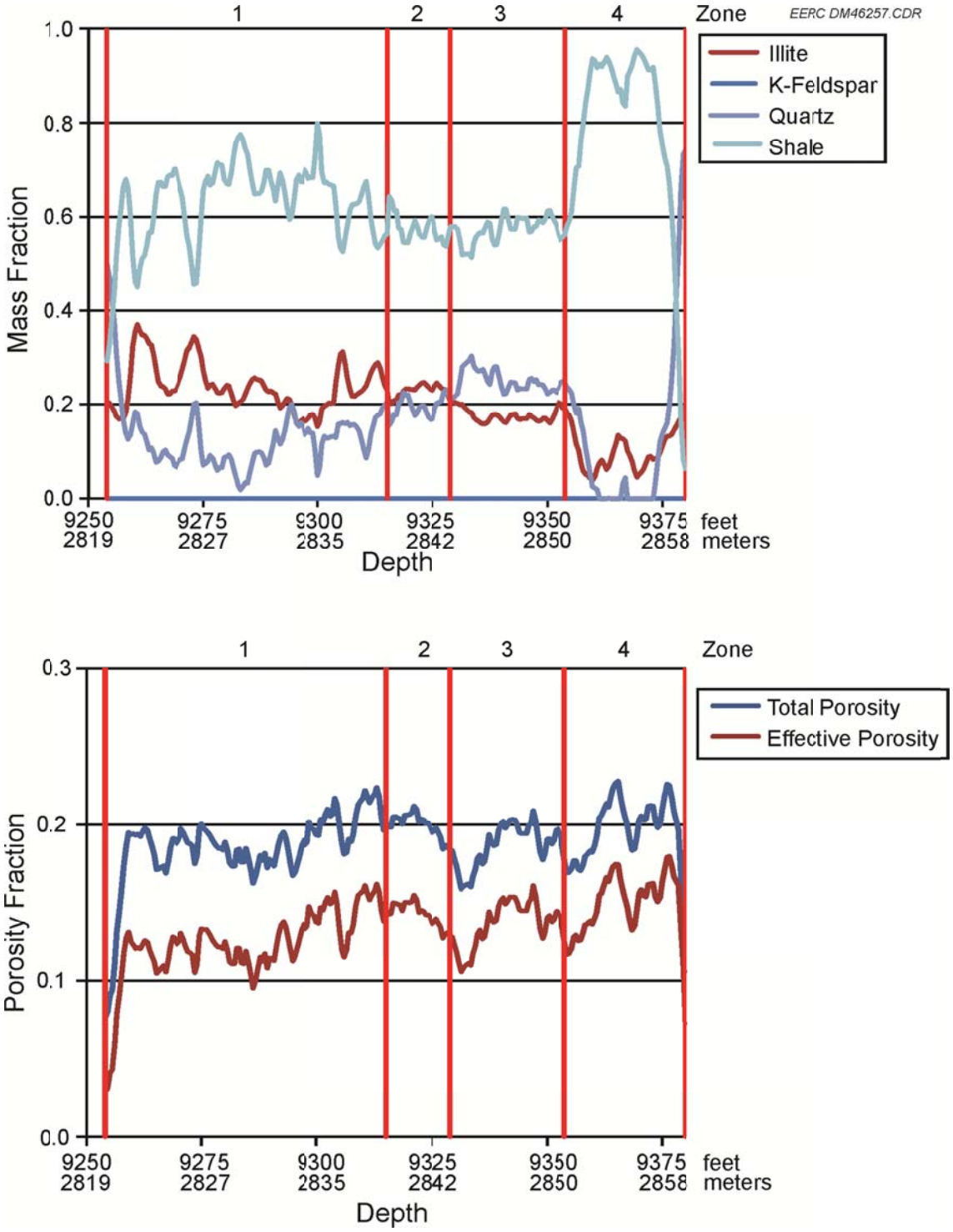



Figure 5. ND 6436 cap rock minerals and porosity as a function of depth.

**Table 2. Average Changes in Water and Mineral Compositions for ND 6436 Well Predicted by PHREEQC Calculations**

| State Identification: ND 6436 | | | |
|---|---|---|---|
| Formation Zone | COSS Predicted Without $CO_2$ | Predicted with $CO_2$ | Difference |
| Formation Water Chemistry | | | |
| pH | 5.847 | 4.342 | −1.505 |
| pE | −2.382 | −0.440 | 1.942 |
| Activity | 0.847 | 0.833 | −0.014 |
| Ionic Strength | 4.334 | 4.262 | −0.072 |
| Total moles $CO_2$ | 2.321E-04 | 0.859 | 0.859 |
| $CO_2$ Fate, moles/kg $H_2O$ | | | |
| $CO_2$ Calcite | 0.000 | 0.000 | 0.000 |
| $CO_2$ Dolomite | 0.000 | 1.058 | 1.058 |
| $CO_2$ Siderite | 0.000 | 0.000 | 0.000 |
| Total Mineral $CO_2$ | 0.000 | 1.058 | 1.058 |
| Solution $CO_2$ | 2.32E-04 | 0.859 | 0.859 |
| Total moles $CO_2$ | 2.32E-04 | 1.92 | 1.916 |
| Formation Capacity | | | |
| Water, kg/$m^3$ formation | 81.206 | 81.206 | 0.000 |
| $CO_2$, moles/$m^3$ formation | 0.019 | 155.625 | 155.604 |
| $CO_2$, kg/$m^3$ formation | 0.000836 | 6.848 | 6.847 |

### Summary of PHREEQC Calculation Results

The ability to effectively model geochemical interactions between rock formations, brine and $CO_2$ are highly dependent on the amount and quality of data. The data most frequently unavailable were formation water analyses and missing elements in water analysis data. Few wells had both water and mineral analyses available. The necessity to extrapolate water analyses to wells some distance away introduces some uncertainty into the calculation results. However, the calculations are still valid for the type of system described by the data.

The variations in formation water, mineral content, and porosity in the COSS result in large variations in the amount of $CO_2$ reacting with the formation water and the rock minerals. These variations occur both geographically between different areas of the COSS and vertically at each location. Averaging of these properties over the total aquifer can result in over- or underestimation of the aquifer capacity. The subdivision into vertical zones with roughly similar mineral composition and porosity appears to improve the predictions. Ideally, the calculations should be performed at the 0.5-foot (0.15-meter) resolution of the mineral analysis data. However this activity would be time-intensive, and the perceived gain may not be worth the additional investment.

The amount of $CO_2$ dissolved in the formation water (as $CO_2$ as opposed to bicarbonates and carbonates) is relatively constant and in the range of 0.50 to 1.39 moles/kg (22 to 61.2 g/kg). The upper end of the range is somewhat higher than for the solubility of $CO_2$ in pure water but is still reasonable. The higher dissolved $CO_2$ values likely result because of extrapolation of the PHREEQC model database to solutions with high salt concentration.

The minerals clinochlore (chlorite group), illite, K-feldspar, microcline, and sanidine are unsaturated and, in the calculations, are predicted to completely dissolve both with and without $CO_2$ present. This is an artifact of the thermodynamic properties in the llnl.dat database. They appear to be thermodynamically unstable relative to quartz, muscovite, kaolinite, and phlogopite which are predicted to form instead. Preliminary calculations indicated that saturation could not be obtained without adding excessive amounts of these minerals. Their dissolution also makes available $K^+$, $Mg^{2+}$, and $Na^+$ in solution potentially available to further react with $CO_2$ to precipitate other minerals, particularly dolomite. For this reason, the reaction of $CO_2$ because of dolomite formation may be overestimated in some cases.

The major predicted interaction of $CO_2$ with the COSS minerals and formation water is the dissolution of calcite concurrently with the formation of dolomite. This occurs when there is a source of $Mg^{2+}$ because of the presence of illite, phlogopite, celadonite, and clinochlore (i.e., biotite, glauconite, and chlorite) since they were not in the llnl.dat database or if there is a high $Mg^{2+}$ concentration in the formation water. As noted, the dissolution of some of these clays because of their thermodynamic values provides a source of magnesium for dolomite formation. Without it, the calcite remains in the solid phase. Further, if a source of calcium is not present, the additional magnesium from the clays remains in the aqueous solution and is predicted to interact with $CO_2$ to form $MgHCO_3^+$.

Some pyrite is predicted to dissolve with the concurrent formation of siderite. This amount is generally small relative to the quantity of pyrite present.

The calculations suggest that $CO_2$ interaction with the COSS mineral phases can occur, with the most important predicted reaction being the dissolution of calcite with the formation of dolomite. It is not known to what extent this reaction occurs because of uncertainties in the thermodynamic data and the lack of kinetic information on dissolution of magnesium containing clays and of calcite. The formation of dolomite may decrease porosity, but the amount of decrease is not known. Dolomite precipitation, while potentially decreasing porosity, does provide for an effective $CO_2$ trapping mechanism.

The most important observation noted in the modeling effort is found in well zones that contain mainly quartz-dominated sandstones. These quartz-rich zones can be extensive and are likely to be the targeted zones for $CO_2$ injection. As expected, very little interaction is seen between the sandstone and $CO_2$ unless dolomite or limestone is present. These nonreactive zones are thus important targets for $CO_2$ sequestration. In many well locations, the quartz-rich region dominated the COSS. It should be noted that, in many of these cases, most of the detailed discussion found in Appendix B will be on the zones where interaction did occur, even though they may not be dominant.

## $CO_2$ EXPOSURE EXPERIMENTS

Laboratory experiments were designed to expose formation samples and simulated brine to supercritical $CO_2$ at relevant reservoir temperatures and pressures. A variety of analytical techniques were used to obtain mineralogical and chemical data for the core samples and brine prior to exposure and following $CO_2$ exposure. The key goals of the exposure tests were to:

- Develop an understanding of the mineral dissolution and precipitation potential resulting from exposure of the COSS rock samples to $CO_2$ in order to forecast potential geochemical changes that may occur as a result of $CO_2$ injection.

- Identify potential changes in the formation brine as a result of $CO_2$ injection to understand potential mineral–fluid interactions.

- Determine the rates at which geochemical reactions could occur to better understand the dynamic nature of the system for future forecasting of potential geochemical changes within the reservoir as a result of $CO_2$ injection.

- Provide experimental data that may be used to validate modeling calculations described previously in this report.

These geochemical data can provide valuable insight regarding the potential impact of $CO_2$ exposure in deep saline formations, like the COSS. Specifically, the results can be used to better understand how $CO_2$ injectivity and mobility will be affected and to refine estimates of the carbon storage potential of particular target zones based on existing formation porosity and geochemical capacity.

### Sample Rock and Brine Sources

Core samples of the COSS from the North Dakota portion of the Williston Basin were obtained from the North Dakota Geological Survey (NDGS) Wilson M. Laird Core and Sample Library in Grand Forks, North Dakota. Specifically cores from NDIC wells ND 6264, ND 9257, and ND 12596 were utilized to obtain relevant samples from the formations of interest. Well ND 12596 was also used in the previously described modeling effort. Samples of the core from well ND 6264 were obtained from five depths ranging from 1855 to 1879 m (6086 to 6165 ft). Samples of the core from well ND 9257 were obtained from three depths ranging from 3593 to 3615 m (11,789 to 11,859 ft). Core samples from two depths were obtained from well ND 12596 at depths of 4512 and 4520.5 m (14,802 and 14,831 ft). Table 3 is a summary of the core sample lithology, depth, and location. A more detailed description of the well locations, core sampling, and sample classification is included in the report describing the geology of the COSS in Appendix A. Figure 6 contains a map showing the juxtaposition of the wells used for the $CO_2$ exposure experiments, with the wells used for the modeling effort previously described.

**Table 3. Core Sample Information**

| Report ID | Lab ID | NDIC Well | Depth, ft | Formation | Classification | Well Latitude | Well Longitude |
|---|---|---|---|---|---|---|---|
| ND 6264-BI-6086 | S-00925 | 6264 | 6086 (1855 m) | Black Island | Quartz arenite sandstone | 46.879 | −100.269 |
| ND 6264-DW-6113 | S-00926 | 6264 | 6113 (1863.2 m) | Deadwood | Dolomitic grainstone | | |
| ND 6264-DW-6114.5 | S-00927 | 6264 | 6114.5 (1863.7 m) | Deadwood | Lithic arentic sandstone | | |
| ND 6264-DW-6126.5 | S-00928 | 6264 | 6126.5 (1867.4 m) | Deadwood | Calcareous sandstone | | |
| ND 6264-DW-6165 | S-00929 | 6264 | 6165 (1879.1 m) | Deadwood | Quartz arenite sandstone | | |
| ND 9257-BI-11789.5 | S-00930 | 9257 | 11789.5 (3593.4 m) | Black Island | Lithic arentic sandstone | 46.838 | −102.34 |
| ND 9257-DW-11832.5 | S-00931 | 9257 | 11832.5 (3606.6 m) | Deadwood | Dolomitic grainstone | | |
| ND 9257-DW-11858.5 | S-00932 | 9257 | 11858.5 (3614.5 m) | Deadwood | Calcitic grainstone | | |
| ND 12596-BI-14802 | S-00933 | 12596 | 14802 (4511.7 m) | Black Island | Quartz arenite sandstone | 47.844 | −103.072 |
| ND 12596-BI-14831 | S-00934 | 12596 | 14831 (4520.5 m) | Black Island | Black shale | | |

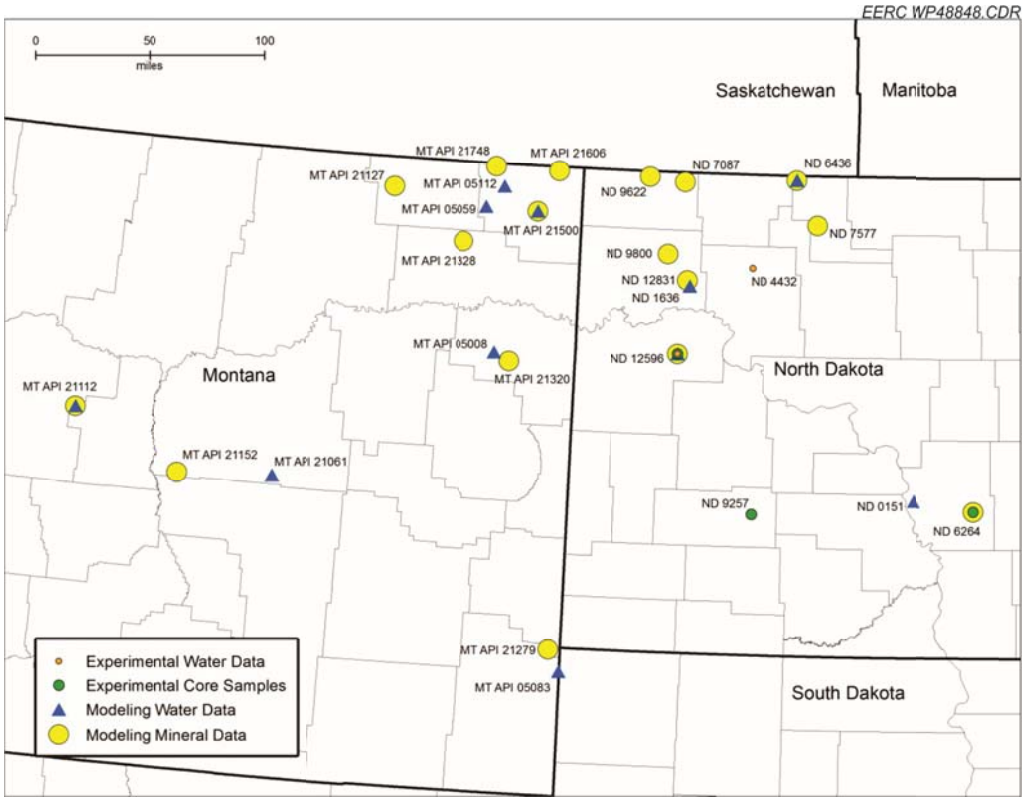



Figure 6. Wells used for $CO_2$ exposure experiments and modeling effort.

The sample naming convention adopted for this portion of the report contains the unique well identifier given by the state of North Dakota, the formation name, and the formation depth. For example, a sample from ND well 12596 taken from the Black Island Formation at a depth of 14802 ft would be ND 12596-BI-14802. This convention was adopted to aid the reader by providing a more descriptive sample name.

Because samples of the formation brine were not available, brine chemistry data for wells ND 12596 and ND 4432 were obtained to allow for creation and use of simulated brine in the exposure experiments. Reproducing the in situ reservoir brine composition for the batch reactor tests was an important consideration since this fluid composition, which is in equilibrium with the reservoir rock and gaseous atmosphere, will influence the type and rate of potential mineral dissolution and/or precipitation reactions. The brine chemistry from well ND 4432 was used as a substitute for well ND 6264 as direct data from well ND 6264 were unavailable. The brine chemistries were used to calculate inputs of laboratory chemicals to make synthetic brines with similar chemistries to formation brines. Table 4 shows the brine chemistries obtained from the well data for wells ND 4432 and ND 12596 as well as analytical results from the synthetic brines. From the data, it can be seen that the synthetic brine for well ND 4432 is a very good approximation of the brine chemistry from the well. The data also show good approximation for Brine 2. At the time that Brine 2 was sampled from the reservoir, it was supersaturated with respect to carbonate and, thus, is difficult or impossible to replicate synthetically. During the making of Brine 2, the precipitation of carbonates (Ca and Mg) along with a small amount of sulfate occurred, resulting in lower carbonate concentration and a decreased pH. Since the exposure experiment entailed $CO_2$ addition, which would more than make up for the lack of carbonate in solution, the brine was used without further manipulation.

**Table 4. Brine Chemistries**

| | Well ND 4432 | Synthetic Brine ND 4432 | Well ND 12596 | Synthetic Brine ND 12596 |
|---|---|---|---|---|
| Na, mg/L | 52,358 | 60,800 | 106,200 | 97,800 |
| Ca, mg/L | 2801 | 2640 | 9020 | 5080 |
| Mg, mg/L | 485 | 292 | 1329 | 1010 |
| Fe, mg/L | | <1 | 2.3 | <1 |
| K, mg/L | | 94 | 1600 | 1840 |
| Cl, mg/L | 85,000 | 91,400 | 174,988 | 172,000 |
| $HCO_3^-$, mg/L | 105 | 102 | 5236 | 10 |
| $SO_4^{2-}$, mg/L | 2757 | 1810 | 1916 | 962 |
| pH | 6.90 | 7.21 | 7.18 | 5.51 |

## $CO_2$ Batch Reactor Experiment

### *Experimental Design*

These experiments were designed to expose selected formation samples to supercritical $CO_2$ in the high-pressure, high-temperature batch reactor. A total of six samples from the Deadwood Formation and four samples from the neighboring Black Island Formation were chosen for exposure studies. Certain assumptions were made regarding average pressure and temperature conditions, brine solution chemistry, and gas composition based on available literature sources. The results of the batch experiment testing provided information and semiquantitative data on potential mineralogical dissolution and/or precipitation reactions in the formation rock following exposure to $CO_2$. In addition, the comparison of baseline brine concentrations to exposed brine concentrations provided data about potential mineral phase dissolution caused by exposure to $CO_2$. The dissolution and precipitation reactions determined by this study have been used for comparison to modeling efforts.

### *Sample Preparation*

Specimen rocks were stored dry at ambient conditions prior to testing. The core samples were split into a pretest and posttest sample to facilitate the start of the exposure test while analysis of the pretest samples was ongoing. Pretest core samples were weighed prior to placement into 60-mL glass jars, which were subsequently filled with brine solution. In addition to the ten core samples, a laboratory standard of $Mg_2SiO_4$ was included with the set utilizing the brine chemistry from well ND 12596. The jars were placed into a set of reaction chambers which were regulated for temperature and pressurized with a $CO_2$ atmosphere.

The samples were incubated in the reaction pressure vessel for a period of 4 weeks (28 days). This 4-week exposure time was conservatively selected for the batch reaction tests based on evaluation of control samples (magnesium silicate, calcite, dolomite, and other minerals) which indicated that a complete carbonation reaction was achieved after approximately 2 weeks. Following the exposure to $CO_2$ at temperature and pressure, the brine and solids were separated via vacuum filtration to minimize the brine content of the solids before drying.

#### *$CO_2$ Exposure Apparatus*

The batch reactor for the exposure experiments consists of high-pressure stainless steel vessels that are housed in an oven for temperature regulation. The vessels are connected to a $CO_2$ source with a control module to supply a $CO_2$ purge prior to obtaining and maintaining $CO_2$ pressure for the duration of the experiment. The components of the batch reactor have been previously described (Hawthorne and others, 2011).

As previously described, the samples were placed into the reactor in 60-mL glass jars. The use of glass jars eliminates contact of the brine with the high-pressure stainless steel vessels, thus minimizing potential undesirable interactions. The lids of the jars were altered to include a ¼-inch vent hole to allow for equilibration with the $CO_2$. The appropriate brine was added to the jars at a 10:1 ratio (brine volume [mL]/rock mass [g]) prior to being placed within the stainless

steel vessels. The vessels were then sealed, placed in the oven, and connected to the control system prior to being brought up to temperature and pressure. Table 5 shows the pressure and temperature conditions for the 28-day test.

### Analytical Methods

A variety of analytical tools and techniques were used to determine the mineralogical and petrophysical characteristics of the COSS rock samples. Specifically, these tools and techniques included SEM, XRD, x-ray fluorescence (XRF), and various wet-chemistry techniques, including ion chromatography (IC) and inductively coupled plasma–mass spectrometry (ICP–MS). When used together, these devices provide a highly developed characterization of sample mineralogy that includes bulk chemistry and crystalline phases as well as trace minerals and elements. A brief description of each device and its applicability follows. Moreover, it was important to consider the results of $CO_2$ exposure testing from several methods provided by the various tools available. This array of testing allowed for detection of mineralogical changes by considering overlapping or contradicting results and selecting and filtering factual data from artifacts created by instruments and/or sampling methods.

**Table 5. Exposure Test Conditions**

| Sample ID | Exposure Pressure, psi | Exposure Temperature, °F | Sample Mass, g | Brine Volume, mL | Well Used for Brine Chemistry |
|---|---|---|---|---|---|
| ND 6264-BI-6086 | 2400 (16.55 MPa) | 155 (68.3°C) | 3.3617 | 34 | 4432 |
| ND 6264-DW-6113 | | | 4.6555 | 47 | 4432 |
| ND 6264-DW-6114.5 | | | 4.2008 | 42 | 4432 |
| ND 6264-DW-6126.5 | | | 4.0824 | 41 | 4432 |
| ND 6264-DW-6165 | | | 3.9927 | 40 | 4432 |
| ND 9257-BI-11789.5 | 5000 (344.47 MPa) | 290 (143.3°C) | 4.0838 | 41 | 12596 |
| ND 9257-DW-11832.5 | | | 4.2936 | 43 | 12596 |
| ND 9257-DW-11858.5 | | | 4.2366 | 42 | 12596 |
| ND 12596-BI-14802 | | | 4.1908 | 42 | 12596 |
| ND 12596-BI-14831 | | | 4.0248 | 40 | 12596 |
| $Mg_2SiO_4$* | | | 4.1387 | 41 | 12596 |

* Magnesium silicate 99% from Alfa Aesar used as a standard.

In brief, the analysis performed on the samples included the following:

- SEM – SEM was used to evaluate the textural, elemental, and mineralogical composition of the samples using backscattered electron (BSE) imaging and energy-dispersive spectrometry (EDS). SEM was also used to identify the chemistry of amorphous substances detected by XRD.

- XRF – XRF was used to determine the bulk chemistry of the samples, reported as bulk oxides. The results were used as a guide to improve mineral characterization by XRD.

- XRD – XRD was used to determine the bulk mineralogy of the samples. The complementary use of XRF and SEM data enhances bulk mineral identification. A Rietveld refinement was used to quantify the mineralogical composition of the samples.

- Wet-Chemistry Analysis – IC and ICP–MS were used to determine the major anions and cations present in the pre- and postbrine samples.

More detailed descriptions of the analytical techniques can be found in Appendix C.

*Uncertainty and Limitations of Analyses*

- A fundamental limitation of XRD, XRF, and SEM is the inability to analyze the same surface or sample (pre- and post-) twice. Thus differences in phase quantification could result from mineralogical variation with the sample.

- While the experimentation is carried out at elevated temperature and pressure, the samples are returned to ambient conditions prior to separation of solids and liquids. Based on the physical data, it is impossible to tell what effect this may have on the experimental results.

**Results of $CO_2$ Exposure Experiments**

Photographs of the preexposure and postexposure core samples were taken to document the condition of the samples and are provided in Appendix C. Noticeable iron oxide staining on the surface of the posttest samples is apparent for several of the samples (see Figure 7 for ND 6264-DW-6126.5). Staining is also apparent for ND 6264-DW-6114.5, ND 6264-DW-6165, and ND 12596-BI-14802 (see Appendix C), presumably due to mobilization of the iron and subsequent deposition on the surface. Minor decomposition of the structure is evident on the filters for most of the samples. Complete decomposition of the structure occurred for ND 6264-DW-6113. The unconsolidated grains were recemented in the bottom of the jar at the end of the exposure test.

The filtered brine solutions, along with the original brine solutions (not exposed), were analyzed for major and minor elements as well as pH. Figures 8 and 9 show the analytical results for the pre- and postexposure brine solutions. The data show a consistent pH decrease for brine ND 4432 and a consistent pH increase for brine ND 12596. The pH decrease for brine ND 4432




Figure 7. Sample ND 6264-DW-6126.5 prior to $CO_2$ exposure (a) and following $CO_2$ exposure (b). Notice the iron staining on the sample following exposure.

is expected because of the addition of $CO_2$ during the exposure test. The increase in pH for brine ND 12596 is believed to be an artifact because the initial pH of the synthetic brine is lower than the formation brine's. These data along with the data from the original brine solutions were used to calculate the change, i.e., dissolution or precipitation, in the chemical constituents of the brine. The data show an increase in alkalinity for all of the samples as would be expected with the exposure to $CO_2$. For brine ND 4432, the decrease in TDS for the five samples indicates mineralization of brine components. Specifically, calcium, sodium, potassium, and chloride showed significant decreases in the brine. While the increase in iron, magnesium, strontium, manganese, and sulfur suggests demineralization of these elements. For brine ND 12596, the TDS increased, suggesting demineralization of all but sulfur.

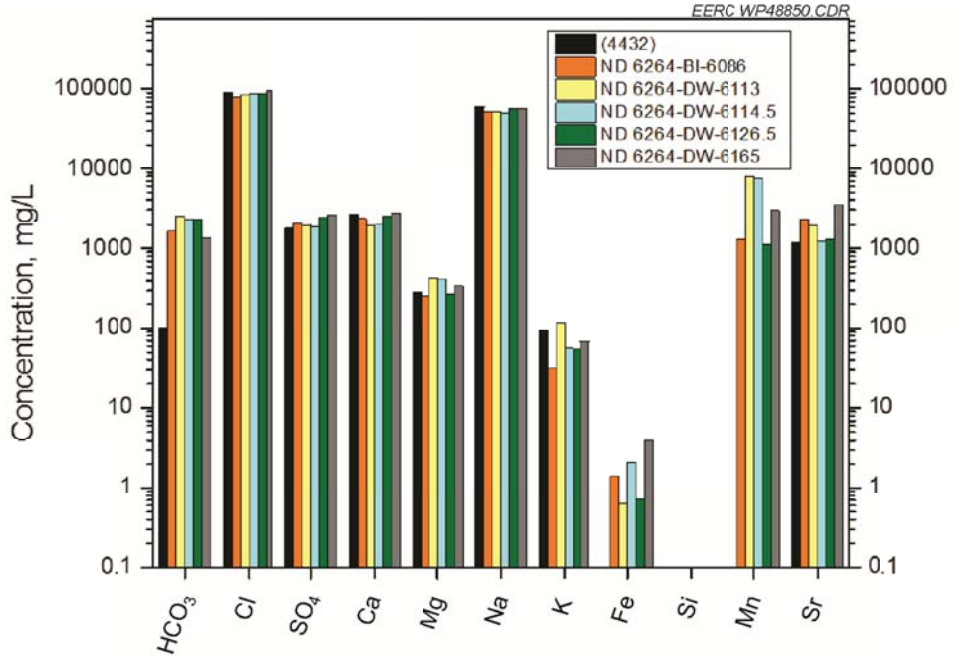



Figure 8. Analytical results for the pre- and postexposure solution, brine ND 4432.

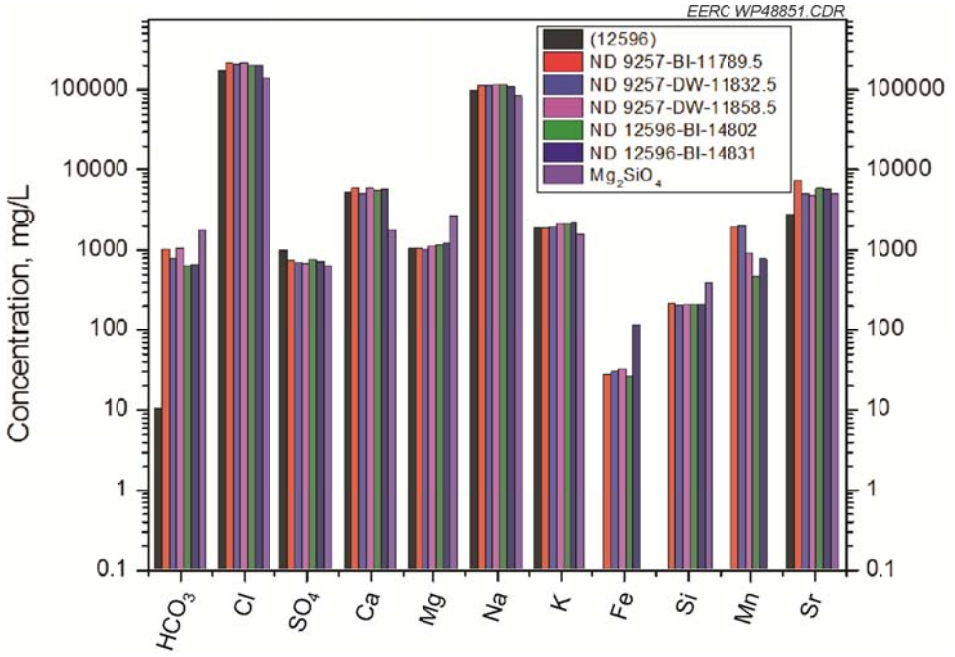



Figure 9. Analytical results for the pre- and postexposure solution: brine and synthetic brine ND 12596.

The XRF results for the preexposure and postexposure core samples are shown in Appendix C. These results are reported as oxides by convention. The data show apparent mineralization of sodium and demineralization of magnesium for the experiments with brine ND 4432, while the experiments with brine ND 12596 showed slight demineralization of sulfur. Results for the individual samples are included in the discussion for those samples.

Quantitative XRD was completed on the core samples identifying the bulk mineralogy for the pre- and post-exposure core samples also found in Appendix C. The major mineralogy matches the classification of the samples from the literature as included in Table 3.

*Summary and Interpretation*

The five core samples from NDIC well ND 6264 represent a series from top to bottom spanning depths from 1855 to 1879 m (6086 to 6165 ft). The series includes the Black Island Formation (ND 6264-BI-6086), which overlays the Deadwood Formation below. The $CO_2$ exposure tests for the samples in this series were carried out at a pressure of 16.55 MPa (2400 psi) and a temperature of 68.3°C (155°F). The brine chemistry is mainly sodium chloride with a TDS of 143,000 mg/L, including minor amounts of calcium and magnesium sulfate.

The core sample ND 6264-BI-6086 was taken from a depth of 1855 m (6086 ft) and is from the lower part of the Black Island Formation within 9.1 m (30 ft) of the lower formation boundary. The classification and mineralogy for this sample identify it as quartz-rich (95%). The difference in brine chemistry as a result of the exposure test, previously shown in Figures 8 and 9, shows a loss of components from the brine, indicating mineralization of primarily sodium chloride. Comparison of pre- and postexposure XRF and XRD data is shown in Table 6. The chemical data show minor increases in sodium and chloride matching the brine chemistry data indicating mineralization of sodium chloride. The mineralogical data also match this with the presence of halite in the postexposure sample. The chemical data indicate some loss of calcium, and the XRD data match this, showing a loss of calcite.

**Table 6. XRF and XRD Pre- and Postexposure Comparison for ND 6264-BI-6086**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 84.7 | 87.5 | Quartz | 95.82 | 91.28 |
| $Al_2O_3$ | 1.7 | 2.0 | Calcite | 1.03 | – |
| $Fe_2O_3$ | 1.30 | 1.70 | Dolomite | 0.54 | 0.62 |
| $TiO_2$ | 0.11 | 0.11 | K-Feldspar | 2.60 | 5.35 |
| $P_2O_5$ | 0.00 | 0.00 | Illite | | |
| CaO | 0.9 | 0.3 | Kaolinite | | |
| MgO | 0.32 | 0.34 | Halite | – | 2.76 |
| $Na_2O$ | 0.30 | 1.23 | Rutile | | |
| $K_2O$ | 0.53 | 0.66 | Pyrite | | |
| $SO_3$ | 0.55 | 0.26 | Gypsum | | |
| Cl | 0.03 | 1.45 | Wollastonite | | |
| MnO | 0.00 | 0.00 | | | |
| Unknown | 9.52 | 4.51 | | | |

An SEM image for the preexposure sample is shown in Figure 10, and an image from the postexposure sample is shown in Figure 11. Additional analyses for both the pre- and postexposure sample can be found in Appendix C.

The figures show the dominance of quartz (Q) along with some feldspar (F). The images capture an evaporite phase that, based on the spectrum and XRD pattern, appears to be thernardite. The carbonates (calcite and dolomite) are relatively small crystals between the quartz matrix, i.e., cement.

The matrix of primarily quartz with some feldspar appears to be unchanged. The presence of halite as an evaporite is clear. An attempt to locate sulfur-containing species was carried out, with the result showing the lack of sulfur species in the postexposure sample.

The core sample ND 6264-DW-6113 is the next in the series from a depth of 1863.2 m (6113 ft). It is from the upper part of the Deadwood Formation. The classification puts this sample as a carbonate (dolomite). The photograph image of the preexposure core sample (Appendix C, Figure C-3) hints at the presence of glauconite (due to the green color). Although the net change in brine chemistry indicates mineralization of calcium, presumably calcium carbonate due to the excess $CO_2$, leaching of several other elements, notably manganese and chloride, indicate demineralization. As previously noted, the structure of this sample was completely decomposed during the 28-day exposure test. Comparison of pre- and postexposure

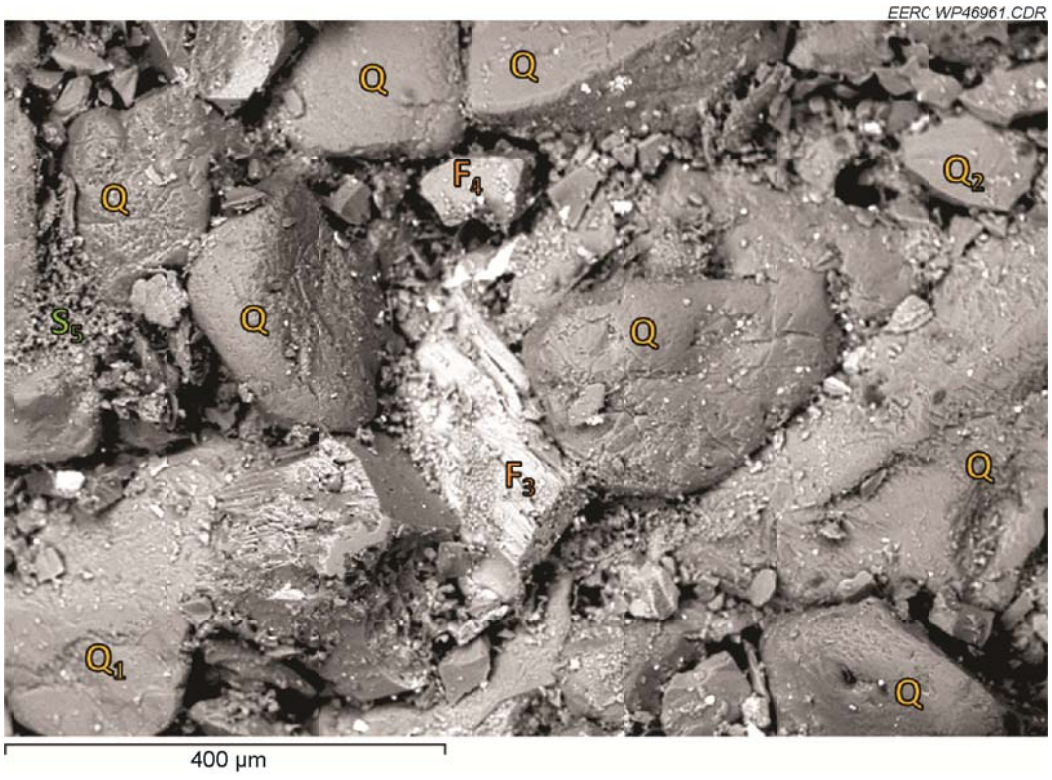



Figure 10. Preexposure SEM image of ND 6264-BI-6086 (Q = quartz and F = feldspar).

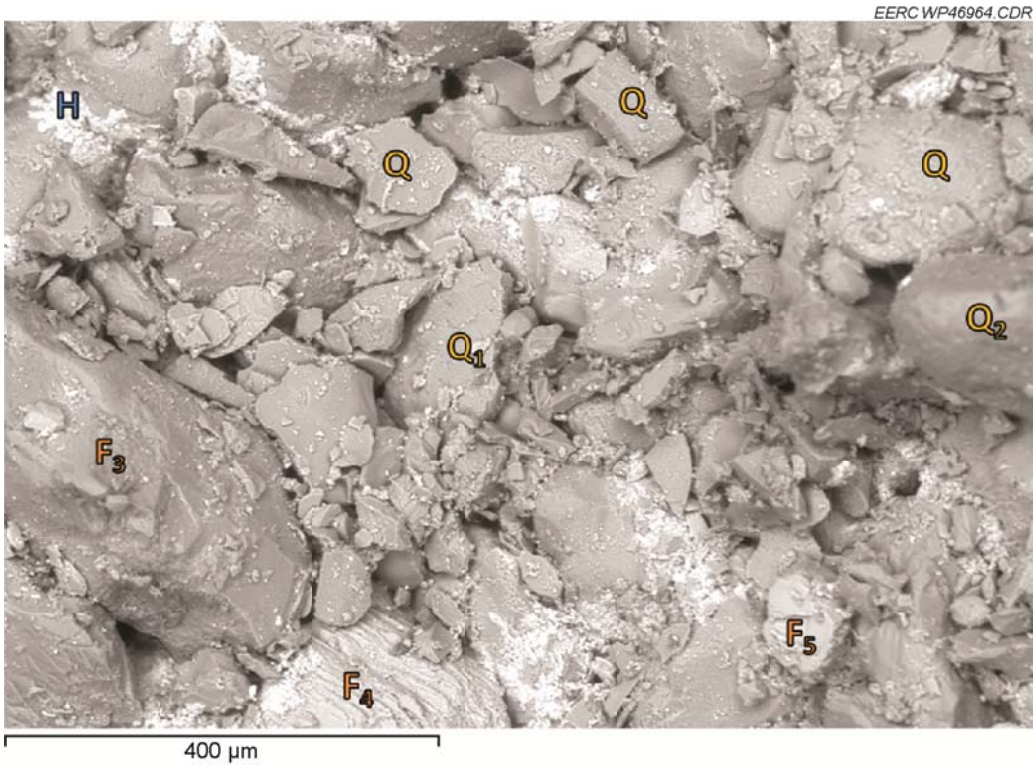



Figure 11. Postexposure SEM image of ND 6264-BI-6086 (H = halite).

XRF and XRD data is shown in Table 7. The XRF chemistry data confirm the leaching of manganese but show an increase of sodium and chloride. This is believed to be an artifact because of the remaining brine that was dried with the postreaction sample. The salt presence was exacerbated because the structure of the sample decomposed during the exposure, and the grains left in the sample jar before drying held a significant amount of liquid. The XRD data confirm a significant percentage of halite in the postreaction sample. The difficulty of sample transfer because of the decomposition of the structure resulted in salt enrichment of the postreaction sample and, therefore, limited the interpretation possible with the XRD data available.

One SEM image for the preexposure sample is shown in Figure 12. Note that glauconite is an iron-rich form of illite. The images show a mixture of dolomite (D) and glauconite (G) with some trace pyrite. In Figure 12, the color pattern seen near the edges of the dolomite crystals is a boundary for iron-rich dolomite which is darker and located in the interior of the mineral grains. This is visible on the preexposure images only because the samples were polished smooth prior to analysis. The postexposure samples were not polished so as not to disturb the surface.

An SEM image for the postexposure sample is shown in Figure 13. Additional SEM analyses of the pre- and postexposure samples can be found in Appendix C. The images show that the matrix of dolomite (D) is relatively unchanged, but it appears that the glauconite (G) structure has changed dramatically. Cracks and fissures are evident among the grain boundaries. The data suggest that the glauconite was recrystallized during the exposure to $CO_2$, resulting in the structural decomposition of the bulk sample.

**Table 7. XRF and XRD Pre- and Postexposure Comparison for ND 6264-DW-6113**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 36.3 | 35.2 | Quartz | 11.29 | 4.06 |
| $Al_2O_3$ | 4.9 | 4.8 | Calcite | | |
| $Fe_2O_3$ | 10.21 | 11.46 | Dolomite | 70.39 | 65.73 |
| $TiO_2$ | 0.19 | 0.14 | K-Feldspar | 10.99 | – |
| $P_2O_5$ | 0.28 | 0.31 | Illite | 7.33 | 16.19 |
| CaO | 19.7 | 14.7 | Kaolinite | | |
| MgO | 7.42 | 5.88 | Halite | – | 14.01 |
| $Na_2O$ | 0.13 | 5.07 | Rutile | | |
| $K_2O$ | 4.95 | 4.59 | Pyrite | | |
| $SO_3$ | 1.48 | 1.52 | Gypsum | | |
| Cl | 0.08 | 8.96 | Wollastonite | | |
| MnO | 0.19 | 0.12 | | | |
| Unknown | 14.20 | 7.19 | | | |

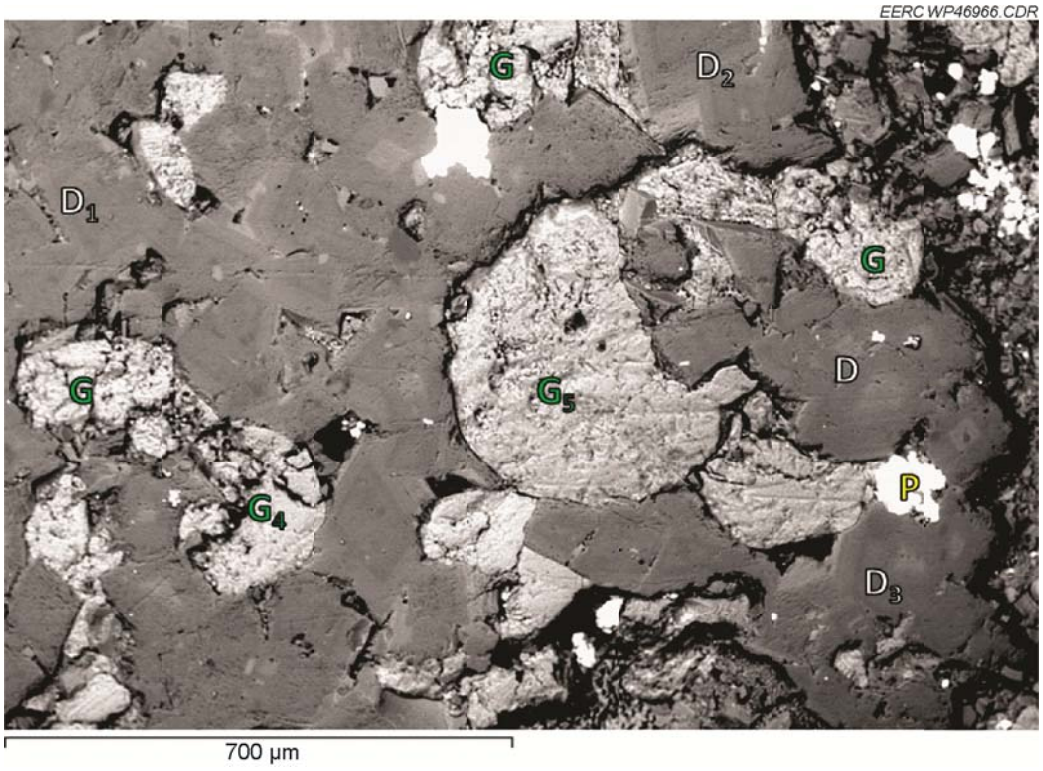



Figure 12. Preexposure SEM Image 2 of ND 6264-DW-6113.

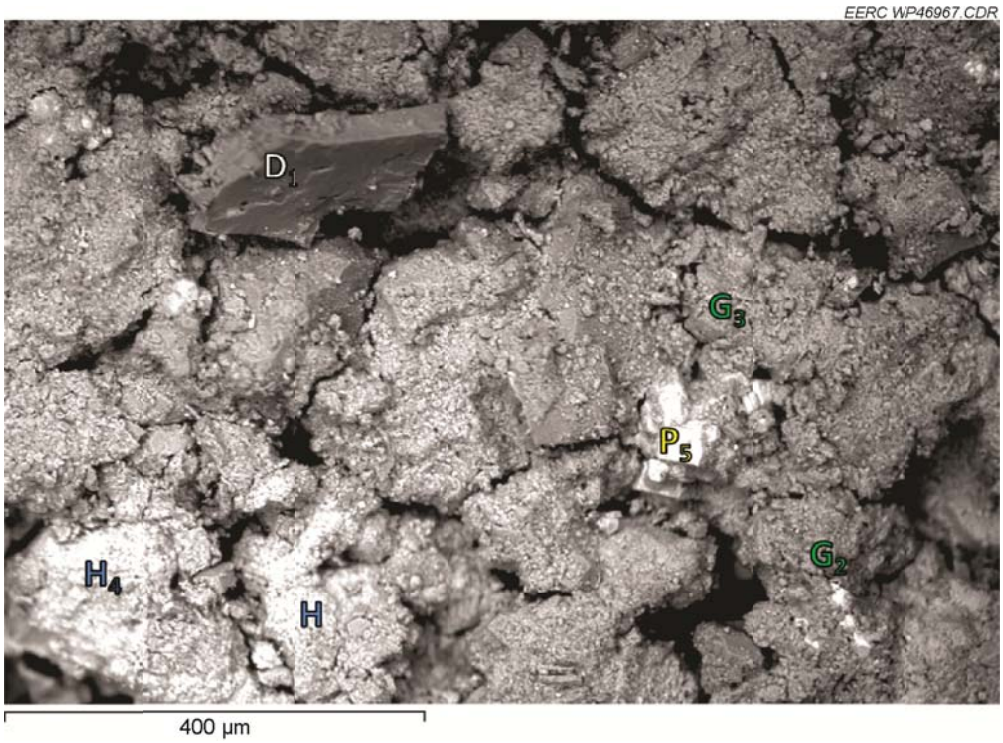



Figure 13. Postexposure SEM image of ND 6264-DW-6113.

The core sample ND 6264-DW-6114.5 was taken from the Deadwood Formation from a depth of 1863.7 m (6114.5 ft). The image of the postexposure core sample (Appendix C, Figure C-6) shows signs of iron leaching and deposition on the surface. The change in brine chemistry (Figures 8 and 9) indicates mineralization of sodium as well as leaching of manganese. The XRF and XRD results for pre- and postexposure samples are compared in Table 8. The XRF chemistry indicates minor mineralization of sodium chloride, and the mineralogy data support this with the presence of halite in the postreaction sample.

SEM images of the pre- and postexposure samples are shown in Figures 14 and 15, respectively. The images and data show the presence of halite (H) in the postexposure sample, primarily on the surface. The dolomite (D) and illite (I) as seen in the preexposure images appear to be the cement for this sandstone, both of which appear to be altered as a result of the $CO_2$ exposure.

The core sample ND 6264-DW-6126.5 was also taken from the Deadwood Formation from a depth of 1867.4 m (6126.5 ft). The classification indicates that this sample is calcite-rich. The postreaction image (Appendix C, Figure C-8) also shows some iron deposition on the surface. The change in brine chemistry (Figures 8 and 9) indicates mineralization of sodium and chloride with some leaching of manganese and sulfate. Table 9 shows the comparison of pre- and postexposure XRF and XRD results. The XRF chemistry shows only minor changes with some mineralization of calcium and demineralization of sulfur. The mineralogy shows slight decreases in dolomite and illite.

**Table 8. XRF and XRD Pre- and Postexposure Comparison for ND 6264-DW-6114.5**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 70.8 | 71.0 | Quartz | 63.49 | 58.18 |
| $Al_2O_3$ | 5.5 | 5.8 | Calcite | – | 1.81 |
| $Fe_2O_3$ | 3.29 | 3.16 | Dolomite | 25.57 | 27.40 |
| $TiO_2$ | 0.19 | 0.20 | K-Feldspar | 8.16 | 10.86 |
| $P_2O_5$ | 0.03 | 0.01 | Illite | 2.78 | – |
| CaO | 8.00 | 7.18 | Kaolinite | | |
| MgO | 3.66 | 3.40 | Halite | – | 1.48 |
| $Na_2O$ | 0.25 | 1.08 | Rutile | | |
| $K_2O$ | 3.70 | 4.16 | Pyrite | – | 0.27 |
| $SO_3$ | 0.66 | 0.49 | Gypsum | | |
| Cl | 0.19 | 1.47 | Wollastonite | | |
| MnO | 0.13 | 0.12 | | | |
| Unknown | 3.57 | 1.88 | | | |

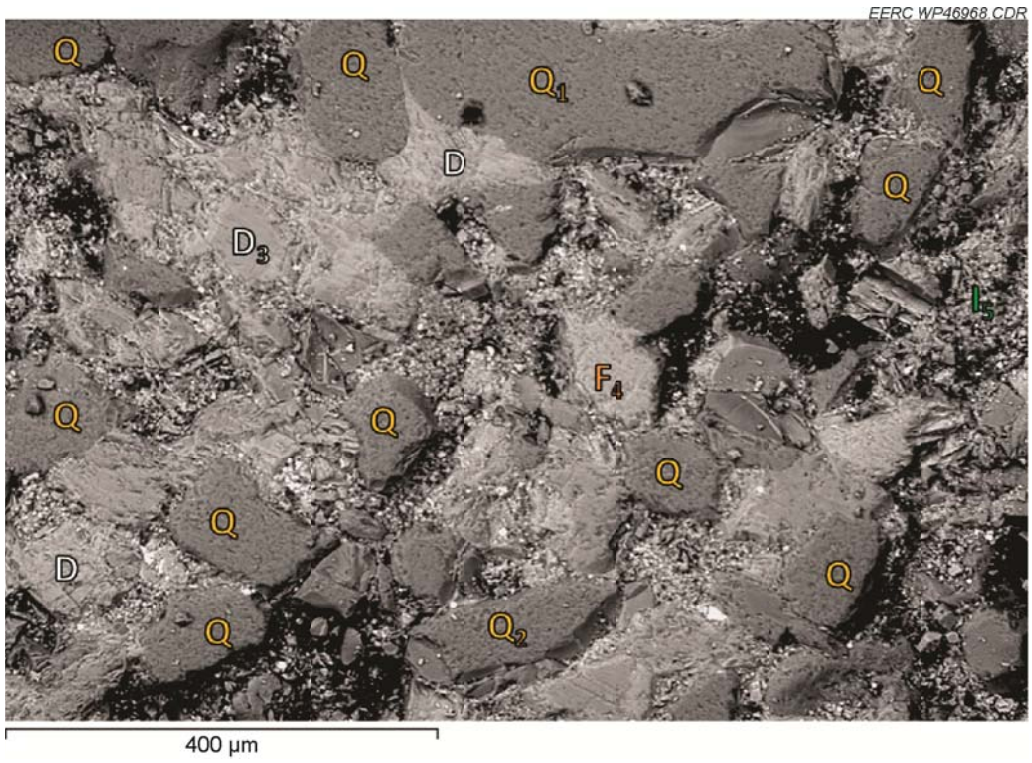



Figure 14. Preexposure SEM image of ND 6264-DW-6114.5.




Figure 15. Postexposure SEM image of ND 6264-DW-6114.5.

**Table 9. XRF and XRD Pre- and Postexposure Comparison for ND 6264-DW-6126.5**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 53.8 | 52.0 | Quartz | 44.02 | 49.64 |
| $Al_2O_3$ | 2.2 | 2.0 | Calcite | 42.12 | 41.56 |
| $Fe_2O_3$ | 1.71 | 1.67 | Dolomite | 8.58 | 4.71 |
| $TiO_2$ | 0.10 | 0.10 | K-Feldspar | 3.89 | 3.49 |
| $P_2O_5$ | 0.00 | 0.14 | Illite | 1.38 | – |
| CaO | 32.7 | 36.8 | Kaolinite | | |
| MgO | 1.01 | 1.18 | Halite | – | 0.60 |
| $Na_2O$ | 0.06 | 0.36 | Rutile | | |
| $K_2O$ | 1.74 | 0.74 | Pyrite | | |
| $SO_3$ | 1.15 | 0.45 | Gypsum | | |
| Cl | 0.07 | 0.71 | Wollastonite | | |
| MnO | 0.06 | 0.07 | | | |
| Unknown | 5.34 | 4.61 | | | |

SEM images of the pre- and postexposure samples are shown in Figures 16 and 17, respectively. Overall, there appears to be very little change as a result of $CO_2$ exposure. Some of the calcite morphology shown in Figure 17 appears to be weathered, but it is difficult to make a conclusion based on the analysis.

The core sample ND 6264-DW-6165 is also part of the Deadwood Formation and is classified as quartz-rich. It was taken from a depth of 1879 m (6165 ft). The image of the postreaction sample (Appendix C, Figure C-10) indicates iron leaching and subsequent deposition on the surface. The change in brine chemistry indicates net demineralization with a slight increase in TDS. A comparison of the XRF and XRD results is shown in Table 10. Only minor changes in chemistry/mineralogy are detectable. The presence of halite in the postreaction sample is minor and is likely an artifact because of the drying process.

SEM images of the pre- and postexposure samples are shown in Figures 18 and 19, respectively. Overall, there appears to be very little change as a result of $CO_2$ exposure with the exception of the presence of halite (H) which, as previously discussed, is likely due to the drying process.

Below the quartz-rich cap rock of the Black Island Formation (ND-6264-BI-6086), the mineralogy of this sequence of samples transitions from dolomite to calcite and back to quartz at the bottom of the sequence. The uniform change from preexposure samples to postexposure samples was the precipitation of halite. The presence of some of the halite in the postreaction samples is most likely due to drying of excess brine. This is supported by morphological analysis using SEM, which indicates the presence of halite crystals on the surface of the sample. The sequence is also noted for the presence of iron in many of the minerals as evidenced by the presence of glauconite and iron-rich dolomite. Iron leaching was also evident in several of the postexposure samples. Mineralogical changes due to exposure to $CO_2$ were evident for calcite and illite, when present, as well as the other cements.

The core samples from NDIC well ND 9257 represent a series from top to bottom spanning the depth from 3593 to 3614.6 m (11,789 to 11,859 ft). The series includes the Black Island and Deadwood Formations, thus spanning the formation boundary. The core samples from NDIC well ND 12596 are both from the Black Island Formation from depths of 4511.6 to 4520.5 m (14,802 and 14,831 ft). The $CO_2$ exposure tests for these samples were carried out at a pressure of 34.5 MPa (5000 psi) and a temperature of 199°C (290°F). The brine chemistry is predominantly sodium chloride with a TDS concentration of 300,000 mg/L. Also included in the brine are minor amounts of calcium, magnesium, and potassium as well as bicarbonate and sulfate. It should be noted that not only is the TDS concentration higher in this brine, but it is also saturated with respect to calcium carbonate.

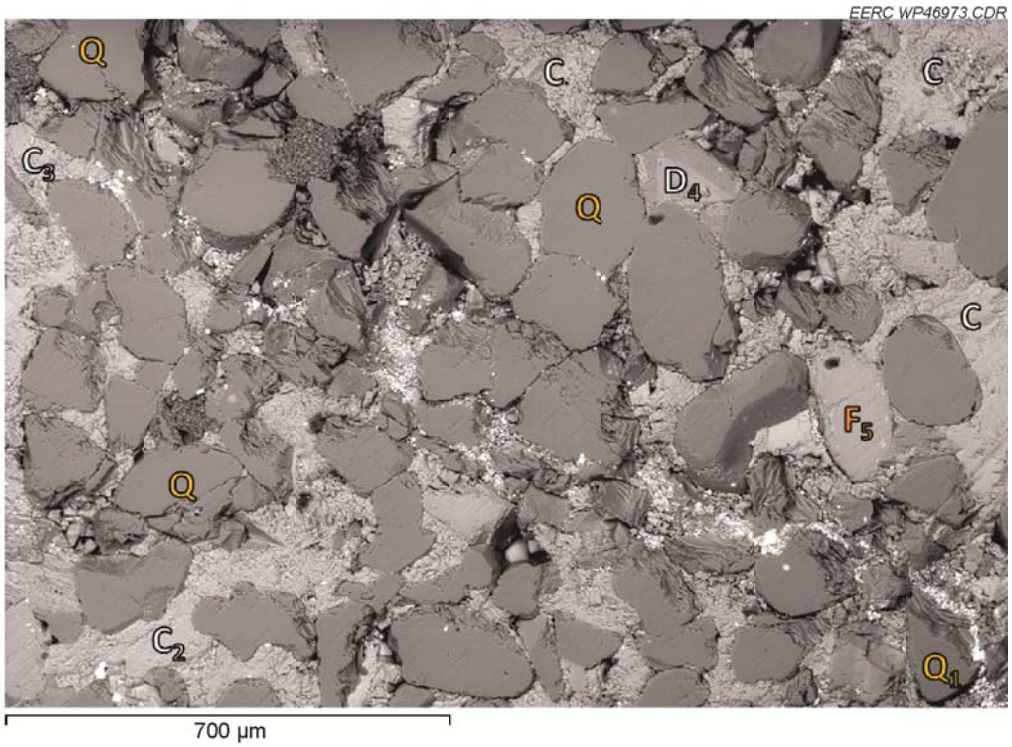



Figure 16. Preexposure SEM image of ND 6264-DW-6126.5.

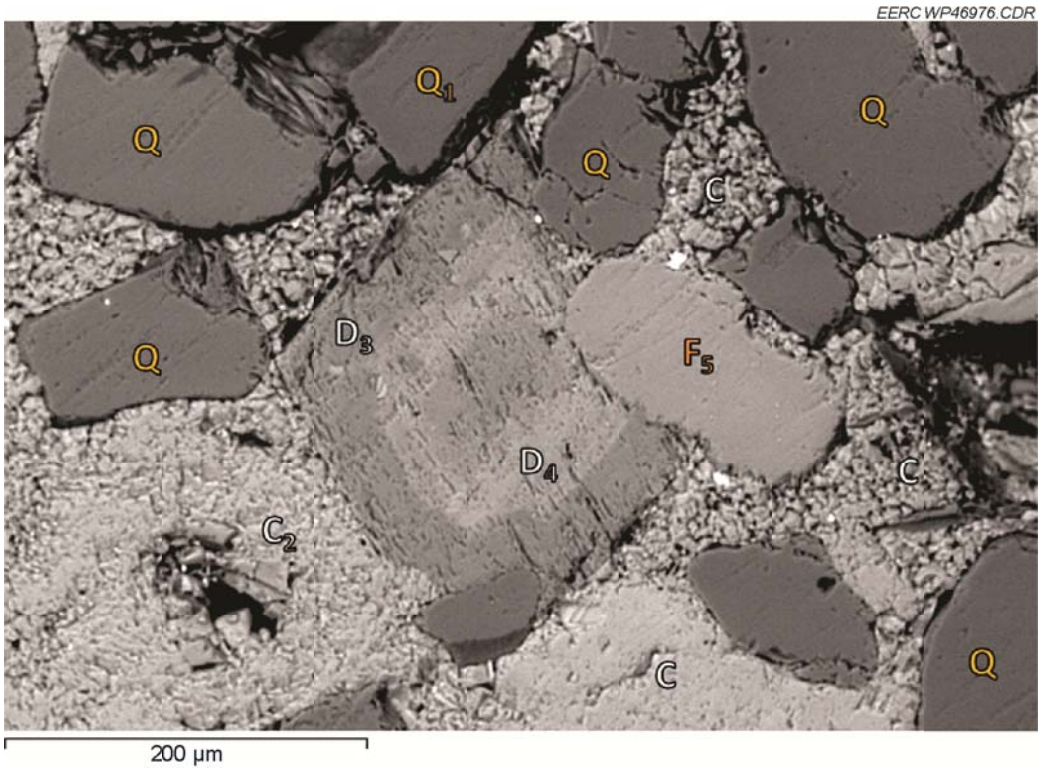



Figure 17. Postexposure SEM Image 2 of ND 6264-DW-6126.5.

**Table 10. XRF and XRD Pre- and Postexposure Comparison for ND 6264-DW-6165**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 79.7 | 81.9 | Quartz | 72.26 | 72.53 |
| $Al_2O_3$ | 8.2 | 5.3 | Calcite | | |
| $Fe_2O_3$ | 2.0 | 1.8 | Dolomite | | |
| $TiO_2$ | 0.27 | 0.15 | K-Feldspar | 25.29 | 24.44 |
| $P_2O_5$ | 0.29 | 1.82 | Illite | 2.45 | – |
| CaO | 0.56 | 2.09 | Kaolinite | | |
| MgO | 0.55 | 0.26 | Halite | – | 1.66 |
| $Na_2O$ | 0.27 | 1.28 | Rutile | – | 0.33 |
| $K_2O$ | 4.56 | 3.20 | Pyrite | – | 1.05 |
| $SO_3$ | 0.69 | 0.51 | Gypsum | | |
| Cl | 0.11 | 1.51 | Wollastonite | | |
| MnO | 0.01 | 0.03 | | | |
| Unknown | 2.76 | 0.04 | | | |

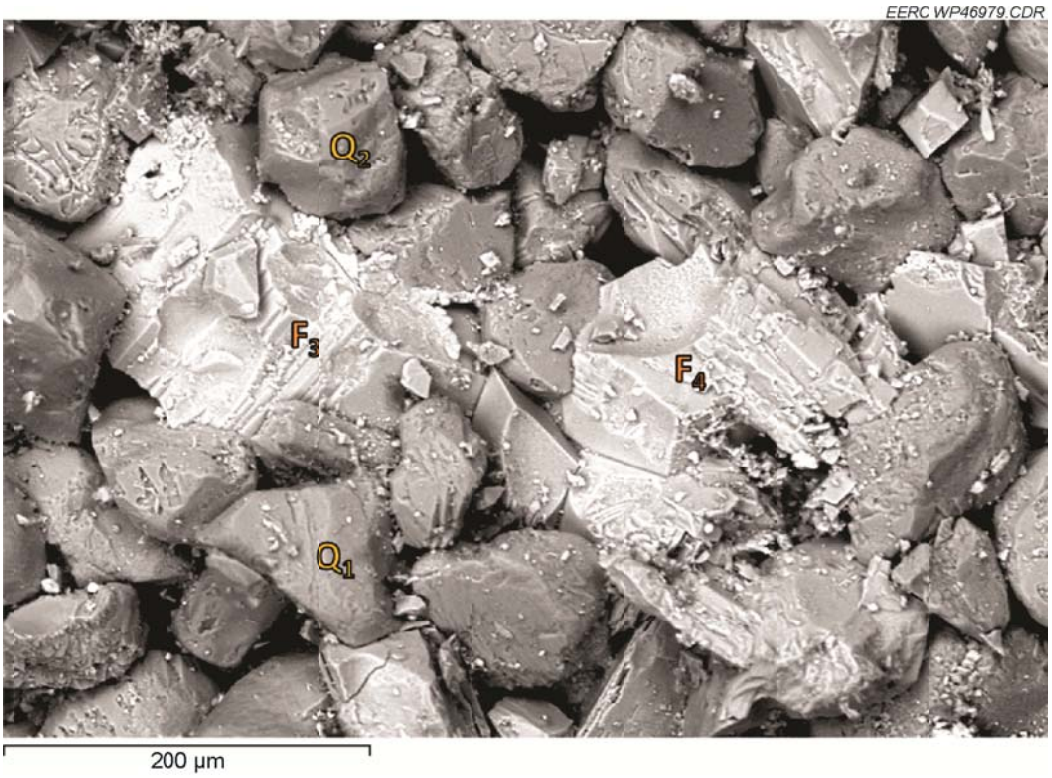



Figure 18. Preexposure SEM image of ND 6264-DW-6165.

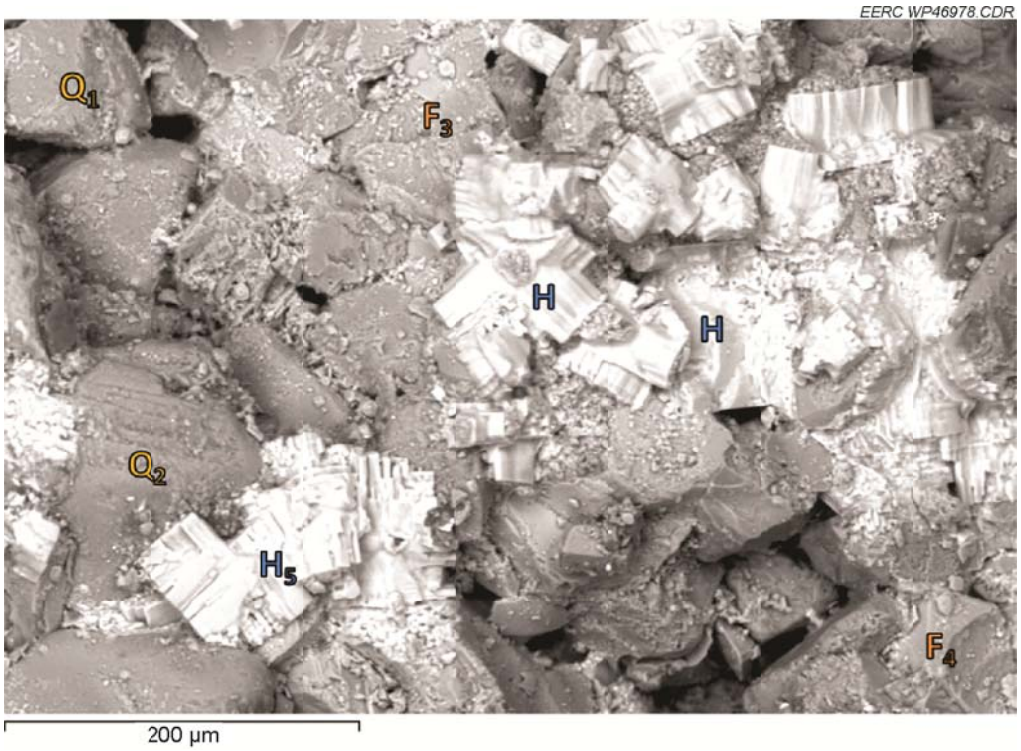



Figure 19. Postexposure SEM image of ND 6264-DW-6165.

The core sample ND 9257-BI-11789.5 was taken from a depth of 3593.4 m (11,789.5 ft) and is from the lower part of the Black Island Formation within 13 m (42.7 ft) of the lower formation boundary. The difference in brine chemistry as a result of the exposure test, previously shown in Figure 9, shows an increase of components in the brine indicating demineralization of primarily sodium chloride. Comparison of pre- and postexposure XRF and XRD data is shown in Table 11. The chemical data show minor increases in sodium, potassium, magnesium, and chloride with only loss of calcium. The mineralogical data match the loss of calcium and the increase of magnesium with the loss of calcite and the increase in dolomite. The presence of halite in the postexposure sample also matches the XRF data.

SEM images of the pre- and postexposure samples (ND 9257-BI-11789.5) are shown in Figures 20 and 21, respectively. The preexposure SEM images suggest that calcite (C) is the cement surrounding the rounded quartz (Q) grains. In the postexposure images, the calcite (C) has been replaced with halite (H). Additional SEM analyses of the pre- and postexposure samples can be found in Appendix C.

The core sample ND 9257-DW-11832.5 is part of the Deadwood Formation and is classified as dolomite-rich grainstone with the preexposure sample being dominated by quartz. It was taken from a depth of 3206.6 m (11,832.5 ft). The major differences based on XRD data (Table 12) may be explained by the pre- and postexposure samples being taken from different halves of the original sample. It may be that the splits indicate a large variability in chemistry/mineralogy for this particular location in the sequence. The photographic image of the original sample (Appendix C, Figure C-13) supports this theory.

**Table 11. XRF and XRD Pre- and Postexposure Comparison for ND 9257-BI-11789.5**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 79.3 | 79.4 | Quartz | 86.48 | 92.31 |
| $Al_2O_3$ | 7.3 | 8.4 | Calcite | 5.22 | 2.33 |
| $Fe_2O_3$ | 2.01 | 2.21 | Dolomite | – | 0.80 |
| $TiO_2$ | 0.28 | 0.47 | K-Feldspar | 2.54 | – |
| $P_2O_5$ | 0.07 | 0.07 | Illite | 3.91 | 1.48 |
| CaO | 3.34 | 1.57 | Kaolinite | 1.85 | 0.62 |
| MgO | 0.63 | 0.92 | Halite | – | 2.25 |
| $Na_2O$ | 0.57 | 1.32 | Rutile | | |
| $K_2O$ | 1.64 | 2.13 | Pyrite | – | 0.21 |
| $SO_3$ | 0.27 | 0.20 | Gypsum | | |
| Cl | 1.34 | 1.63 | Wollastonite | | |
| MnO | 0.02 | 0.01 | | | |
| Unknown | 3.18 | 1.67 | | | |

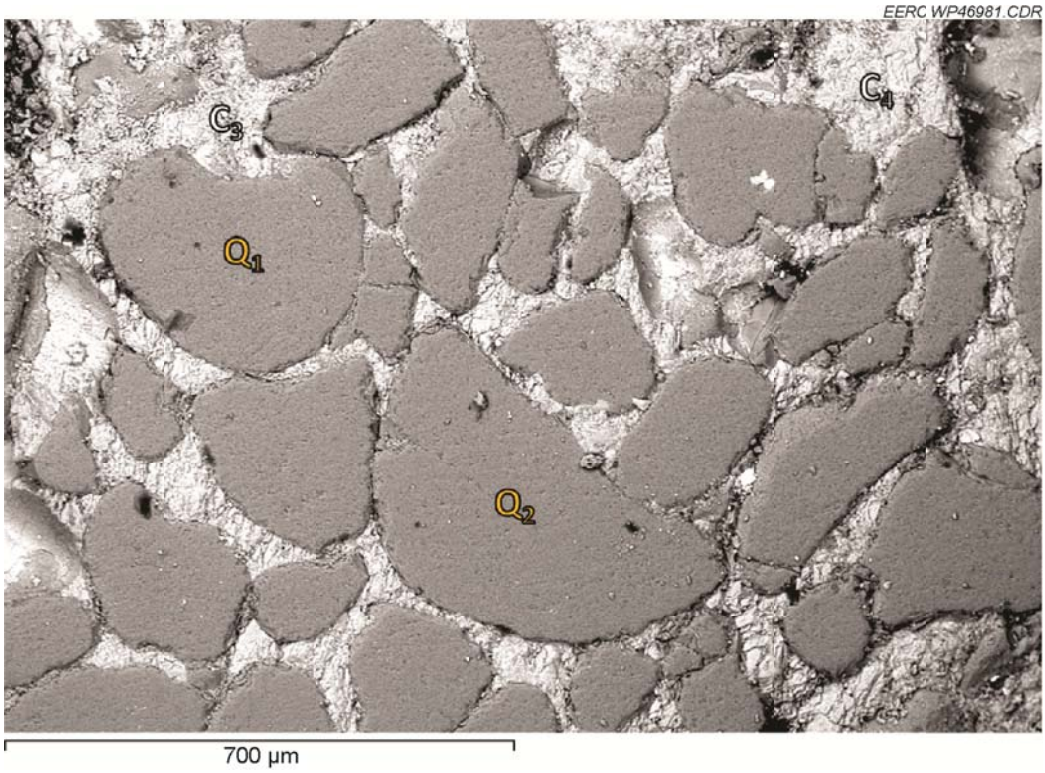



Figure 20. Preexposure SEM image of ND 9257-BI-11789.5.

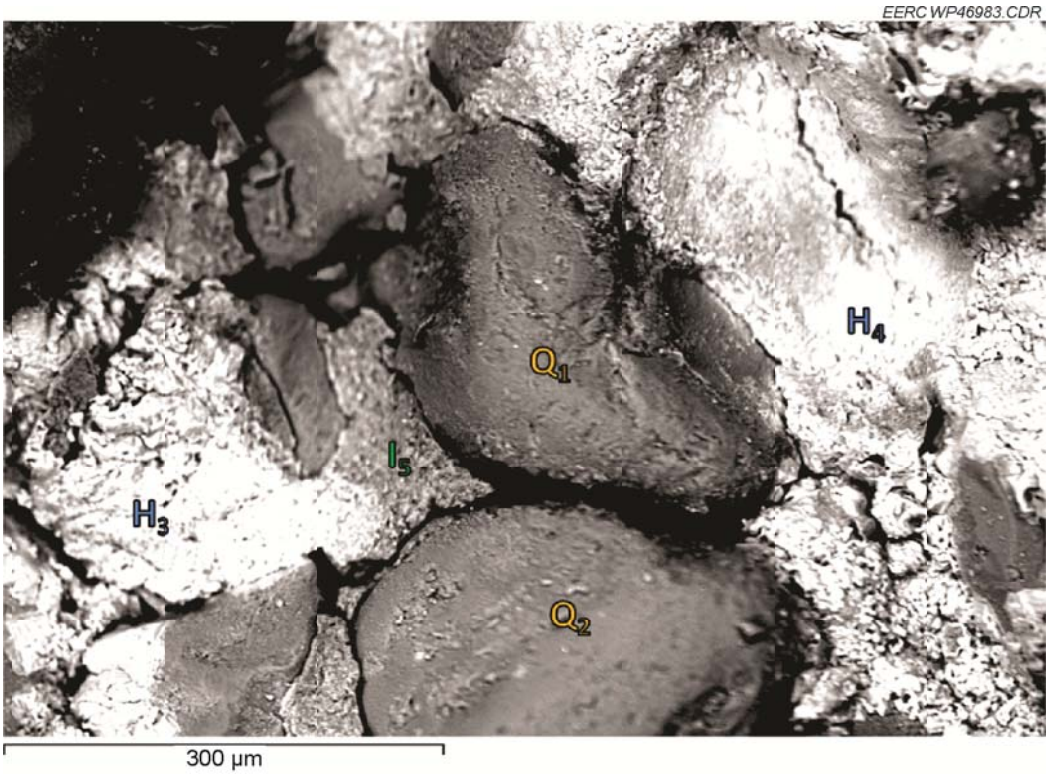



Figure 21. Postexposure SEM image of ND 9257-BI-11789.5.

**Table 12. XRF and XRD Pre- and Postexposure Comparison for ND 9257-DW-11832.5**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 60.2 | 48.1 | Quartz | 39.61 | 28.02 |
| $Al_2O_3$ | 14.8 | 10.1 | Calcite | 0.62 | 0.09 |
| $Fe_2O_3$ | 3.42 | 3.27 | Dolomite | 16.95 | 42.14 |
| $TiO_2$ | 0.54 | 0.32 | K-Feldspar | 13.91 | 21.40 |
| $P_2O_5$ | 0.17 | 0.21 | Illite | 27.78 | 6.12 |
| CaO | 5.76 | 15.31 | Kaolinite | 1.13 | 0.09 |
| MgO | 3.72 | 6.56 | Halite | | 1.80 |
| $Na_2O$ | 0.34 | 0.83 | Rutile | | |
| $K_2O$ | 5.66 | 4.60 | Pyrite | | |
| $SO_3$ | 0.29 | 0.25 | Gypsum | – | 0.34 |
| Cl | 0.44 | 1.14 | Wollastonite | | |
| MnO | 0.05 | 0.12 | | | |
| Unknown | 4.51 | 9.13 | | | |

SEM images of the pre- and postexposure samples (ND 9257-DW-11832.5) are shown in Figures 22 and 23, respectively. The images show some interesting iron chemistry as the middle of the dolomite crystals are iron-rich. It is unknown whether this is a result of changing iron chemistry during formation or from iron leaching following formation. The morphology of dolomite shown in the postexposure images appear to show weathering, but since the preexposure samples were polished prior to analysis, there is no direct comparison. It could be interpreted from the etching on the preexposure samples as being similar. Other than the halite which appears to be on the surface, there does not appear to be much change based on the SEM images.

The final sample in the sequence for ND 9257 is core sample ND 9257-DW-11858.5. It is part of the Deadwood Formation and is classified as calcite-rich grainstone, with dolomite being a major crystalline phase as well. It was taken from a depth of 3614.5 m (11,858.5 ft). Only minor changes are seen in the XRF and XRD data presented in Table 13.

SEM images of the pre- and postexposure samples are shown in Figures 24 and 25, respectively. Similar to the previous sample, the morphology, calcite (C) in this sample, in the postexposure images appears to show weathering. However, the preexposure samples were polished prior to analysis so there is no direct comparison. From etching on the preexposure samples, it could be interpreted as similar. It is interesting to note that the dolomite (D) crystals do not show weathering in this sample. Other than the halite which appears to be on the surface, there does not look to be much change based on the SEM images and only minor changes noted in the XRD data.




Figure 22. Preexposure SEM image of ND 9257-DW-11832.5.

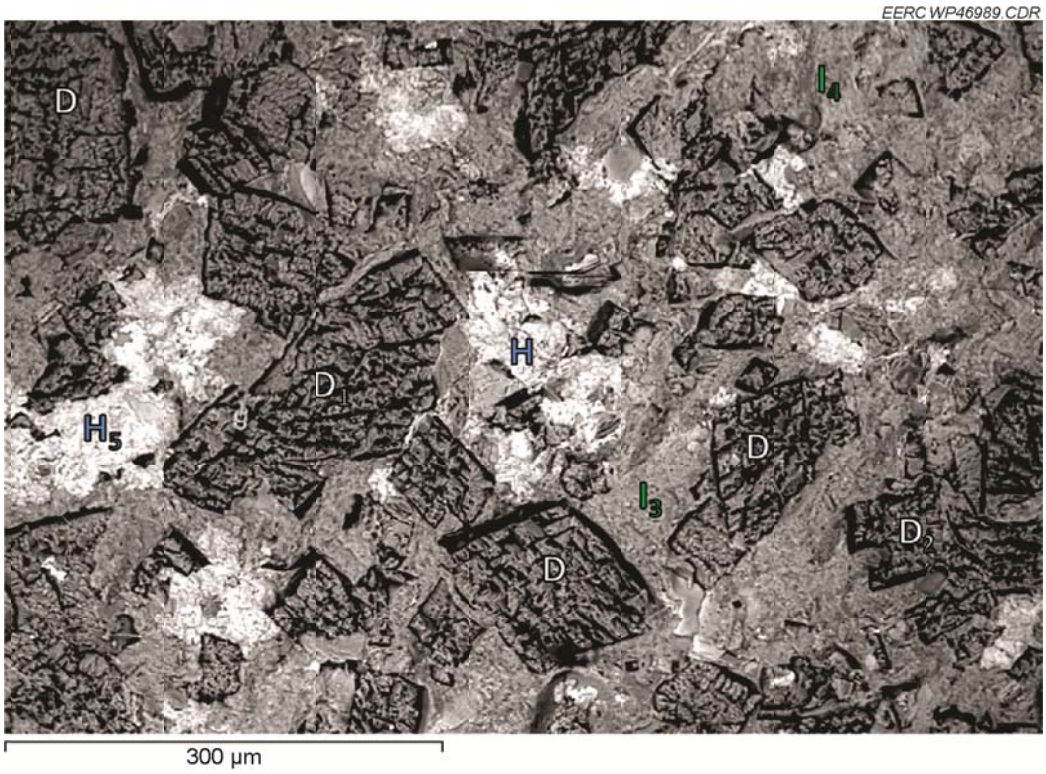



Figure 23. Postexposure SEM Image 2 of ND 9257-DW-11832.5.

**Table 13. XRF and XRD Pre- and Postexposure Comparison for ND 9257-DW-11858.5**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 23.0 | 22.0 | Quartz | 8.95 | 7.35 |
| $Al_2O_3$ | 4.5 | 4.6 | Calcite | 57.96 | 51.84 |
| $Fe_2O_3$ | 2.12 | 2.19 | Dolomite | 25.76 | 32.83 |
| $TiO_2$ | 0.16 | 0.15 | K-Feldspar | 2.94 | 4.40 |
| $P_2O_5$ | 0.09 | 0.08 | Illite | 4.40 | 1.04 |
| CaO | 48.36 | 46.25 | Kaolinite | | |
| MgO | 3.08 | 4.42 | Halite | | |
| $Na_2O$ | 0.16 | 0.49 | Rutile | | |
| $K_2O$ | 2.44 | 2.42 | Pyrite | – | 1.31 |
| $SO_3$ | 0.72 | 0.51 | Gypsum | | |
| Cl | 0.63 | 0.98 | Wollastonite | – | 1.23 |
| MnO | 0.08 | 0.11 | | | |
| Unknown | 14.66 | 15.75 | | | |

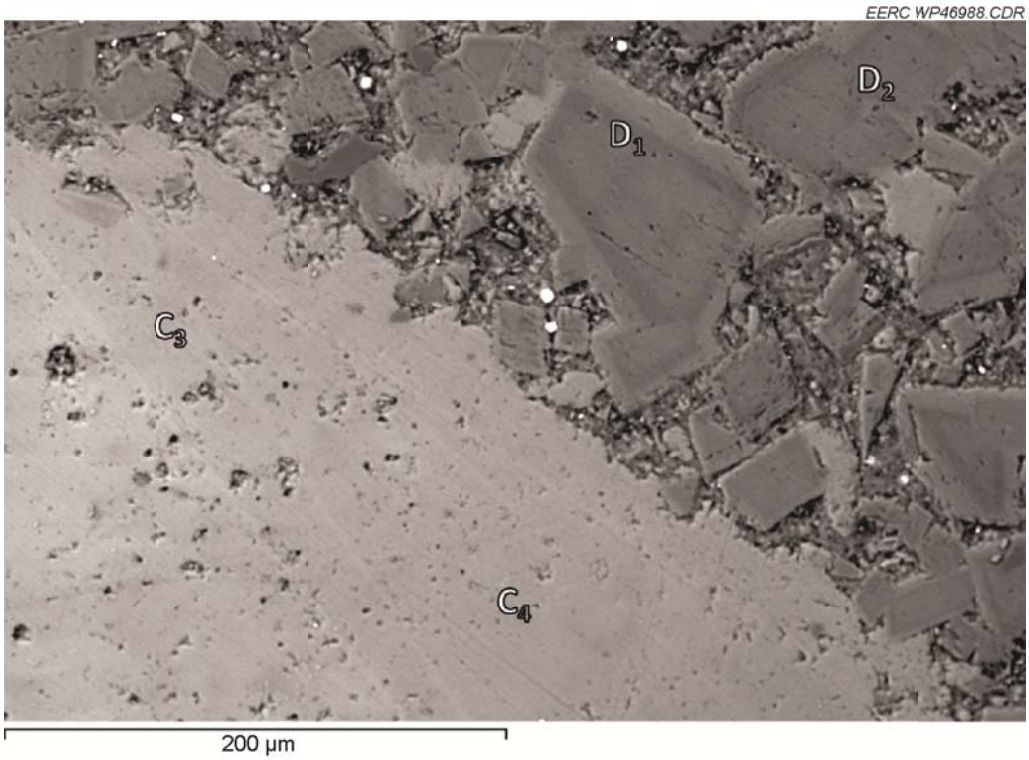



Figure 24. Preexposure SEM image of ND 9257-DW-11858.5.

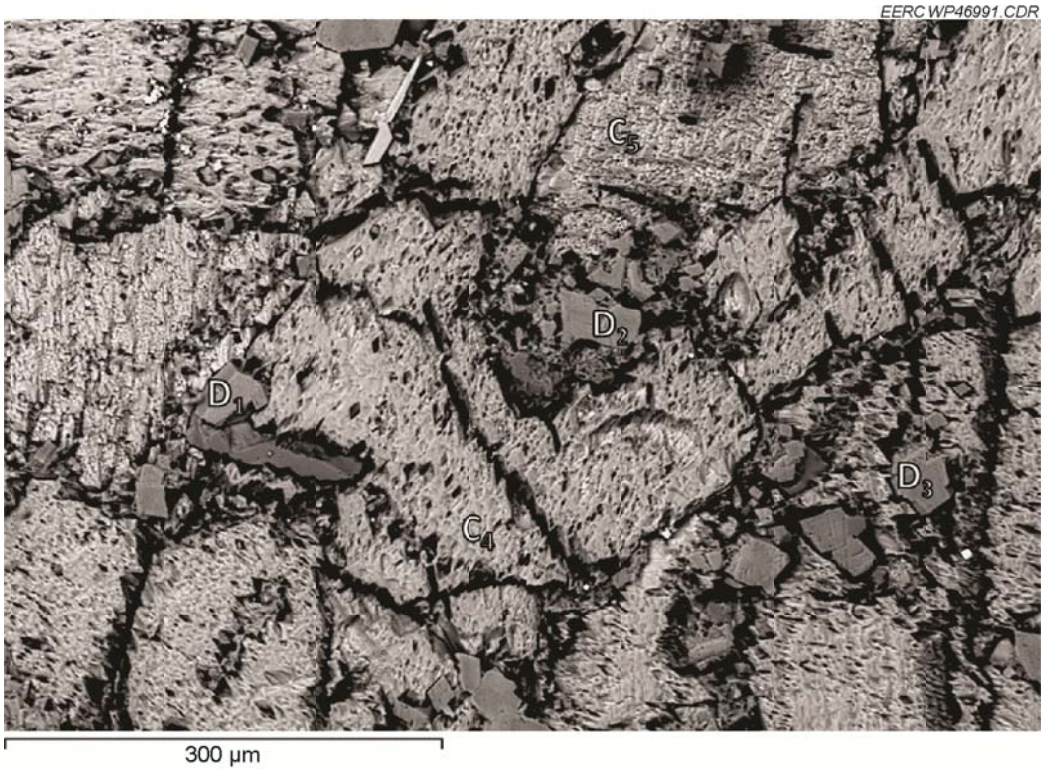



Figure 25. Postexposure SEM image of ND 9257-DW-11858.5.

The remaining two core samples come from ND 12596; note that information from this well was also used in the modeling portion of this study. The first sample in the sequence (ND 12596-BI-14802) is part of the Black Island Formation and is classified as a quartz-rich sandstone. It was taken from a depth of 4511.7 m (14,802 ft). The XRF and XRD analysis (Table 14) indicates the sample is almost completely quartz in nature. Little difference is seen in the pre- and postexposure sample.

SEM images of the pre- and postexposure samples (ND 12596-BI-14802) are shown in Figures 26 and 27, respectively. The SEM images show the quartz to be a mass as opposed to individual grains. Other than halite on the surface of the postexposure sample, very little change is seen. Additional SEM analyses of the pre- and postexposure samples can be found in Appendix C.

The final sample in the sequence for well ND 12596 (ND 12596-BI-14831) is part of the Black Island Formation and is classified as a black shale. While most of the Black Island Formation is sandstone, there are shale structures present that may act as "baffles," diverting the flow of $CO_2$ up and around the structure. It was taken from a depth of 4520.5 m (14,831 ft). The XRF and XRD analysis (Table 15) indicates the sample is dominated by quartz and a mixture of illite and kaolinite clays. Little change is observed in the pre- and postexposure analysis of this sample.

SEM images of the pre- and postexposure samples (ND 12596-BI-14831) are shown in Figures 28 and 29, respectively. The SEM images show very little change as a result of $CO_2$ exposure. Additional SEM analyses of the pre- and postexposure samples can be found in Appendix C.

**Table 14. XRF and XRD Pre- and Postexposure Comparison for ND 12596-BI-14802**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 84.9 | 88.9 | Quartz | 100.00 | 94.60 |
| $Al_2O_3$ | 1.6 | 1.7 | Calcite | | |
| $Fe_2O_3$ | 1.72 | 2.34 | Dolomite | | |
| $TiO_2$ | 0.20 | 0.19 | K-Feldspar | – | 3.60 |
| $P_2O_5$ | 0.02 | 0.00 | Illite | | |
| CaO | 0.08 | 0.10 | Kaolinite | | |
| MgO | 0.14 | 0.20 | Halite | – | 1.15 |
| $Na_2O$ | 0.20 | 0.60 | Rutile | | |
| $K_2O$ | 0.25 | 0.27 | Pyrite | – | 0.65 |
| $SO_3$ | 0.28 | 0.63 | Gypsum | | |
| Cl | 0.33 | 0.73 | Wollastonite | | |
| MnO | 0.00 | 0.01 | | | |
| Unknown | 10.27 | 5.18 | | | |

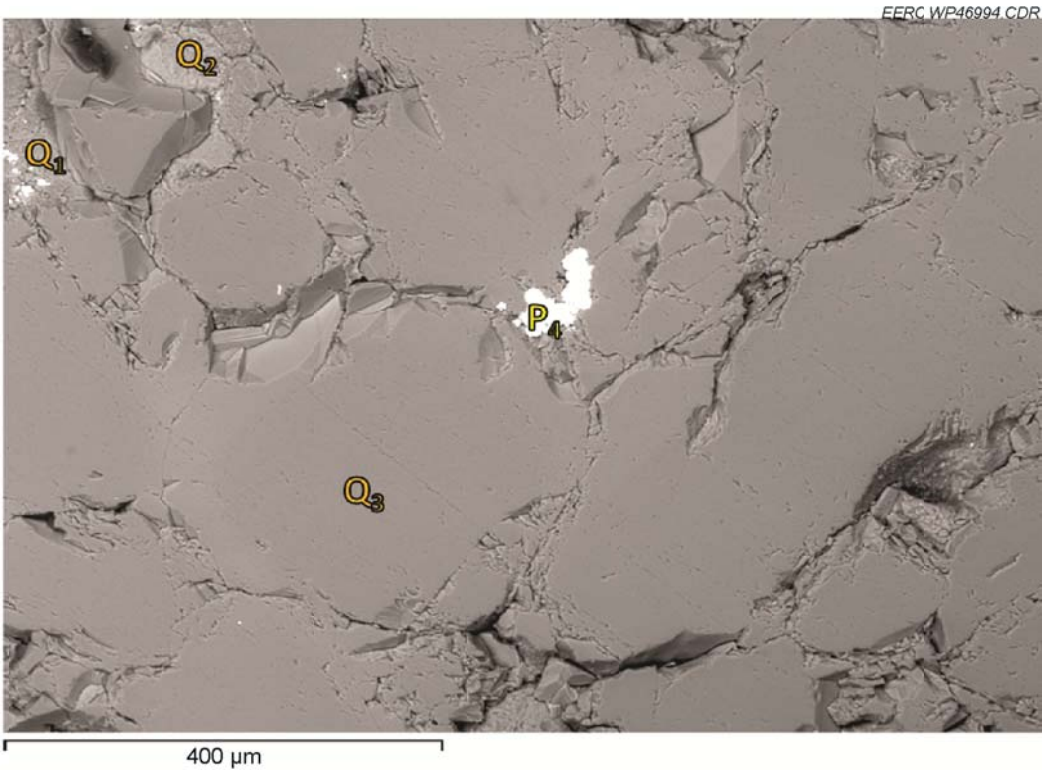



Figure 26. Preexposure SEM image of ND 12596-BI-14802.

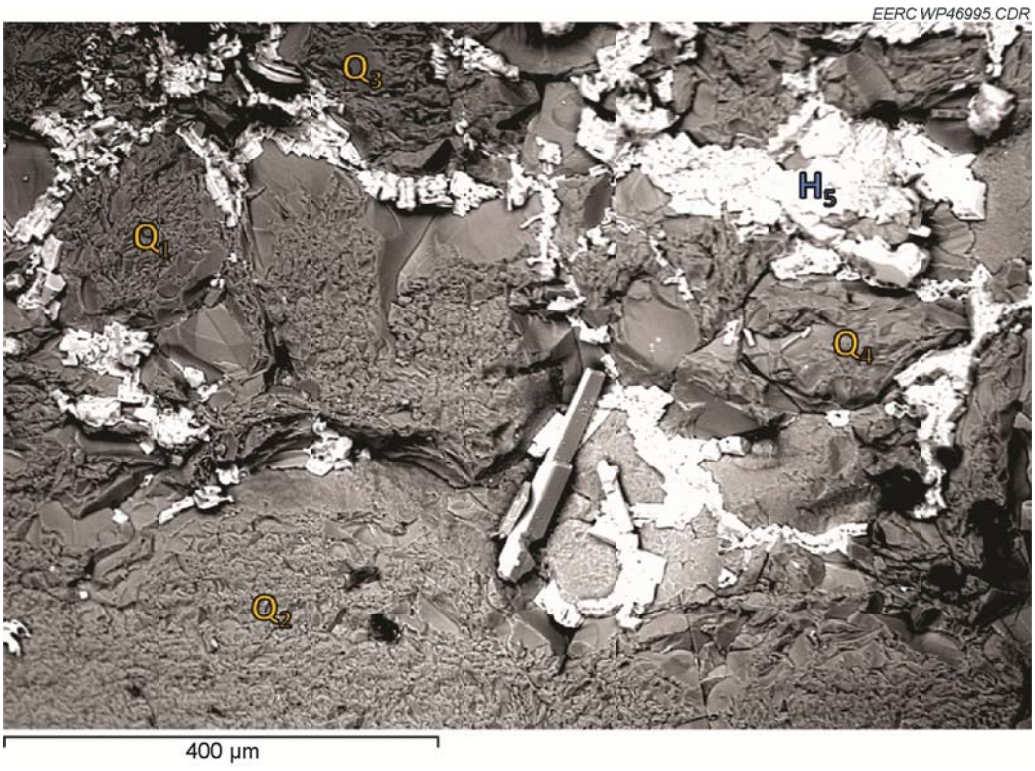



Figure 27. Postexposure SEM image of ND 12596-BI-14802.

**Table 15. XRF and XRD Pre- and Postexposure Comparison for ND 12596-BI-14831**

| XRF, wt% as oxides | | | XRD, wt% | | |
|---|---|---|---|---|---|
| | Pre- | Post- | | Pre- | Post- |
| $SiO_2$ | 61.2 | 60.3 | Quartz | 45.56 | 40.74 |
| $Al_2O_3$ | 22.2 | 21.7 | Calcite | | |
| $Fe_2O_3$ | 5.83 | 5.36 | Dolomite | | |
| $TiO_2$ | 1.20 | 1.22 | K-Feldspar | 3.52 | 13.65 |
| $P_2O_5$ | 0.06 | 0.05 | Illite | 27.86 | 10.03 |
| CaO | 0.15 | 0.02 | Kaolinite | 23.08 | 34.85 |
| MgO | 1.52 | 1.50 | Halite | – | 0.73 |
| $Na_2O$ | 0.18 | 0.63 | Rutile | | |
| $K_2O$ | 3.63 | 3.90 | Pyrite | | |
| $SO_3$ | 0.41 | 0.34 | Gypsum | | |
| Cl | 0.23 | 0.64 | Wollastonite | | |
| MnO | 0.01 | 0.01 | | | |
| Unknown | 3.41 | 4.25 | | | |

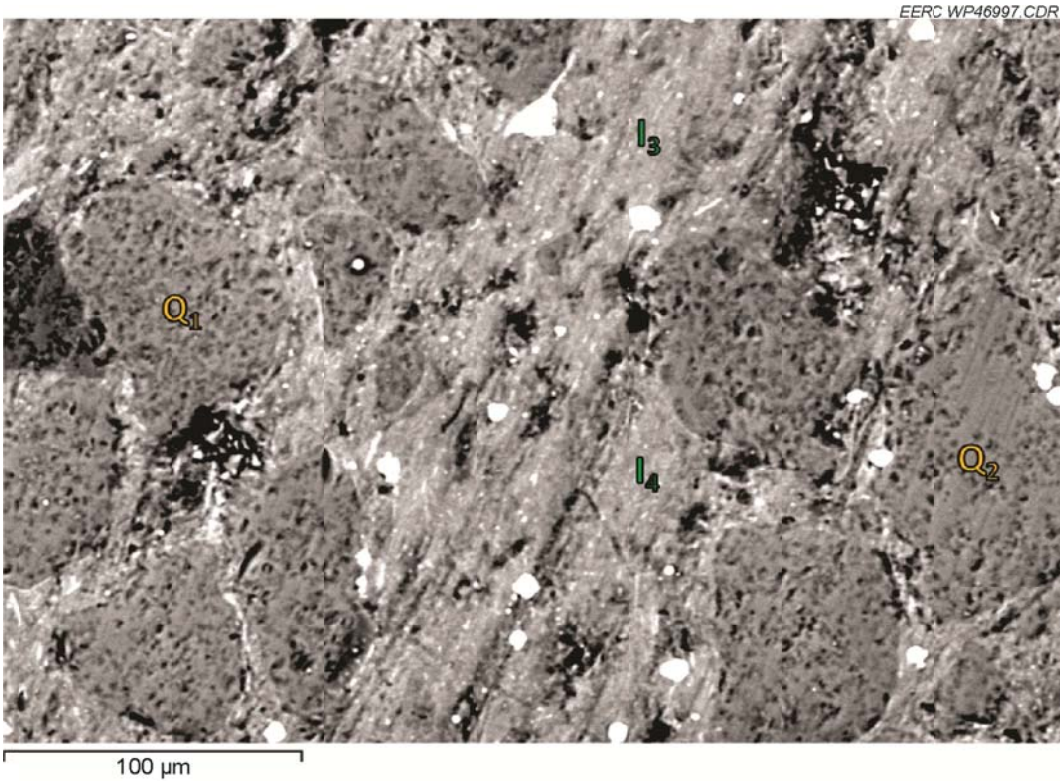



Figure 28. Preexposure SEM image of ND 12596-BI-14831.

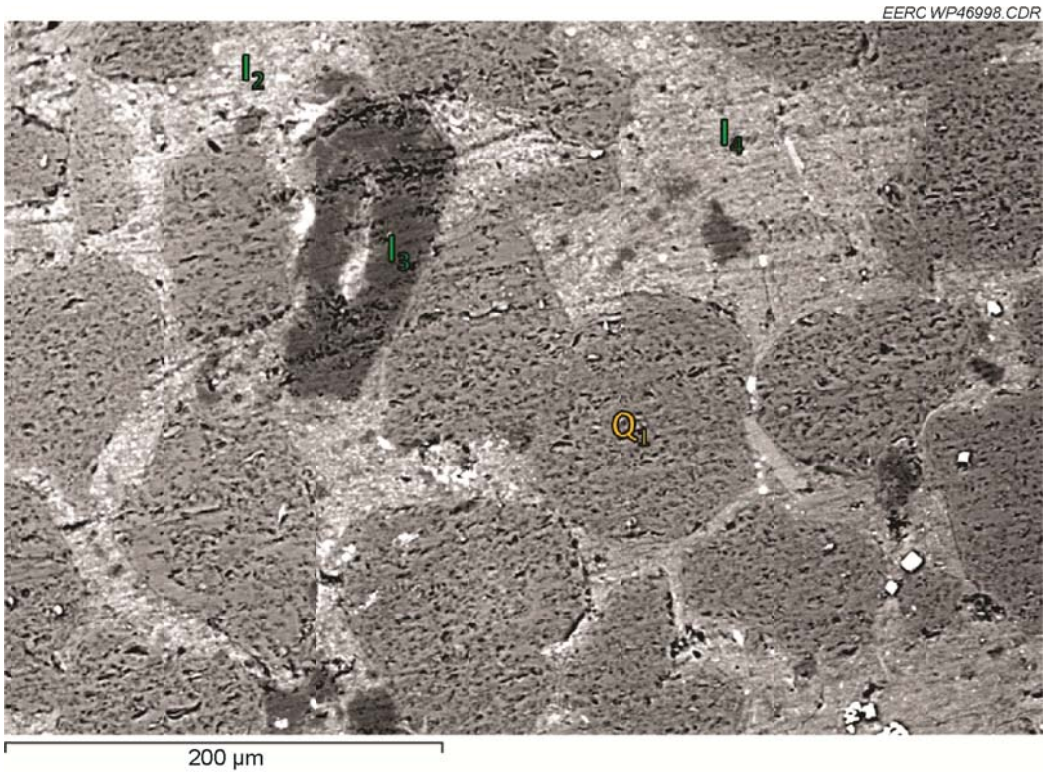



Figure 29. Postexposure SEM image of ND 12596-BI-14831.

### Comparison of $CO_2$ Exposure Experiments with PHREEQC Calculations

PHREEQC calculations were performed to compare the results with the experimental data. The compositions of the two synthetic brines given in Table 4 were used, along with the mineral compositions determined by quantitative XRD analysis of the preexposure samples. Values of elements in the brine below detection limits were taken as the detection limit. Because of the small size and thinness of the samples, sample masses and brine volumes given in the exposure test conditions of Table 3 were used to define the mass of rock in contact with the brine. Note that this assumes that all of the minerals are in contact with the brine and $CO_2$ (100% porosity). The calculations were performed as described previously for the well PHREEQC analyses. One data set (ND 9257-DW-11858.5) failed to converge on a solution in the calculations and is omitted from the comparisons. The lack of convergence may be due to information available in the database; however, it is difficult to speculate.

#### *Comparison of Brine Solutions*

The PHREEQC calculations systematically predict a lower pH for the solutions compared to the experimentally measured pH. It should be noted that the calculated values are at the temperature of the experiments (155°F [68°C] and 290°F [143.3°C]) and that the brines were depressurized and cooled to ambient temperature before the pH measurements were made. Both the loss of $CO_2$ from solution at lower pressure and the lower temperature would be expected to raise the measured pH.

Good agreement was observed between most major constituents in the brine. The experiments and the calculated concentrations for Al, Ca, Na, Cl, and Mg for both brines ND 12596 and ND 4432 agree well. Iron concentrations agree well with the measured concentrations for the brine ND 4432 postleaching samples but are an order of magnitude lower for the brine ND 12596 samples. It should be noted that the PHREEQC input for these samples does not contain any iron-bearing minerals, so cannot account for small amounts of iron present in the samples. The calculated K concentrations are higher for the brine ND 4432 samples, but agree reasonably well for the brine ND 12596 samples. Si calculated values are in good agreement with the brine ND 4432 sample values, but are lower than the experimental values for the brine ND 12596 samples.

Sulfur and carbon were two elements where differences were detected. Sulfur is one element that is calculated to be lower than the experimental concentrations for the brine ND 4432 samples, but is more similar but still lower than the experimental values for the brine ND 12596 samples. Carbon is predicted to be higher than the measured values for all sample brines. It appears that this is a consequence of the experimental analyses being performed after depressurization and the subsequent outgassing of $CO_2$ from the brines.

*Comparison of Mineral Transformations*

A difference in the mineral data is that the PHREEQC calculations did not predict the formation of halite for any of the samples. In all cases, halite was predicted to be unsaturated in the brines. The observation of halite coatings on the postexposure samples is likely due to evaporation of residual brine before analysis or the brine becoming more concentrated because of water evaporation after the experiments, thereby changing the saturation conditions.

Moderate agreement is observed between the XRD results and the calculations. With the exception of ND-12596-BI-14802, which shows a small decline, the amount of silica (quartz) is calculated to increase for the samples. In contrast, the XRD analyses show the amount of quartz decreasing for the majority of the cases.

When present, part or all the calcite is calculated to dissolve. The exception was sample ND 6264-DW-6126.5 with a high (42%) initial calcite concentration. The behavior of ND 9257-DW-11858.5 possibly would be similar, but the calculations failed to converge to a solution for this sample. The XRD results show a similar trend of decreasing calcite. However, the calculated values match the experimental ones only when the calcite is completely dissolved or is zero.

The calculated changes to dolomite do not match as well with the XRD results, with the experimental data generally showing an inverse trend to the calculations. It should be noted that in samples ND 6264-BI-6086, ND 6264-DW-6113, and ND 6264-DW-6114.5 solid dolomite is predicted to dissolve. This is in contrast to the trend found for the previously presented well mineral calculations, where dolomite consistently increased. This difference appears to be due to the much lower mineral:brine ratio used in the experiments.

Illite and K-feldspar are predicted to completely dissolve in the calculations. This was seen in the calculations for the well mineral data both with and without $CO_2$ present and is due to the thermodynamic values for these minerals in the llnl.dat dataset. The XRD data show mixed increases and decreases for concentrations of K-feldspar and a general trend of decreases in illite with the exception of sample ND 6264-DW-6113. Agreement with these particular minerals is fair to good.

Kaolinite is calculated to show a general increase except for samples ND 9257-BI-11789.5, ND 9257-BI-11832.5, and ND 12596-BI-14831. The XRD data indicate either no change in kaolinite or small decreases. The exception is sample ND 12596-BI-14831, which has a large increase.

Small amounts of goethite and rutile are predicted to form but were not detected by the XRD analysis. Muscovite is also predicted to form in decent amounts in preference to the illite and K-feldspar. No evidence of muscovite was seen in the XRD analyses. A small amount of strontianite is also predicted to precipitate. As noted, this mineral was included because preliminary calculations indicated that it was above its saturation point. No evidence of strontianite was seen in the XRD analysis.

## CONCLUSIONS

As would be expected, the ability to effectively model geochemical interactions between rock formations, brine, and $CO_2$ are highly dependent on the amount and quality of data. The data most frequently unavailable were formation water analyses and the quality of the water analysis data (what elements were analyzed). Few wells used in this study had both water and mineral analyses available which necessitated the extrapolation of water analyses from wells some distance away, thus introducing some uncertainty into the calculation results. However, the calculations are still valid for the type of system described by the data.

The variations in formation water, mineral content, and porosity in the COSS result in large variations in the amount of $CO_2$ reacting with the formation water and the rock minerals. These variations occur both geographically between different areas of the COSS and vertically at each location. Averaging of these properties over the total saline system can result in over- or underestimation of the COSS capacity. The subdivision into vertical zones with roughly similar mineral composition and porosity appears to improve the predictions.

The major predicted interaction of $CO_2$ with the COSS minerals and formation water is the dissolution of calcite concurrently with the formation of dolomite. This occurs when there is a source of $Mg^{2+}$ because of the presence of illite, phlogopite, glauconite, and clinochlore or if there is a high $Mg^{2+}$ concentration in the formation water. This phenomenon was also observed in the laboratory experiments.

Glauconite was also observed to be an important mineral in the study. Glauconite was observed to completely dissolve in $CO_2$ exposure. This phenomenon in glauconite-rich areas may increase permeability as well as provide a mineral-trapping mechanism for $CO_2$.

In the calculations, illite and K-feldspar are predicted to completely dissolve. This was seen in the calculations for the well mineral data both with and without $CO_2$ present and is due to the thermodynamic values for these minerals in the llnl.dat dataset. The XRD data show mixed increases and decreases for concentrations of K-feldspar and a general trend of decreases in illite. Illite and K-feldspar behavior was mixed for the laboratory experiments but, in general, was in agreement with the calculated results.

The interaction and $CO_2$ trapping by mineralization can be a major source of $CO_2$ sequestration in the COSS. The most important mineralization reaction (seen in both calculations and experimentation) was the dissolution of calcite with the formation of dolomite.

Both the experimental data and calculations suggest that $CO_2$ will remain trapped in deep saline sandstone formations and the interactions with cap rock will be limited to the interface between the shale, $CO_2$, and brine. The low porosity/permeability of the cap rock shale prevents migration of the $CO_2$ to fresh surfaces available for reaction. Because the majority of the $CO_2$ will be injected into quartz-rich sandstone formations, limited reaction between $CO_2$ and COSS sandstone is expected.

## FUTURE EFFORTS

Future efforts on the modeling front should focus on obtaining more robust thermodynamic data for modeling efforts, both in brine chemistry, supercritical $CO_2$ fluid data, and mineral data. It will also become increasingly important to more closely determine the effects of pressure gradients on the injection system. As $CO_2$ is injected, the pressure front will decrease sharply with distance. One key question to be addressed is how this will affect the geochemistry as far as creating/destroying porosity from $CO_2$–rock interactions.

New efforts on the experimental front are also needed. One of the major challenges facing this type of work is the heterogeneity of the rock samples. When destructive methods are used (XRD, XRF), it is very difficult to obtain representative samples to determine if small increases or decreases in certain mineral phases are, indeed, a reality. The use of SEM tools may be necessary to help in this challenge by "indexing" the samples to ensure the same area is analyzed pre- and postexposure. However, because SEM/EDS is merely a surface technique, this type of sampling may lead to excessive charging, poor image quality, and EDS spectra.

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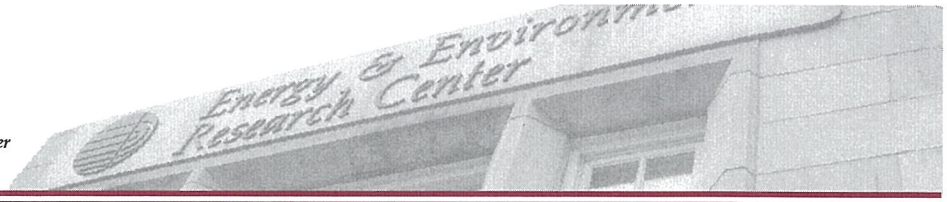
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# APPENDIX A

# CHARACTERIZATION OF ICEBOX, DEADWOOD, AND BLACK ISLAND FORMATION SAMPLES




# CHARACTERIZATION OF ICEBOX, DEADWOOD, AND BLACK ISLAND FORMATION SAMPLES

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# CHARACTERIZATION OF ICEBOX, DEADWOOD, AND BLACK ISLAND FORMATION SAMPLES

## INTRODUCTION

Rocks of the Cambro-Ordovician system era extend throughout a 310,000-square-mile portion of the Williston and Alberta Basins in the states of North Dakota, South Dakota, Nebraska, Wyoming, and Montana and the Canadian provinces of Alberta, Saskatchewan, and Manitoba (Figure 1). The stratigraphic group is located at the base of the sedimentary succession and represents the first 50 million years of sedimentary history in both basins. This succession of rocks has the potential to be used as a regional sink for anthropogenic carbon dioxide ($CO_2$) (Bachu and others, 2012). However, because of the depth and lack of significant hydrocarbon exploration, there is relatively little information available on the geological, geochemical, and mineralogical characteristics of the formations within this stratigraphic succession; hence, significant research and analysis are required to advance knowledge about $CO_2$ storage opportunities in this extensive regional sink. Figure 2 is an illustration of the sedimentary succession of rocks making up the focus area of this study and their respective roles in the storage of anthropogenic $CO_2$.

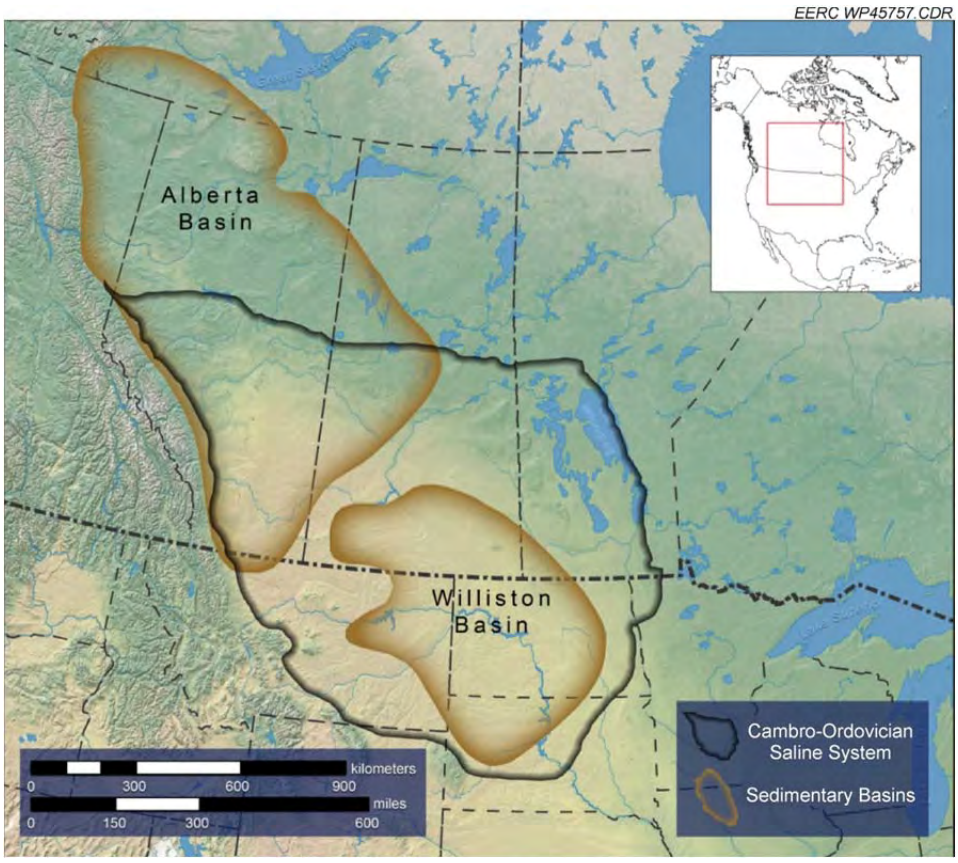



Figure 1. Map illustrating the regional extent of the Cambro-Ordovician system.

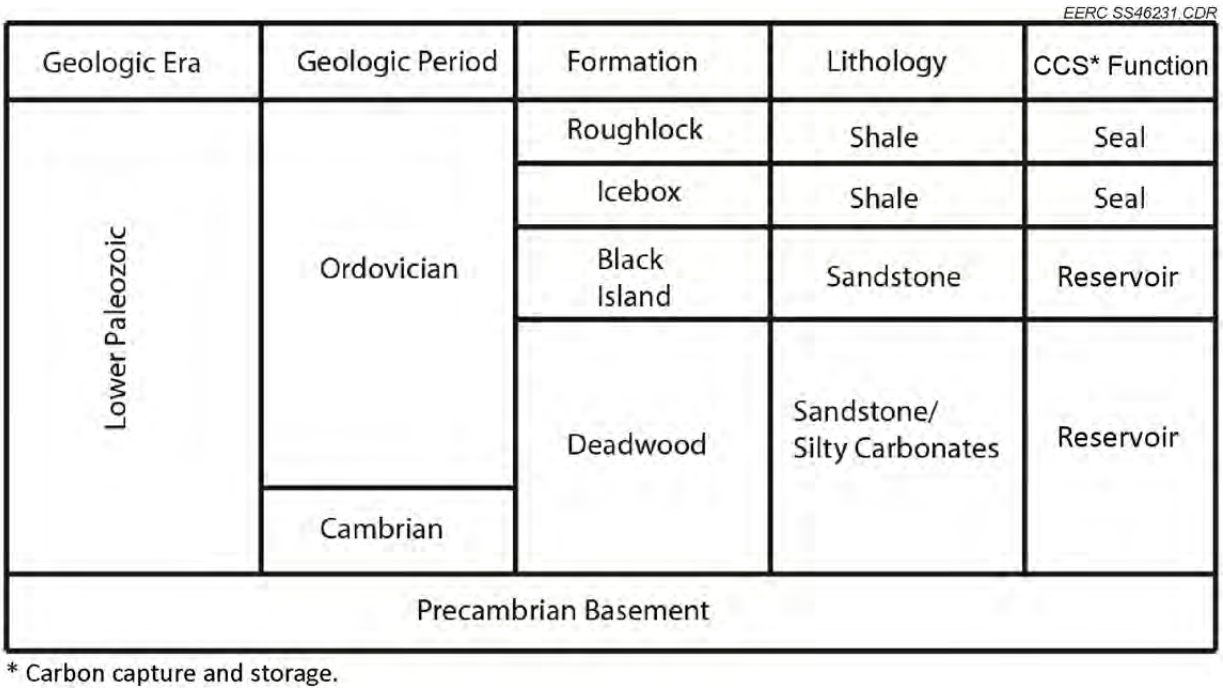



Figure 2. Stratigraphy of sedimentary succession of rocks making up the study area.

Laboratory analyses were conducted on 18 samples by the Energy & Environmental Research Center (EERC). The samples are representative of the Black Island and Icebox Formations (Ordovician age) and Deadwood Formation (Ordovician and Cambrian age). Characterization testing included porosity, mineralogy, permeability, petrographic attributes, and classification of depositional and energy environments. The goal of this characterization activity was to develop a basic understanding of rock properties of the studied formations and to provide data sets that may be useful in the development of static geologic models for dynamic simulations of $CO_2$ storage scenarios in the region. This report presents a description of the sample selection, analysis methods, results, and discussion for future studies.

## SAMPLE SELECTION AND METHODS OF ANALYSIS

### Sample Selection

Cambro-Ordovician samples were identified and collected from the North Dakota Geological Survey (NDGS) Wilson M. Laird Core and Sample Library in Grand Forks, North Dakota. Samples were collected in October and November 2011 by EERC personnel, with assistance provided by NDGS Core and Sample Library personnel. Figure 3 shows an example of the core as it was sampled. Eighteen samples representing a variety of rock fabrics ranging from reservoir-quality to cap (Icebox) were selected for analysis. The samples were chosen from NDIC Well Nos. 17467, 9800, 12596, 9257, and 6264. The location of these wells within North Dakota is shown in Figure 4.




Figure 3. NDIC Well 17467 Deadwood Formation core plug and slab samples collected from the NDGS Core and Sample Library.

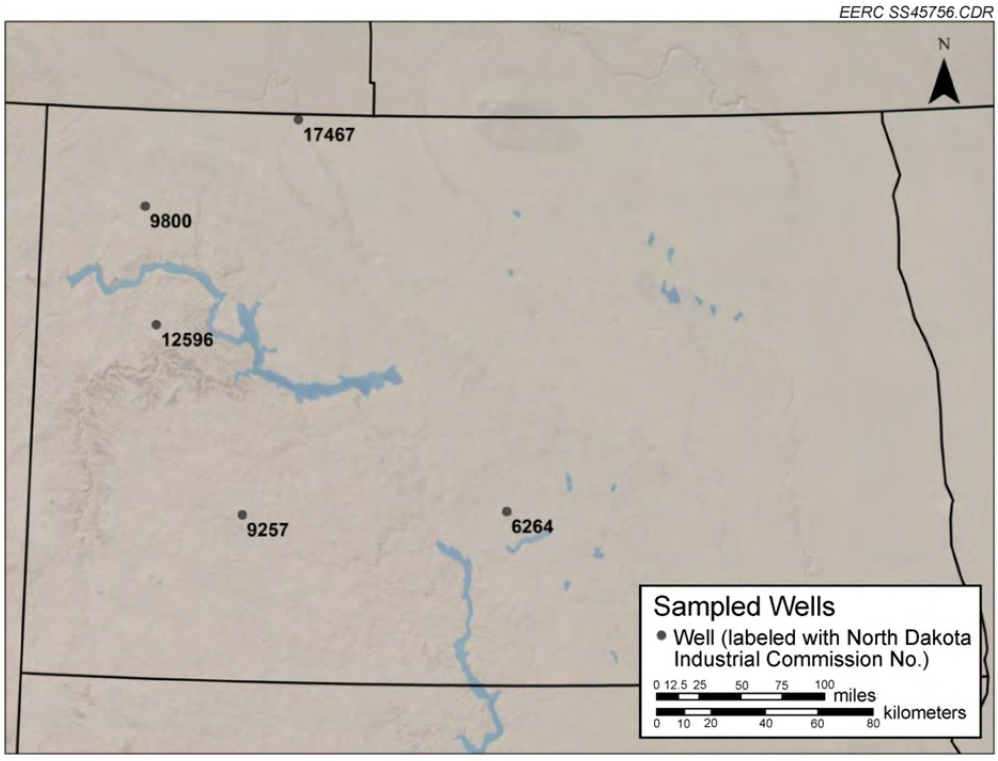



Figure 4. Location of sampled wells within North Dakota.

**Methods of Analysis**

The samples collected were characterized in detail for several rock and fluid properties such as porosity, mineralogy, permeability to water, petrographic attributes, and classification of depositional and energy environments. Because of limitations in the sizes and/or shapes of some samples, a select set of six samples was prepared for effective porosity measurements using a gas pycnometer and for permeability-to-water measurements using a flexible-wall permeameter. Table 1 contains sample descriptions and a matrix indicating the analyses performed for each sample. Detailed descriptions of the analytical methods are provided in Appendix A. A brief description of each technique is provided here:

- **Petrographic analysis –** Petrographic analysis involves photographing the samples as-received, creation and description of thin sections, identification and estimation of mineral assemblages, porosity prevalence through point counting, mineral cement identification, description of microstructure, and assignment and classification of petrographic energy environment and depositional environment.

- **Gas pycnometry –** A gas pycnometer measures skeletal or grain volume of each sample. Computer-controlled valves and digital pressure transducers are used to measure a pressure difference with a fixed amount of pressurized gas. The grain volume of a sample is determined by gas applying Boyle's law equations, and bulk volume is measured with a digital caliper. The pore volume is calculated by subtracting grain volume from bulk volume.

- **Permeability –** Through the use of a flexible-wall permeameter at near-ambient-pressure conditions, a rock's ability to transmit fluids is measured.

- **X-ray diffraction (XRD) analysis –** XRD is the standard method for determining bulk mineralogy of materials. The complementary use of x-ray fluorescence (XRF) and scanning electron microscopy (SEM) data enhances bulk mineral identification. Rietveld refinement was used to quantify the mineralogical composition of the samples.

  – **XRD clay typing –** This technique entails the separation and concentration of the clay fraction of a sample for detailed XRD analysis. A flowchart for the identification of clay based on the response to different treatments is used to systematically identify the clay.

- **XRF analysis –** XRF is used to determine the bulk chemistry of the samples, reported as elemental oxide wt%. The results are used as a guide to improve mineral characterization by the XRD technique.

- **SEM –** SEM techniques were used to evaluate the textural, elemental, and mineralogical composition of the samples using backscattered electron (BSE) imaging and energy-dispersive spectrometry (EDS). EDS was used to create maps showing the mineralogical composition of select samples. The SEM method also allows for the

**Table 1. Sample Information and Analysis Matrix**

| Sample ID | NDIC[1] Well | Formation | Depth, ft | Petrographic Analysis | XRF | XRD | SEM | Effective Porosity[2] | Thin-Section Point Count Porosity | Permeability to Water |
|---|---|---|---|---|---|---|---|---|---|---|
| S-00925 | 6264 | Black Island | 6086.0 | X[3] | X | X | X | – | X | – |
| S-00926 | 6264 | Deadwood | 6113.0 | X | X | X | X | – | X | – |
| S-00927 | 6264 | Deadwood | 6114.5 | X | X | X | X | – | X | – |
| S-00928 | 6264 | Deadwood | 6126.5 | X | X | X | X | – | X | – |
| S-00929 | 6264 | Deadwood | 6165.0 | X | X | X | X | – | X | – |
| S-00768 | 17467 | Deadwood | 9440.1 | X | X | X | – | X | X | X |
| S-00769 | 17467 | Deadwood | 9443.1 | X | X | X | – | X | X | X |
| S-00773 | 17467 | Deadwood | 9450.3 | X | – | – | – | X | X | X |
| S-00772 | 17467 | Deadwood | 9459.3 | X | – | – | – | X | X | X |
| S-00771 | 17467 | Deadwood | 9462.1 | X | – | – | – | X | X | X |
| S-00770 | 17467 | Deadwood | 9473.2 | X | – | – | – | X | X | X |
| S-00930 | 9257 | Black Island | 11,789.5 | X | X | X | X | – | X | – |
| S-00931 | 9257 | Deadwood | 11,832.5 | X | X | X | X | – | X | – |
| S-00932 | 9257 | Deadwood | 11,858.5 | X | X | X | X | – | X | – |
| S-00774 | 9800 | Icebox | 13,995.0 | – | X | X | X | – | – | – |
| S-00775 | 9800 | Icebox | 14,012.0 | – | X | X | X | – | – | – |
| S-00933 | 12596 | Black Island | 14,802.0 | X | X | X | X | – | X | – |
| S-00934 | 12596 | Black Island | 14,831.0 | – | X | X | X | – | – | – |

[1] North Dakota Industrial Commission.
[2] Effective porosity determined on core plugs using gas pycnometry.
[3] X indicates that the analysis was performed.

possibility of detecting and identifying the chemistry of amorphous substances that cannot be determined by the XRD technique.

## RESULTS AND DISCUSSION

### Petrographic Analysis of Thin Sections

The depositional environment of the Cambro-Ordovician system is complex and varies from marginal marine to deep marine throughout the study area. Most of the samples analyzed represent a complex nearshore environment similar to that illustrated in Figure 5. Because of the complex nature of the samples, the method of classifying each sample according to a depositional environment along with an energy environment was chosen. Estimations of depositional and energy environments were determined based on both mineralogical content and observable rock fabric. These estimations revealed physical characteristics that occurred during the processes of sedimentation and postdepsitional, diagenesis. Characterizing the samples as low, medium, high, or a combination of energies assists in developing an overall understanding of the mineral assemblages that may be expected (Figure 6). Clastic/sandstone classification was performed according to the Dott classification system (Dott, 1964), while carbonates were classified utilizing Dunham classification systems (Dunham, 1962). Depositional and energy environments and classifications for each sample are shown in Table 2.

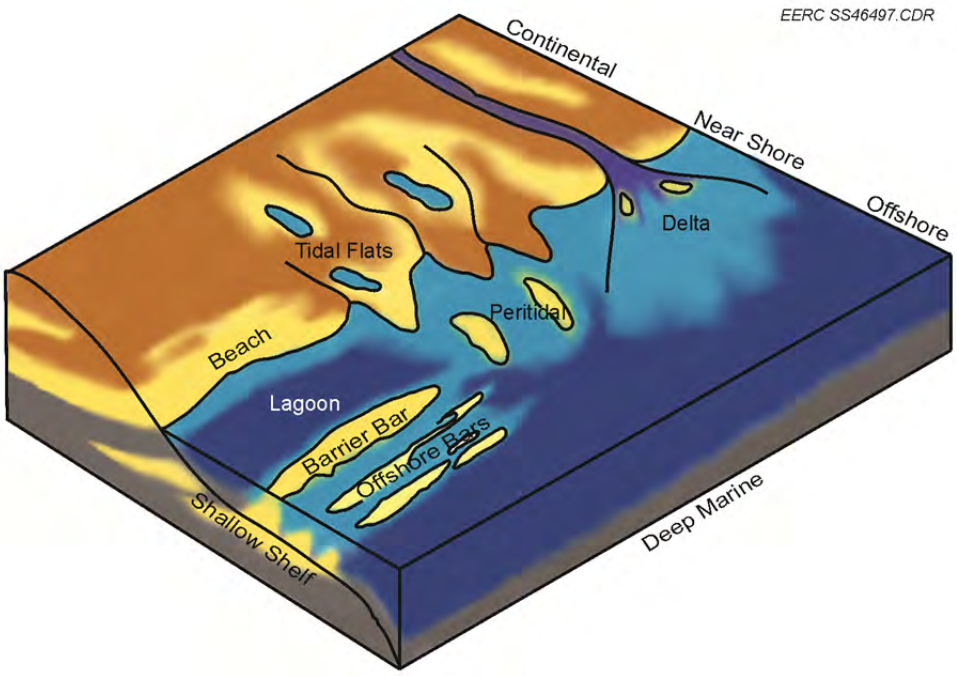



Figure 5. An illustration of various depositional environments, many of which describe the complex set of facies changes represented in the Cambro-Ordovician strata.

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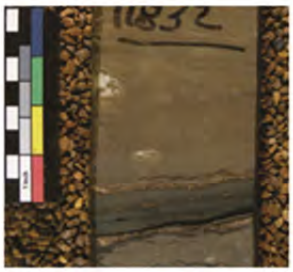
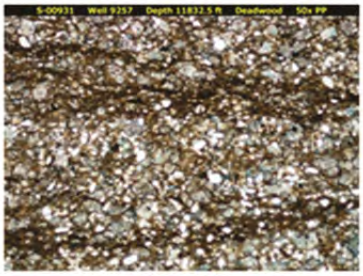
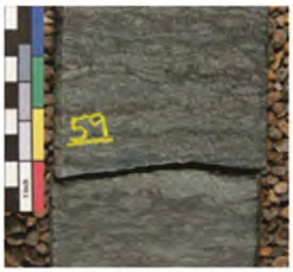
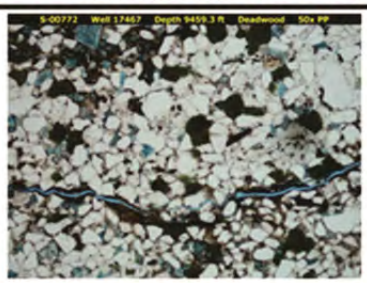
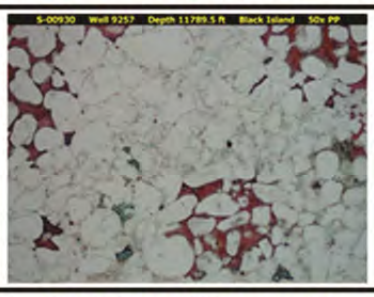
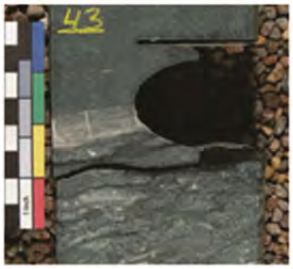
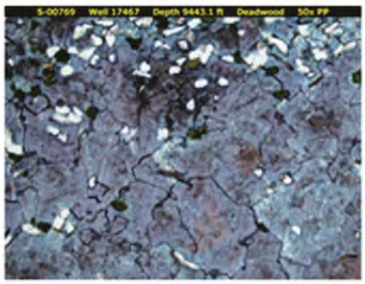
| NDIC Well No. | Depth, ft | Core Image, wet | Thin-Section Image, 50x | Depositional/Energy Environment |
|---|---|---|---|---|
| 9257 | 11,832.5 |  |  | Lagoon/Low |
| 17467 | 9459.3 |  |  | Beach/Medium |
| 9257 | 11,789.5 |  |  | Beach/High |
| 17467 | 9443.1 |  |  | Shallow Shelf/Low–Medium |

Figure 6. Image of Deadwood and Black Island Formation cores (left) from NDIC Wells 9257 and 17467 compared with the corresponding photomicrographs (right) to illustrate the different depositional and energy environments present within the study area. The varying degrees of sorting, grain size, and composition illustrate the unique lithologic characteristics of each interpreted environment. These characteristics impact the quality of the resulting reservoir.

**Table 2. Energy and Depositional Environments and Classification of Samples**

| Sample ID | Formation | NDIC Well | Depth, ft | Energy Environment | Depositional Environment | Lithology | Dott Classification | Dunham Classification |
|---|---|---|---|---|---|---|---|---|
| S-00925 | Black Island | 6264 | 6086.0 | High | Beach | Sandstone | Quartz arenite sandstone | N/A[1] |
| S-00926 | Deadwood | 6264 | 6113.0 | Low–medium | Shallow shelf | Silty dolostone | N/A | Glauconitic grainstone |
| S-00927 | Deadwood | 6264 | 6114.5 | Low–medium | Beach | Sandstone | Dolomitic arentic sandstone | N/A |
| S-00928 | Deadwood | 6264 | 6126.5 | Low–medium | Lagoonal | Wackestone | N/A | Silty wackestone |
| S-00929 | Deadwood | 6264 | 6165.0 | Low–medium | Beach | Sandstone | Quartz arenite sandstone | N/A |
| S-00768 | Deadwood | 17467 | 9440.1 | Medium | Shallow shelf/beach | Sandstone | Dolomitic sandstone | N/A |
| S-00769 | Deadwood | 17467 | 9443.1 | Low–medium | Lagoonal/peritidal | Silty dolostone | N/A | Dolomitic grainstone |
| S-00773 | Deadwood | 17467 | 9450.3 | Medium | Shallow shelf/beach | Sandstone | Dolomitic sandstone | N/A |
| S-00772 | Deadwood | 17467 | 9459.3 | Medium | Beach | Sandstone | Glauconitic sandstone | N/A |
| S-00771 | Deadwood | 17467 | 9462.1 | High | Beach | Sandstone | Quartz arenite sandstone | N/A |
| S-00770 | Deadwood | 17467 | 9473.2 | High | Beach | Sandstone | Quartz arenite sandstone | N/A |
| S-00930 | Black Island | 9257 | 11,789.5 | Low–medium | Tidal flats | Sandstone | Calcareous sandstone | N/A |
| S-00931 | Deadwood | 9257 | 11,832.5 | Low | Lagoonal | Silty dolostone | N/A | Dolomitic grainstone |
| S-00932 | Deadwood | 9257 | 11,858.5 | Low–medium | Shallow shelf | Grainstone | N/A | Dolomitic wackestone |
| S-00774 | Icebox | 9800 | 13,995.0 | Low | Marine | Shale | N/A | Mudstone |
| S-00775 | Icebox | 9800 | 14,012.0 | Low | Marine | Shale | N/A | Mudstone |
| S-00933 | Black Island | 12596 | 14,802.0 | Medium–high | Beach | Sandstone | Quartz arenite sandstone | N/A |
| S-00934 | Black Island | 12596 | 14,831.0 | Low | Marine | Shale | N/A | Mudstone |

[1] Not applicable.

Three Deadwood Formation samples (S-00928, S-00769, and S-00931) were described as representing a low-energy lagoonal class (Appendix B). A lagoonal environment suggests that deposition occurred in a shallow body of water along a coast protected from wave action. Typical lagoonal deposits are typically fine-grained, silty, or muddy sediments with small amounts of (commonly laminated) wind-blown sand (Boggs, 2006). Lagoonal deposits may also be bioturbated, contain ripple marks, or contain evaporates (such as gypsum or anhydrite). The samples identified here were composed of fine-grained, silty dolostones with both dolomitic-(S-00928 and S-00769) and mud-supported (S-00931) matrices. All three samples included subangular to subrounded quartz clasts, and two of the samples illustrated moderate sorting (S-00769 and S-00931). S-00928 also contained anhydrite inclusions. The combination of a fine-grained matrix with a variety of inclusions (also including fossils and other minor minerals) led to the lagoonal interpretation (Figure 7).

Four additional samples (S-00926, S-00768, S-00773, and S-00932) were classified as shallow shelf deposits (Appendix B). This type of deposition consists of locations between beaches and deep ocean slopes. A shallow shelf can experience a wide range of energy environments (low–high) displaying a wide range of clastic and carbonate depositional features. These include fine to coarse grain sizes, moderate sorting, rounded clastic or carbonate grains, and storm deposits which may rework existing sedimentary structures or entrain a wide variety of detrital grains (Boggs, 2006). The shallow shelf samples all shared a relatively high concentration of carbonate grains but had also undergone substantial dolomitization, altering the original sedimentary fabric. The samples also exhibited a wide variety of sedimentary characteristics ranging from fine-grained, tight carbonates to moderately sorted sandstones (Figures 8–10). The poor sorting, mixed-grain type (micritic mud holding coarse quartz grains) and the presence of several broken fossils suggest that Sample S-00932 may be an example of a storm deposit.

The three shale samples (S-00774, S-00775, and S-00934) represented a low-energy, deep marine environment (Appendix B). Deep marine sediments are typically composed of thinly laminated clays or calcareous/siliceous oozes (Boggs, 2006). These were all very fine grained, fissile shale with significant clay content and fine laminations.

The remaining samples are represented as beach deposits (Appendix B). Beach depositional environments, such as barrier bar, offshore, nearshore, and delta have typically higher-energy environments resulting in high degrees of roundness, spericity, and sorting (Figure 6). Beach deposits may also contain either calcareous or siliceous grains or exhibit cross stratification or bioturbation (Boggs, 2006). Samples identified as beach deposits generally exhibited sub- to well-rounded grains which were moderately to well sorted (Figures 11–15). Some samples (S-00930 and S-00772) contained intergranular clays, which suggests deposition occurring at the margin of the edge of shoreline, below the wave base. Other samples (S-00929 and S-00927) contained more angular grains and poor sorting which may be indicative of storm deposits.

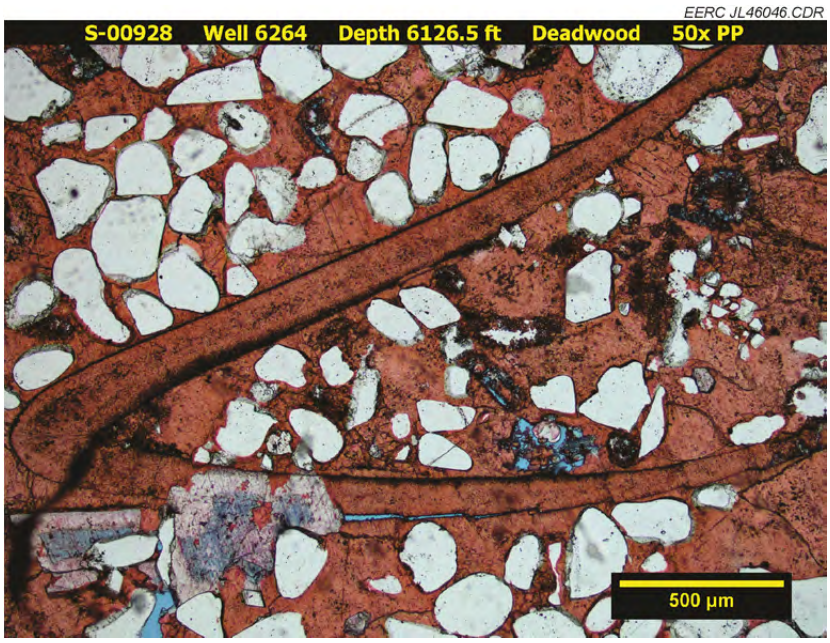



Figure 7. Photomicrograph of a Deadwood Formation thin section showing a well-cemented, fossil-rich, and zoned carbonate crystallization. Sample S-00928 was obtained from Well 6264 at 6126.5 ft and imaged at 50× magnification under plane-polarized light. This sample has nonconnected moldic porosity due to mineral dissolution.

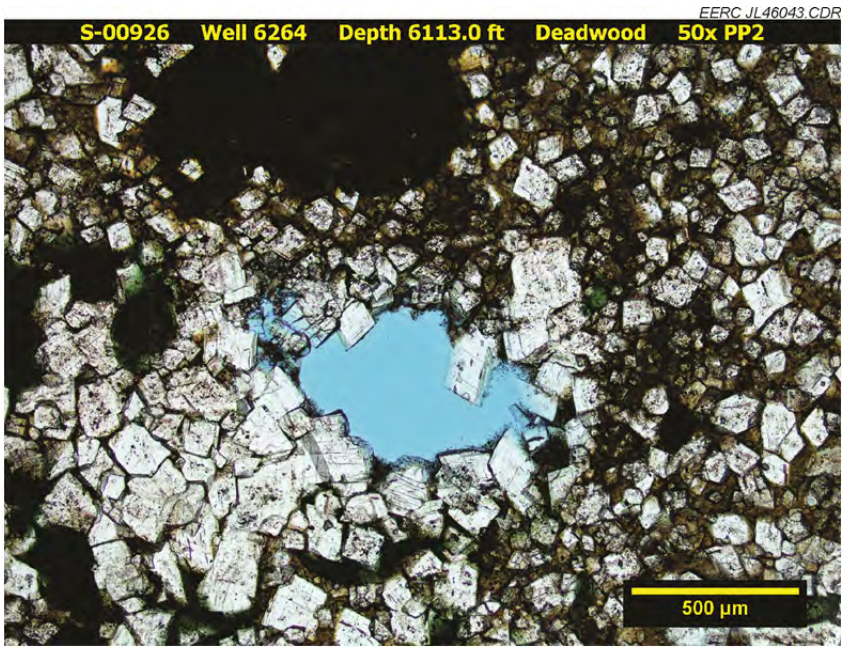



Figure 8. Photomicrograph of a Deadwood Formation thin section showing carbonate mineralization and vuggy porosity. Sample S-00926 was obtained from Well 6264 at 6113.0 ft and imaged at 50× magnification under plane-polarized light.

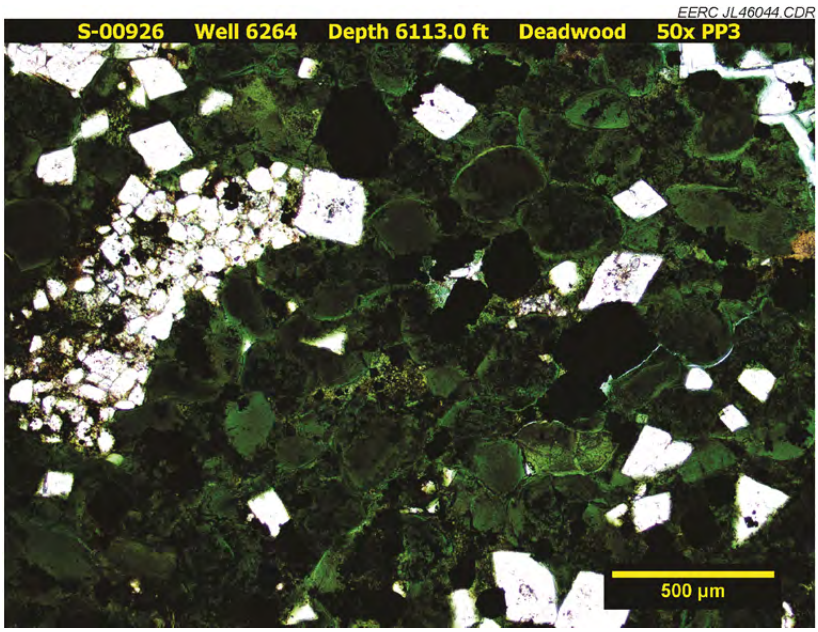



Figure 9. Photomicrograph of a Deadwood Formation thin section displaying a high concentration of glauconite and pyrite. Sample S-00926 was obtained from Well 6264 at 6113.0 ft and imaged at 50× magnification under plane-polarized light.

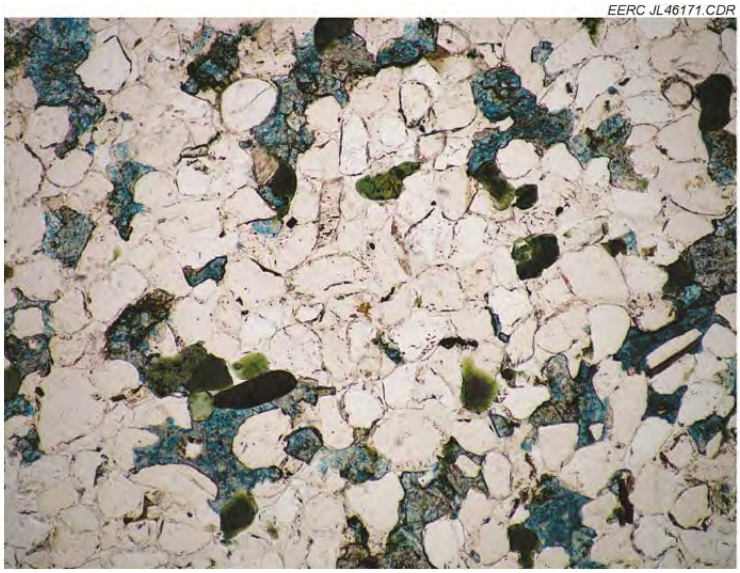



Figure 10. Photomicrograph of a Deadwood Formation thin section displaying a clastic environment. Sample S-00773 was obtained from Well 17467 at 9450.3 ft, imaged at 50× magnification under plane-polarized light. This sample illustrates secondary subhedral dolomitic diagenesis (blue grains were dyed with potassium ferricyanide) and quartz overgrowth, together nearly eliminating original porosity.

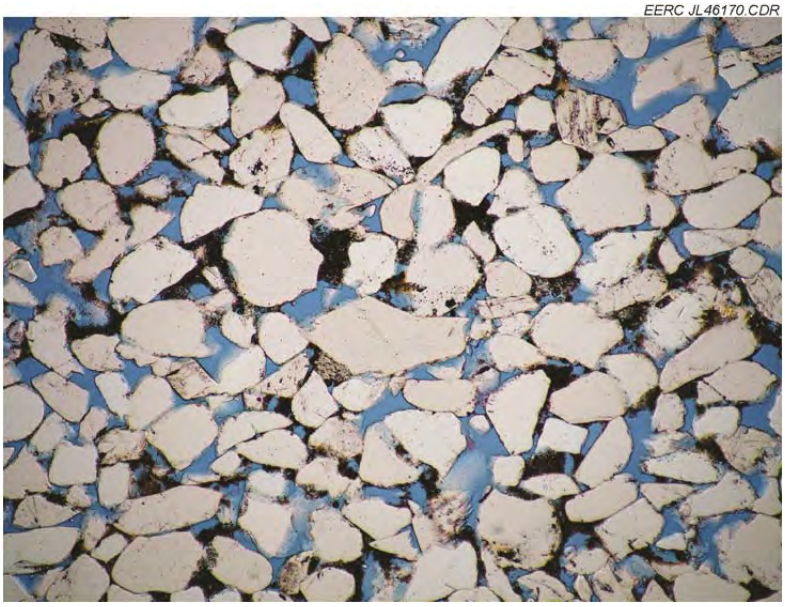



Figure 11. Photomicrograph of a Black Island Formation thin section displaying fairly clean sandstone having experienced cement dissolution. This characteristic, along with moderately good sorting, few sutured contacts, and few quartz overgrowths, makes for possible reservoir rock. This sample is composed of angular to subrounded quartz grains with intergranular porosity. Sample S-00925 was obtained from Well 6264 at 6086.0 ft and imaged at 50× magnification under plane-polarized light.

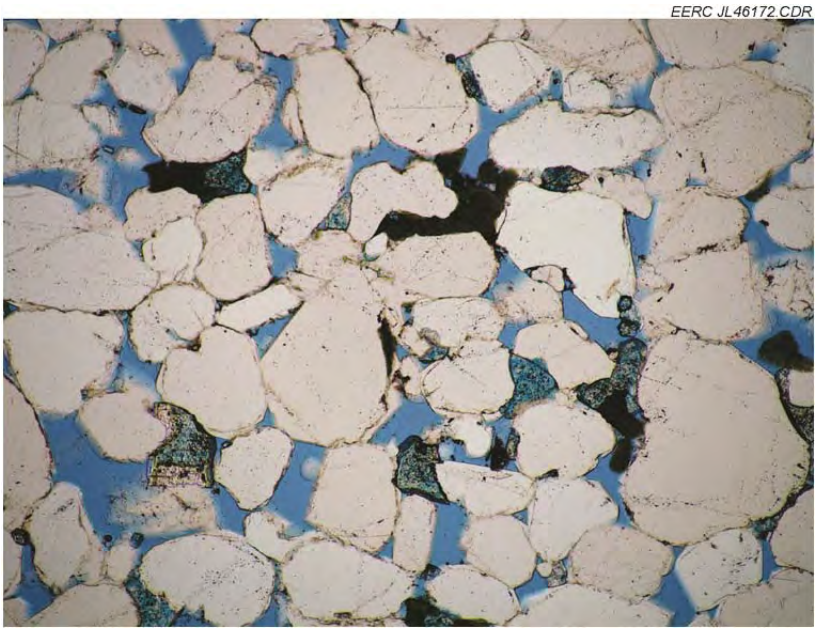



Figure 12. Photomicrograph of a Deadwood Formation thin section displaying fairly clean sandstone undergoing some storage-reducing diagenetic events: carbonate mineralization, quartz overgrowths, and compaction. Sample S-00771 was obtained from Well 17467 at 9462.1 ft and imaged at 50× magnification under plane-polarized light.

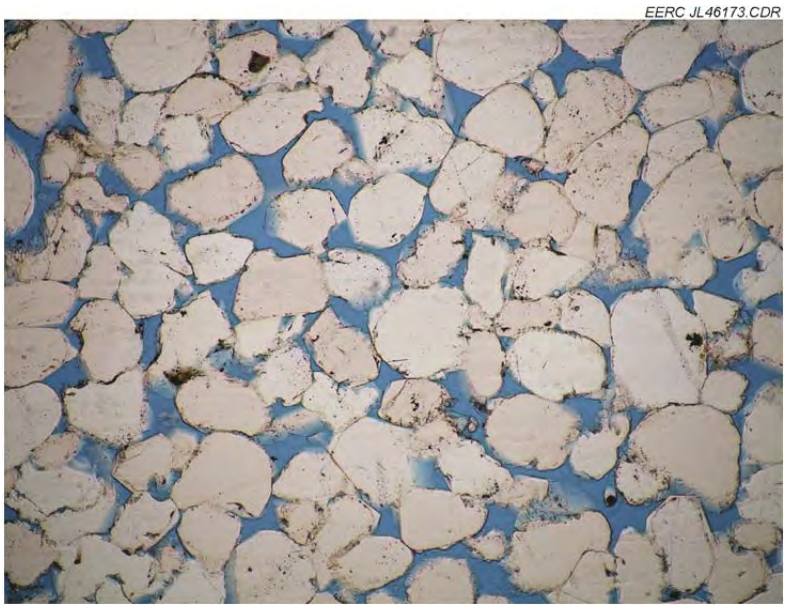



Figure 13. Photomicrograph of a Deadwood Formation thin section representing very clean sandstone. Conversely to the previous figure, this sample represents good reservoir characteristics: little cementation, predominantly point contacts present, mild quartz overgrowth, no dolomitization, and minute compaction. Sample S-00770 was obtained from Well 17467 at 9473.2 ft, imaged at 50× magnification under plane-polarized light.

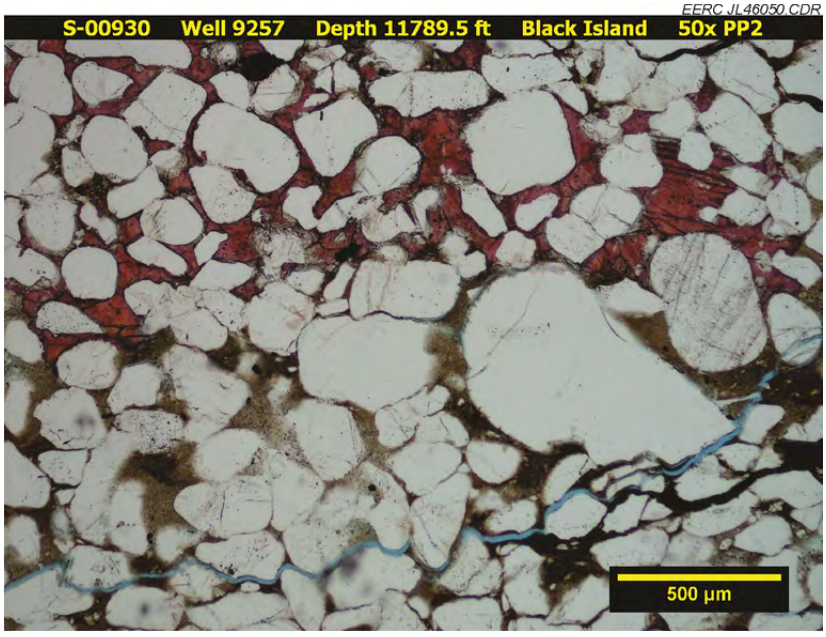



Figure 14. Photomicrograph of a Black Island Formation thin section illustrating two different cementing agents: top cement is micrite dyed with Alizarin red, and bottom cement is illite/kaolinite clays. Porosity is limited to fractures and rare cement dissolution. Sample S-00930 was obtained from Well 9257 at 11,789.5 ft and imaged at 50× magnification under plane-polarized light.

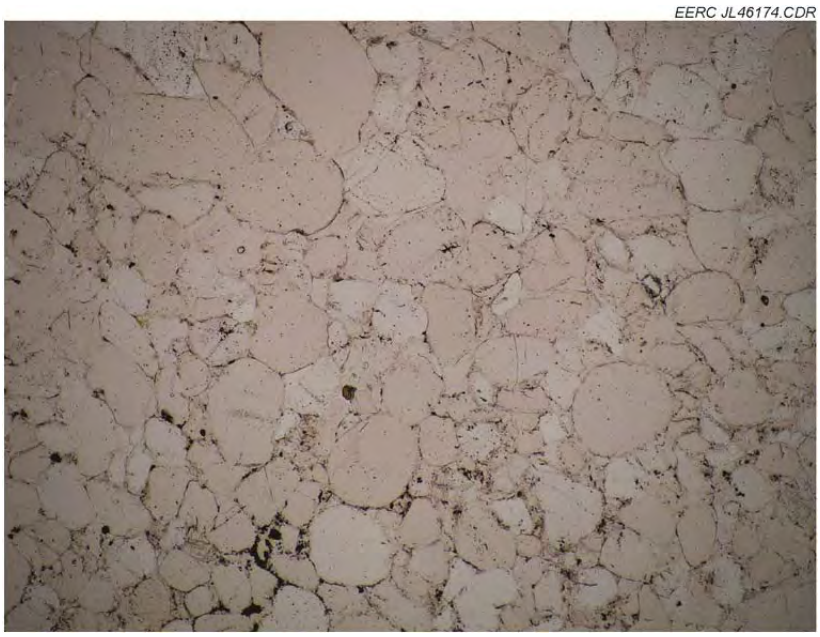



Figure 15. Photomicrograph of a Black Island Formation thin section representing very tightly packed sandstone composed primarily of quartz displaying no porosity. Sample S-00933 was obtained from Well 12596 at 14,802 ft and imaged at 50× magnification under plane-polarized light.

**Porosity Determinations**

Porosity determinations were produced utilizing two methods: gas pycnometry and thin-section point-counting analysis. In this study, six samples were found to be suitable for preparation using this technique. These six samples all came from the Deadwood Formation within the depth interval of 9440–9475 ft (see Table 3). All but three samples had porosity estimates made through point counting of thin sections as part of petrographic analysis. Three black shales from the Icebox and Black Island Formations were not analyzed using this technique because of the tight fabric characteristic in shales. Shale grains are typically smaller than 30 µm (standard thin-section thickness), which leads to limitations in observing porosity and grain assemblages. All of the porosity estimates obtained through the point-counting technique on thin-section microphotographs are presented in Table 4 and Appendix A.

Resulting thin-section porosity estimates range from none observed to 21%, and gas pycnometer-derived effective porosity within the Deadwood Formation reservoir ranges from ~3% to ~17%. In general, these types of discrepancies in porosity demonstrate the heterogeneous nature of these samples. The variety of energy environments observed in the sample set accounts for the observed ranges in porosity.

**Table 3. Gas Pycnometer-Derived Effective Porosity of Core Plug Samples of Deadwood Formation Obtained from NDIC Well 17467**

| Sample ID | Depth, ft | Mass, g | Skeletal Density, g/cm$^3$ | Effective Porosity, % |
|---|---|---|---|---|
| S-00768 | 9440.1 | 80.0 | 2.724 | 3.71 |
| S-00769 | 9443.1 | 85.7 | 2.850 | 3.24 |
| S-00773 | 9450.3 | 81.9 | 2.755 | 4.81 |
| S-00772 | 9459.2 | 70.4 | 2.680 | 4.36 |
| S-00771 | 9462.1 | 71.7 | 2.617 | 14.70 |
| S-00770 | 9473.2 | 66.1 | 2.654 | 16.84 |

**Table 4. Porosity Estimated Through Point-Counting Method on Thin-Section Microphotographs**

| Sample ID | NDIC Well | Depth, ft | Estimated Porosity, % | Porosity Type(s) |
|---|---|---|---|---|
| S-00925 | 6264 | 6086.0 | 21.0 | Intergranular/cement dissolution |
| S-00926 | 6264 | 6113.0 | 2.0 | Vuggy/fracture |
| S-00927 | 6264 | 6114.5 | 14.0 | Intergranular/cement dissolution |
| S-00928 | 6264 | 6126.5 | 3.0 | Intergranular/moldic |
| S-00929 | 6264 | 6165.0 | 12.8 | Intergranular |
| S-00768 | 17467 | 9440.1 | NO[1] | Fracture |
| S-00769 | 17467 | 9443.1 | NO | None observed |
| S-00773 | 17467 | 9450.3 | NO | None observed |
| S-00772 | 17467 | 9459.3 | 4.6 | Fracture |
| S-00771 | 17467 | 9462.1 | 10.4 | Intergranular |
| S-00770 | 17467 | 9473.2 | 13.6 | Intergranular |
| S-00930 | 9257 | 11,789.5 | 4.6 | Fracture/cement dissolution |
| S-00931 | 9257 | 11,832.5 | 0.4 | Fracture |
| S-00932 | 9257 | 11,858.5 | 0.6 | Fracture |
| S-00774 | 9800 | 13,995.0 | NT[2] | – |
| S-00775 | 9800 | 14,012.0 | NT | – |
| S-00933 | 12596 | 14,802.0 | NO | None observed |
| S-00934 | 12596 | 14,831.0 | NT | – |

[1] None observed.
[2] Not tested.

### Permeability to Water

Six core plug samples were tested using a flexible-wall permeameter at near-ambient-pressure conditions. Table 5 presents the permeability-to-water values measured for the six depths, which were subsequently correlated to the gas pycnometer porosity measurements. Four

**Table 5. Permeability to Water of Deadwood Formation Core Plug Samples Obtained from NDIC Well 17467**

| Sample ID | Depth, ft | Length, cm | Diameter, cm | Permeability, mD |
|---|---|---|---|---|
| S-00768 | 9440.1 | 5.039 | 3.744 | 0.009 |
| S-00769 | 9443.1 | 4.822 | 3.747 | 0.021 |
| S-00773 | 9450.3 | 5.078 | 3.749 | 0.024 |
| S-00772 | 9459.2 | 4.910 | 3.747 | 0.069 |
| S-00770 | 9462.1 | 50.77 | 3.741 | 528.2 |
| S-00771 | 9473.2 | 4.914 | 3.750 | 654.2 |

of the six samples (S-00768, S00769, S-00773, and S-00772) were tight and illustrated little porosity, around 3–4 vol%, which, when compared to data from each respective well file, was within ~1.5 vol%. The other two intervals (S-00771 and S-00770) demonstrated much higher permeability and porosity measurements. These two intervals are representative of a high-energy beach environment, which are known to produce well-sorted and rounded to well-rounded grains. Two of the tight samples (S-00773 and S-00772) are representative of a medium-energy beach environment, which should show similar measured porosity and permeability data; however, the values are drastically different. After analyzing the mineralogy of these samples through thin-section analysis, it was observed that these samples also showed signs of postdepositional dolomitization and other diagenetic changes occurring that included the formation of glauconite. The mineralization of dolomite and glauconite most likely filled the pore space of the previously porous, beach-deposited rock to form a much tighter rock.

### XRD, XRF, and SEM Analysis

The EERC's Natural Materials Analytical Research Laboratory utilizes XRD, XRF, and SEM analyses to identify the mineralogical and chemical composition of materials. The data from these techniques are interpreted in conjunction with one another; for example, XRF and SEM results can serve as a guide to identify mineral phases in XRD diffractograms based on the mineral database searches in the accompanying XRD software. Results from XRF analysis provide bulk chemical compositions of the phases (traditionally reported as oxides), which allows for narrow and targeted searches in the XRD mineral databases, thus enhancing both the efficiency and effectiveness of XRD analysis. SEM analysis was performed to obtain high-resolution, high-magnification BSE images to show the texture and other features of the samples in detail, and more importantly, to obtain quantitative data on the concentrations (wt%) of the different elements present.

A summary of the SEM, XRD, and XRF results is presented in Table 6 (detailed analysis by sample is presented in Appendix A). The major and minor mineral phases identified by XRD, with refinement using SEM and XRF, are presented in decreasing order of presence. Quantitative XRF results are usually reported for a select set of most commonly encountered mineral-forming elements and are reported as the corresponding oxide in wt%. The results greater than 1 wt% as an oxide are provided in decreasing order in Table 6, as these are most likely to include the chemicals noted in the SEM and XRD results. Complete XRF chemical compositions, XRD diffractograms, and examples of SEM images are presented in Appendix B.

**Table 6. Summary of SEM Analysis, Quantitative-Phase XRD Analysis, and XRF Chemical Composition Results**

| ID | Formation | Depth, ft | SEM Phases | XRD Phases | wt% | XRF Results as Oxides[1] | wt% |
|---|---|---|---|---|---|---|---|
| S-00925 | Black Island | 6086.0 | Quartz | Quartz | 88.1 | $SiO_2$ | 81.67 |
| | | | K-feldspar | Amorphous | 8.1 | Unknowns[2] | 9.52 |
| | | | Pyrite | Sanidine | 2.4 | $Al_2O_3$ | 1.74 |
| | | | Sodium sulfate | Calcite | 1.0 | $Fe_2O_3$ | 1.30 |
| | | | Anorthite | Dolomite | 0.5 | | |
| S-00926 | Deadwood | 6113.0 | Dolomite | Dolomite | 52.4 | $SiO_2$ | 36.26 |
| | | | Glauconite | Amorphous | 25.5 | CaO | 19.71 |
| | | | Quartz | Quartz | 8.4 | Unknowns | 14.20 |
| | | | K-feldspar | Sanidine | 8.2 | $Fe_2O_3$ | 10.21 |
| | | | Pyrite | Illite | 5.5 | MgO | 7.42 |
| | | | Apatite | | | $K_2O$ | 4.95 |
| | | | | | | $Al_2O_3$ | 4.89 |
| | | | | | | $SO_3$ | 1.48 |
| S-00927 | Deadwood | 6114.5 | Quartz | Quartz | 63.5 | $SiO_2$ | 70.84 |
| | | | Anhydrite | Dolomite | 25.6 | CaO | 8.00 |
| | | | Dolomite (Fe-rich) | Sanidine | 8.2 | $Al_2O_3$ | 5.45 |
| | | | Zircon | Illite | 2.8 | $K_2O$ | 3.70 |
| | | | K-feldspar | | | MgO | 3.66 |
| | | | Illite | | | Unknowns | 3.57 |
| | | | Iron oxide (hematite) | | | $Fe_2O_3$ | 3.29 |
| S-00928 | Deadwood | 6126.5 | Calcite | Quartz | 39.3 | $SiO_2$ | 53.82 |
| | | | Quartz | Calcite | 37.6 | CaO | 32.70 |
| | | | Pyrite | Amorphous | 10.7 | Unknowns | 5.34 |
| | | | Dolomite | Dolomite | 7.7 | $Al_2O_3$ | 2.23 |
| | | | K-feldspar | Sanidine | 3.5 | $K_2O$ | 1.74 |
| | | | Illite | Illite | 1.2 | $Fe_2O_3$ | 1.71 |
| | | | Anhydrite | | | $SO_3$ | 1.15 |
| | | | | | | MgO | 1.01 |
| S-00929 | Deadwood | 6165.0 | Quartz | Quartz | 63.9 | $SiO_2$ | 79.66 |
| | | | Apatite | Microcline | 17.2 | $Al_2O_3$ | 8.23 |
| | | | K-feldspar | Amorphous | 11.5 | $K_2O$ | 4.56 |
| | | | Zircon | Sanidine | 5.2 | Unknowns | 2.76 |
| | | | | Illite | 2.2 | $Fe_2O_3$ | 1.99 |

[1] Only XRF results greater than 1 wt% as an oxide are shown. All values are provided in Appendix B on a per sample basis.

[2] Unknowns include all elements that XRF does not analyze, such as carbon and oxygen, which are part of carbonates.

[3] Not tested.

Continued…

**Table 6. Summary of SEM Analysis, Quantitative-Phase XRD Analysis, and XRF Chemical Composition Results (continued)**

| ID | Formation | Depth, ft | SEM Phases | XRD Phases | wt% | XRF Results as Oxides[2] | wt% |
|---|---|---|---|---|---|---|---|
| S-00768 | Deadwood | 9440.1 | NT[3] | Quartz | 37.0 | $SiO_2$ | 59.52 |
| | | | | Dolomite | 27.9 | CaO | 11.44 |
| | | | | Amorphous | 12.7 | Unknowns | 6.34 |
| | | | | Microcline | 9.6 | $Al_2O_3$ | 6.16 |
| | | | | Illite | 7.9 | $Fe_2O_3$ | 5.80 |
| | | | | Sanidine | 5.1 | $K_2O$ | 4.72 |
| | | | | | | MgO | 4.42 |
| S-00769 | Deadwood | 9443.1 | NT | Dolomite | 73.2 | CaO | 33.27 |
| | | | | Quartz | 12.2 | $SiO_2$ | 22.35 |
| | | | | Amorphous | 8.5 | Unknowns | 21.41 |
| | | | | Illite | 5.1 | MgO | 8.57 |
| | | | | Calcite | 0.9 | $Fe_2O_3$ | 8.42 |
| | | | | | | $Al_2O_3$ | 2.42 |
| | | | | | | $K_2O$ | 2.01 |
| S-00930 | Black Island | 11,789.5 | Illite | Quartz | 61.9 | $SiO_2$ | 79.34 |
| | | | Quartz | Amorphous | 28.4 | $Al_2O_3$ | 7.28 |
| | | | Halite | Calcite | 3.7 | CaO | 3.34 |
| | | | Calcite | Illite | 2.8 | Unknowns | 3.18 |
| | | | Pyrite | Microcline | 1.8 | $Fe_2O_3$ | 2.02 |
| | | | Rutile | Kaolinite | 1.3 | $K_2O$ | 1.64 |
| | | | | | | Cl | 1.34 |
| S-00931 | Deadwood | 11,832.5 | Quartz | Quartz | 32.3 | $SiO_2$ | 60.25 |
| | | | Dolomite | Illite | 22.7 | $Al_2O_3$ | 14.78 |
| | | | K-feldspar | Amorphous | 18.5 | CaO | 5.76 |
| | | | Apatite | Dolomite | 13.8 | $K_2O$ | 5.66 |
| | | | Illite | Microcline | 1.3 | Unknowns | 4.51 |
| | | | | Kaolinite | 0.9 | MgO | 3.72 |
| | | | | Calcite | 0.5 | $Fe_2O_3$ | 3.42 |
| S-00932 | Deadwood | 11,858.5 | Calcite | Calcite | 49.1 | CaO | 48.36 |
| | | | Dolomite | Dolomite | 21.8 | $SiO_2$ | 23.01 |
| | | | Pyrite | Amorphous | 15.3 | Unknowns | 14.66 |
| | | | Illite | Quartz | 7.6 | $Al_2O_3$ | 4.47 |
| | | | Wollastonite | Illite | 3.7 | MgO | 3.08 |
| | | | | Microcline | 0.5 | $K_2O$ | 2.44 |
| | | | | | | $Fe_2O_3$ | 2.12 |

[1] Only XRF results greater than 1 wt% as an oxide are shown. All values are provided in Appendix B on a per sample basis.

[2] Unknowns include all elements that XRF does not analyze, such as carbon and oxygen, which are part of carbonates.

[3] Not tested.

Continued…

**Table 6. Summary of SEM Analysis, Quantitative-Phase XRD Analysis, and XRF Chemical Composition Results (continued)**

| ID | Formation | Depth, ft | SEM Phases | XRD Phases | wt% | XRF Results as Oxides[2] | wt% |
|---|---|---|---|---|---|---|---|
| S-00774 | Icebox | 13,995.0 | NT | Kaolinite | 28.8 | $SiO_2$ | 53.21 |
| | | | | Amorphous | 20.3 | $Al_2O_3$ | 28.63 |
| | | | | Quartz | 18.2 | Unknowns | 6.05 |
| | | | | Illite | 12.3 | $Fe_2O_3$ | 4.55 |
| | | | | Muscovite | 12.0 | MgO | 1.31 |
| | | | | Microcline | 6.8 | $TiO_2$ | 1.00 |
| | | | | Anatase | 1.5 | | |
| S-00775 | Icebox | 14,012.0 | NT | Quartz | 36.3 | $SiO_2$ | 57.88 |
| | | | | Kaolinite | 20.3 | $Al_2O_3$ | 25.74 |
| | | | | Illite | 13.8 | Unknowns | 5.26 |
| | | | | Muscovite | 12.4 | $Fe_2O_3$ | 4.48 |
| | | | | Amorphous | 9.0 | $K_2O$ | 3.42 |
| | | | | Microcline | 3.6 | MgO | 1.27 |
| | | | | Sanidine | 3.2 | $TiO_2$ | 1.02 |
| | | | | Anatase | 1.4 | | |
| S-00933 | Black Island | 14,802.0 | Quartz | Quartz | 100 | $SiO_2$ | 84.89 |
| | | | Pyrite | | | Unknowns | 10.27 |
| | | | Illite | | | $Fe_2O_3$ | 1.72 |
| | | | Rutile | | | $Al_2O_3$ | 1.59 |
| | | | Ankerite | | | | |
| S-00934 | Black Island | 14,831.0 | Pyrite | Quartz | 42.4 | $SiO_2$ | 61.15 |
| | | | Quartz | Illite | 26.0 | $Al_2O_3$ | 22.17 |
| | | | Kaolinite | Kaolinite | 21.5 | $Fe_2O_3$ | 5.83 |
| | | | Zircon | Amorphous | 6.8 | $K_2O$ | 3.63 |
| | | | Rutile | Microcline | 3.3 | Unknowns | 3.41 |
| | | | Illite | | | MgO | 1.52 |
| | | | | | | $TiO_2$ | 1.20 |

[1] Only XRF results greater than 1 wt% as an oxide are shown. All values are provided in Appendix B on a per sample basis.
[2] Unknowns include all elements that XRF does not analyze, such as carbon and oxygen, which are part of carbonates.
[3] Not tested.

Mineralogical results of XRD, XRF, and SEM demonstrate the heterogeneous nature of the rock within the wells sampled. As shown in Table 7, the total clay content ranged from 0% to 53%, with shale (the two Icebox and one Black Island Formation) samples showing the highest clay content, in the range of 46% to 53%.

XRD clay analysis was performed on five samples to determine the types of clay present in the samples because it can be difficult to distinguish between clay types with conventional XRD methods. In Table 7, the K-feldspar category includes microcline and sanidine while the total

**Table 7. Conventional XRD K-Feldspar and Total Clay Groupings, wt%**

| ID | Formation | Depth, ft | K-Feldspars | Total Clays |
|---|---|---|---|---|
| S-00925 | Black Island | 6086.0 | 2.4 | 0.0 |
| S-00926 | Deadwood | 6113.0 | 8.2 | 5.5 |
| S-00927 | Deadwood | 6114.5 | 8.2 | 2.8 |
| S-00928 | Deadwood | 6126.5 | 3.5 | 1.2 |
| S-00929 | Deadwood | 6165.0 | 22.4 | 2.2 |
| S-00768 | Deadwood | 9440.1 | 14.6 | 7.9 |
| S-00769 | Deadwood | 9443.1 | 0.0 | 5.1 |
| S-00930 | Black Island | 11,789.5 | 1.8 | 4.1 |
| S-00931 | Deadwood | 11,832.5 | 1.3 | 23.6 |
| S-00932 | Deadwood | 11,858.5 | 2.5 | 3.7 |
| S-00774 | Icebox | 13,995.0 | 6.8 | 53.1 |
| S-00775 | Icebox | 14,012.0 | 6.7 | 46.5 |
| S-00933 | Black Island | 14,802.0 | 0.0 | 0.0 |
| S-00934 | Black Island | 14,831.0 | 3.3 | 51.9 |

clays include kaolinite, illite, and chlorite. The three shale samples, which contained the highest amounts of clays, were evaluated with this technique to identify the types of clays in greater detail. In addition to the kaolinite identified through the conventional XRD method, biotite and some mixed smectite layers were identified in the two Icebox Formation samples. The Black Island Formation shale was evaluated by XRD, clay-typing XRD, and SEM. The clays noted were kaolinite, biotite, chlorite, and illite.

Two Deadwood Formation samples from Well 17467 (S-00768 from 9440.1 ft and S-00769 from 9443.1 ft) were also analyzed by XRD clay analysis since they had 8% and 5% total clay indicated by contentional XRD analysis. Few or no clay structures were noted in these samples by XRD clay typing, which is contrary to the results obtained from optical microscope observations. The photomicrographs viewed in plane-polarized light showed distinct grains that were believed to be glauconite: a clay and an iron potassium phyllosilicate (mica group) mineral with a characteristic green color. Deadwood Formation Sample S-00926 (Well 6264, depth 6113.0 ft) showed a greater amount of glauconite present in the optical microscope observations than these samples and contained nearly 6% total clays. Although glauconite can be easily identified using optical microscopy, a decision was made to study Sample S-00926 as the representative sample to verify and confirm glauconite's presence by quantitative microanalysis using SEM.

The identification of glauconite through XRD is complicated because it has chemistry similar to K-feldspar and illite clays and has very fine crystals that have diffraction patterns similar to amorphous minerals. In addition, the glauconite peak in diffractograms (if at all present) will appear at the same location as illite peaks, thus making it difficult to resolve. In this work, further optical microscope investigations revealed that glauconite is microcrystalline, which explains the difficulty of detecting it by XRD analysis. However, quantifying the chemical composition of the mineral using EDS in SEM offers a means to differentiate between glauconite

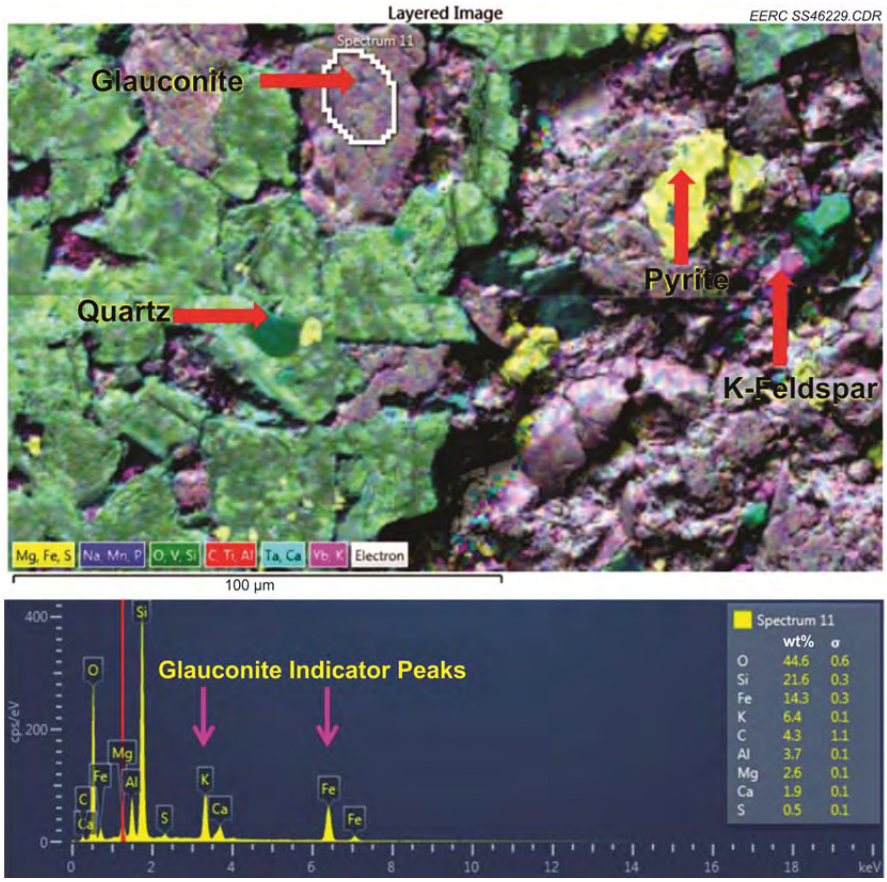



Figure 16. Mineral map of Sample S-00926 showing both texture and occurrence of glauconite and other mineral phases.

and other minerals with similar chemistries. The mineral phase circled in Figure 16 is identified as glauconite, as its spectrum shows the characteristic iron and potassium peaks. Most potassium-rich minerals like illite and K-feldspars often contain trace to minor amounts of iron. Based on the quantified chemistry shown in the upper right insert of the spectrum, the high iron content in the absence of sulfur, which would have been a pyrite, was helpful in concluding that the mineral phase is glauconite. The relative amounts of the different elements vary and provide a means to differentiate the mineral phases. This interpretation is consistent with results obtained on other glauconite samples that were found in the literature (Thompson and Hower, 1975; Bentor and Kastner, 1965).

SEM BSE images can be used to identify mineral phases present in minute amounts, such as the apatite shown in Figure 17. The crystalline signal for this was likely too weak to identify through XRD.

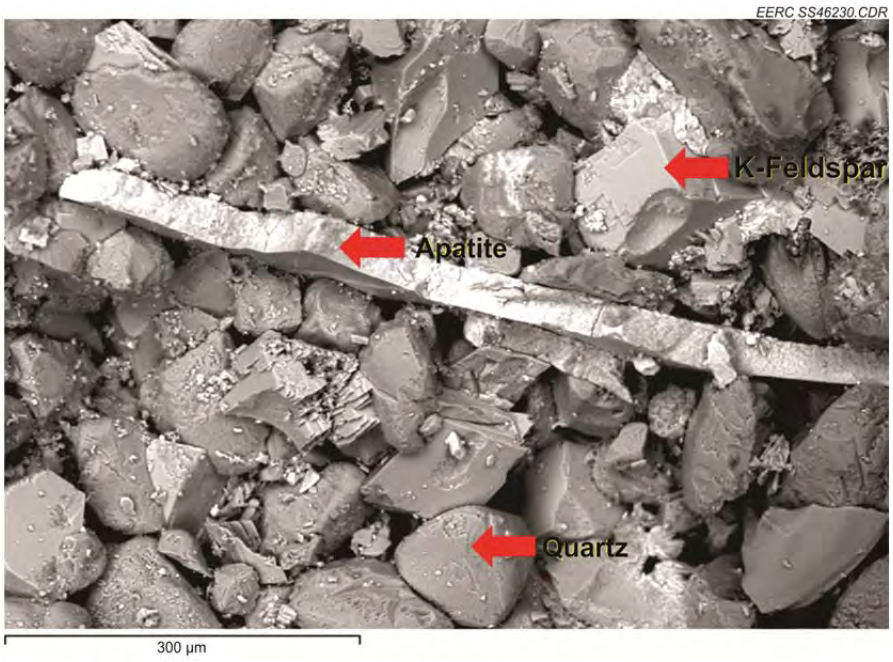



Figure 17. SEM BSE image of S-00929 showing large quartz and K-feldspar grains with an apatite sheet embedded in the rock.

## SUMMARY

Several analytical techniques and the petrographic thin-section analysis method were employed to characterize 18 Cambro-Ordovician rock samples from the Deadwood, Black Island, and Icebox Formations. Table 8 provides a summary of the energy and depositional environments, porosity, and permeability for the samples.

Depositional and energy environments were classified for each sample based on mineralogy fabric and assemblages. The samples analyzed from the Cambro-Ordovician represented a marginal marine and marine environment. The presence of minerals such as glauconite and dolomite, noted by examination of the thin sections and confirmed through XRD and SEM analysis, indicates there was postdepositional secondary mineral formation, most likely due to fluid chemistry changes over time within the sample area.

The energy environments ranged from low to high within the sample set and were interpreted to represent beach, lagoonal, shallow shelf, and deep marine environments. This high variability is consistent with depositional environments previously interpreted for the Cambro-Ordovician system.

Porosity determinations were produced utilizing two methods: gas pycnometry and point-counting analysis. Six Deadwood Formation samples were found to be suitable for gas pycnometry. Porosity estimations through thin-section point-counting analysis were conducted

**Table 8. Summary of Petrograhic Properties Determined for the Deadwood, Black Island, and Icebox Formations**

| Sample ID | NDIC Well | Depth, ft | Energy Environment | Depositional Environment | Thin-Section Point-Counting Porosity, % occurrence | Permeability, mD |
|---|---|---|---|---|---|---|
| S-00925 | 6264 | 6086.0 | High | Beach | 21.0 | NT[1] |
| S-00926 | 6264 | 6113.0 | Low–medium | Shallow shelf | 2.0 | NT |
| S-00927 | 6264 | 6114.5 | Low–medium | Beach | 14.0 | NT |
| S-00928 | 6264 | 6126.5 | Medium–high | Beach | 3.0 | NT |
| S-00929 | 6264 | 6165.0 | Low–medium | Beach | 12.8 | NT |
| S-00768 | 17467 | 9440.1 | Medium | Beach | NO[2] | 0.009 |
| S-00769 | 17467 | 9443.1 | Low–medium | Lagoonal | NO | 0.021 |
| S-00773 | 17467 | 9450.3 | Medium | Shallow shelf/beach | NO | 0.024 |
| S-00772 | 17467 | 9459.3 | Medium | Beach | 4.6 | 0.069 |
| S-00771 | 17467 | 9462.1 | High | Beach | 10.4 | 654 |
| S-00770 | 17467 | 9473.2 | High | Beach | 13.6 | 528 |
| S-00930 | 9257 | 11,789.5 | High | Beach | 4.6 | NT |
| S-00931 | 9257 | 11,832.5 | Low | Lagoonal | 0.4 | NT |
| S-00932 | 9257 | 11,858.5 | Low–medium | Shallow shelf | 0.6 | NT |
| S-00774 | 9800 | 13,995.0 | Low | Marine | NT[2] | NT |
| S-00775 | 9800 | 14,012.0 | Low | Marine | NT | NT |
| S-00933 | 12596 | 14,802.0 | Medium–high | Beach | NO | NT |
| S-00934 | 12596 | 14,831.0 | Low | Marine | NT | NT |

[1] Not tested.
[2] None observed.

on samples other than the black shales. Thin-section porosity estimates range from not observed to 21%, and gas pycnometer-derived effective porosity ranged from ~3% to ~17%. Water permeability results ranged 0.009 to 654 mD. In general, these types of discrepancies in porosity and permeability show the heterogeneous nature of these samples.

XRD, XRF, and SEM techniques were used in conjunction to identify mineral phases present in the rock samples. The results demonstrated the heterogeneous nature of the rock within the wells. The three shale samples showed the highest clay content, in the range of 46%–53%, which is consistent with the rocks being very fine-grained shale. The samples identified as silty dolostone through thin-section interpretation typically showed higher weight percentages of dolomite by XRD. The sandstone samples generally had high-weight-percentage quartz identified. Glauconite, which is difficult clay to identify with XRD, was identified through SEM and thin-section petrographic analysis.

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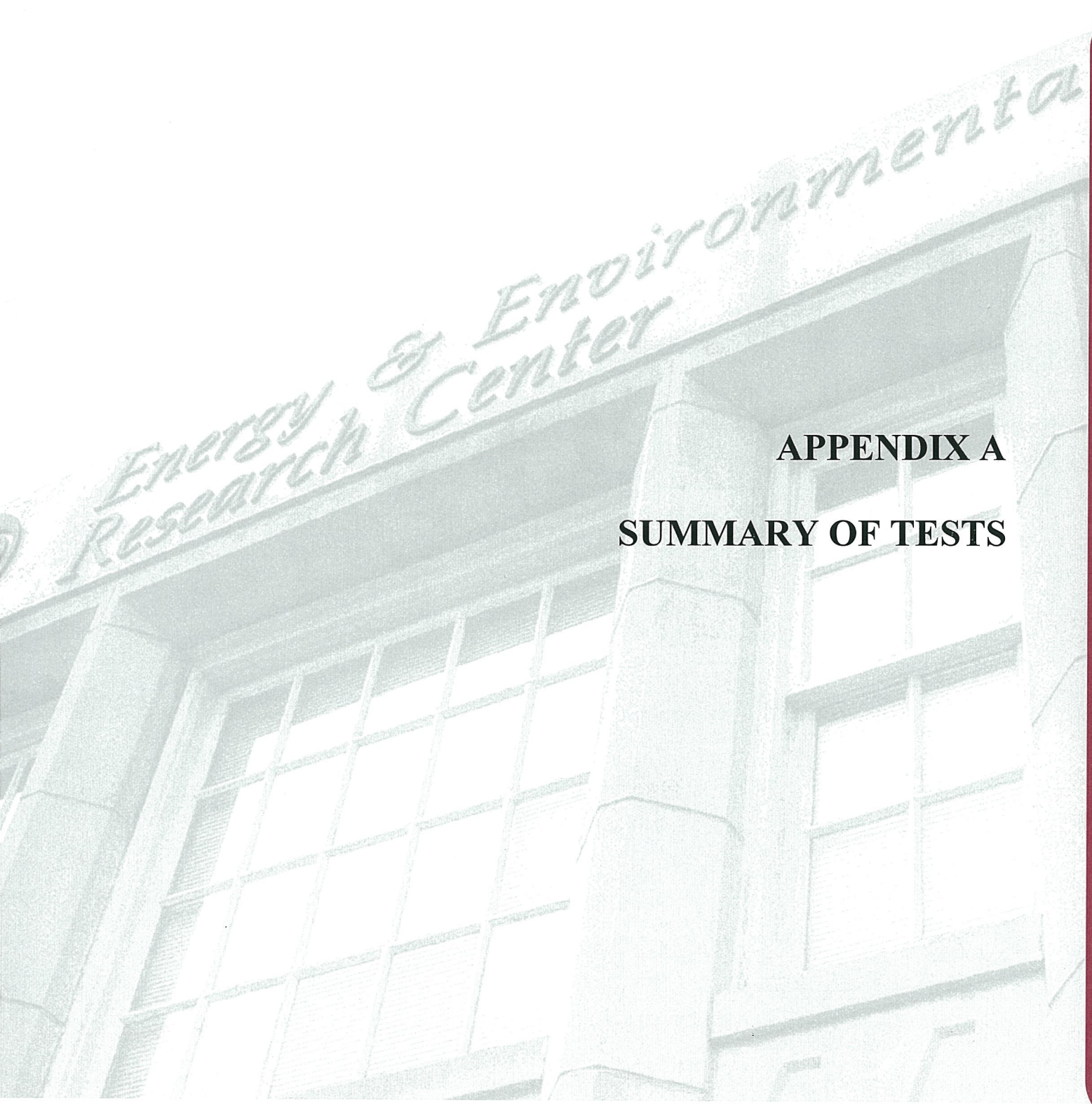
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# APPENDIX A

# SUMMARY OF TESTS

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# SUMMARY OF TESTS

## THIN-SECTION PRODUCTION AND RELATED ANALYSES

Thin sections were prepared by Wagner Petrographic. Samples were assigned an identification number, then trimmed to fit a microscope slide. The samples were dried at 150°F and casted in blue-dyed epoxy under vacuum. Samples were flattened/polished on a 125-μm lap wheel and taken progressively to 10 μm using finer grits. Each sample was placed on a microscope slide; after the curing process, the sample was cut off. Cut-off slides were thinned and finished on a lap wheel to 6 μm. At this point, Alizarin red and potassium ferricyanide stains were applied to aid in the identification of calcite and ferrous minerals.

The thin sections were analyzed and photographed using a petrographic microscope. Mineralogical assemblages and prevalence were determined and estimated through the use of standard optical techniques utilizing a combination of plane-polarized and cross-polarized light. Photomicrographs were produced at 50× and 100× magnification with plane- and cross-polarized light. Additional photographs depicting specific features were also collected.

Porosity measurements were quantified by utilizing point-counting software (JMicroVision Version 1.27). A random grid of 500 points per sample was determined and classified as rock or pore. Point counting was completed on a full-scale scan of the whole thin section to present the most representative analysis of the sample.

## EFFECTIVE POROSITY ON SIX CORE PLUGS

Samples were cleaned through a Soxhlet/Dean–Stark extraction process. Toluene was used as the agent to extract water and oil. The samples were distilled for a minimum of 48 hours or until water was no longer accumulating in the condenser. After no increase in water volume occurred for 24 hours, the sample was allowed to air-dry in the fume hood. Next, the sample was dried in an oven at 240°F for 24 hours or until the weight of the sample stabilized.

Prior to porosity testing, bulk volume was determined. Suitable sample size and geometry are required to determine accurate bulk volume for effective porosity measurements using gas pycnometry. Samples with irregular or undefined geometries are not suitable for this measurement. Dried plug samples were evaluated for bulk volume with a digital caliper. Three measurements for length and three measurements for diameter were averaged for calculation of bulk volume. Dry sample mass was measured and divided by bulk volume to calculate bulk density.

Effective porosity testing was performed using a gas pycnometer, which exposes a known volume of gas to a chamber containing the dry sample. The test produces measurement of grain volume, which enables the porosity calculation when compared with bulk volume.

## PERMEABILITY TO WATER ON SIX CORE PLUGS

Permeability-to-water measurements were taken using a flexible-wall permeameter. The permeameter data interpreted with Darcy's law can be used to calculate the flow rate of a fluid through a sample. The apparatus uses a flexible sleeve to cover the rock, which helps control the flow through the sample. Confining pressure is applied to the outside of the sleeve containing the rock sample. The flexible-wall permeameter can accept samples up to 4 inches long with a diameter of 1–1.5 inches. Accurate measurements of mass, length, and diameter are taken of samples pre- and postwater exposure. With the sample in the sleeve, constant head pressure is applied to the lowest face of the sample. Once the system has reached a steady state of flow, volume measurements are taken over a span of time that is sample-specific. Measurements are dictated by the flow rate and volume of the flexible-wall permeameter. Results are reported in millidarcies (mDs).

## X-RAY FLUORESCENCE ANALYSIS

X-ray fluorescence (XRF) is a technique that is used to measure the bulk elemental composition of samples. The device allows semiquantitative and quantitative determinations of elements with atomic numbers of 6 to 92 (i.e., carbon to uranium), with accuracies down to the ppm level (typically reported as wt%). Quantitative results are usually reported for a select set of most commonly encountered mineral-forming elements, including Si, Al, Fe, Ti, P, Ca, Mg, Na, K, and S, and are reported as the corresponding oxide in wt%. Semiquantitative results are typically used to aid in the mineral searches during x-ray diffraction (XRD) analysis. Although XRF by itself cannot distinguish elemental arrangements, it excels at detecting products of trace minerals, elemental replacement, and small concentrations of elements that may be found in accessory minerals.

## X-RAY DIFFRACTION MINERALOGICAL ANALYSIS

Mineralogical analysis was conducted on powdered core fragments by use of a Bruker S8 Advance XRD. This device records crystal lattice patterns providing semiquantitative determination of sample mineralogy and elemental and mineralogical phases. Samples were prepared by reducing a portion of the bulk sample in a percussion mill, followed by grinding into a powder using a micronizing mill. The sample was then dried and prepared as a randomly oriented powdered XRD sample.

The DIFFRAC$^{plus}$ EVA software system, by Bruker AXS, was used to remove the background and Kα2 peaks from the diffraction pattern and identify the crystalline phases. The software accessed the PDF-2 database to perform an automated search for phases that matched peaks in the diffraction pattern. Imported XRF data were used to guide the operator in choosing elements to filter, typically using the highest elemental concentrations from the XRF data during the early stages of searching followed by lower concentration elements to account for smaller peaks. The existence of amorphous phases and the nature of semiquantitative XRD analysis will not provide complete closure between XRF and XRD results but is used to ensure that phases are

not misidentified. After this, a Rietveld quantitative phase analysis was performed using whole-pattern general least-squares refinement to quantify mineral constituents.

### *XRD Clay Typing*

Oriented clay XRD analysis was completed on several samples for determination of detailed clay mineral assemblages. For clay analysis, a decantation method first separated the clay fraction from the silt fraction. An oriented aggregate sample was made from the clay fraction to force platelike particles to lie flat, allowing the incident and diffracted beams to strongly interact with the [*0,0,l*] planes within the clay phases. XRD analysis of these low-angle reflections allowed the direct observation of the spacing between these planes. The gallery layer peak appears at low angles (large d-spacing) and corresponds to reflections from the [*0,0,l*] planes. The amount of asymmetry indicates the possibility of mixed swelling and nonswelling clays. Turbostratic defects, where planes in the crystal structure slip out of alignment, are caused by small variations in the orientation of unit cells to each other. Because these defects are small, there may appear to be broad asymmetry in the [*h,k,0*] plane reflections. These are illustrated in Figure A-1. The degree to which changes in spacing occurred after the sample absorbed ethylene glycol was used to determine whether the clay had a smectite (swelling) component. For a sample with a high concentration of clay, it was possible to identify mixed-layer clays and to determine the ratio between illite group and smectite group layers by following procedures similar to U.S. Geological Survey methodology (Poppe and others, 2001; Środoń, 1980). The glycolation methodology flowchart that defines end member products is presented in Figure A-2.

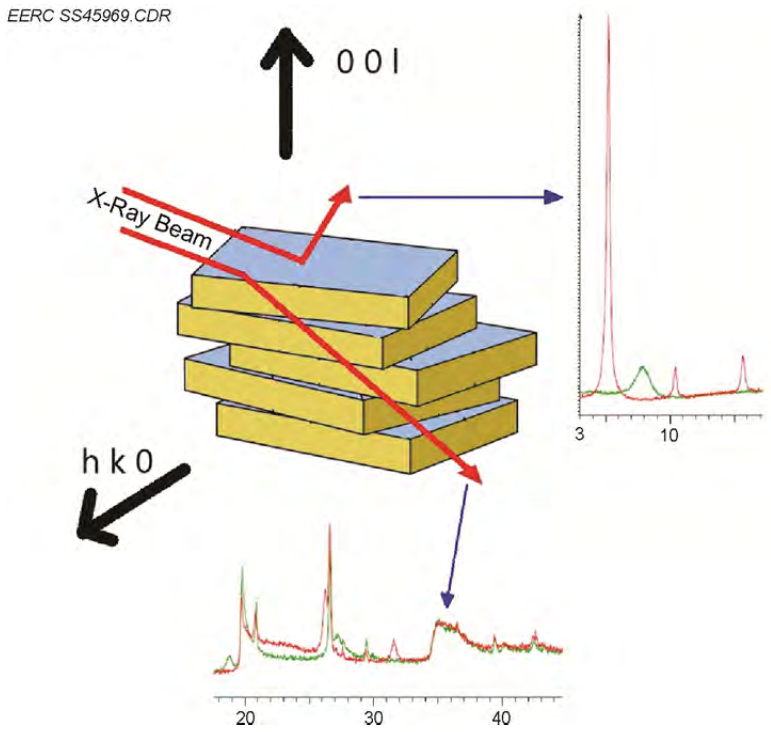



Figure A-1. Illustration to explain the sources of gallery layer peaks and turbostratic asymmetry in XRD patterns of clay-containing samples.

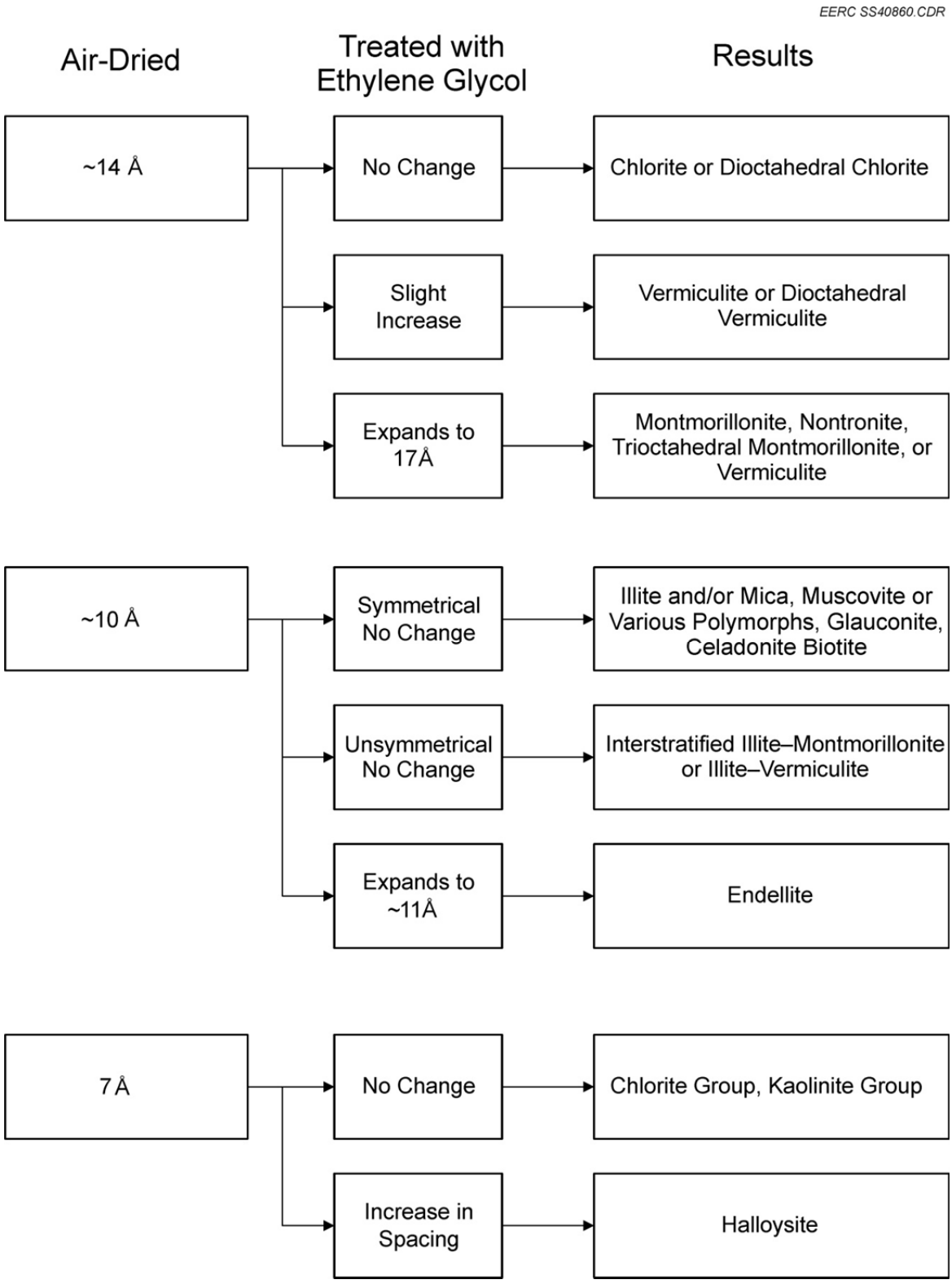



Figure A-2. Glycolation methodology flowchart.

### Scanning Electron Microscopy

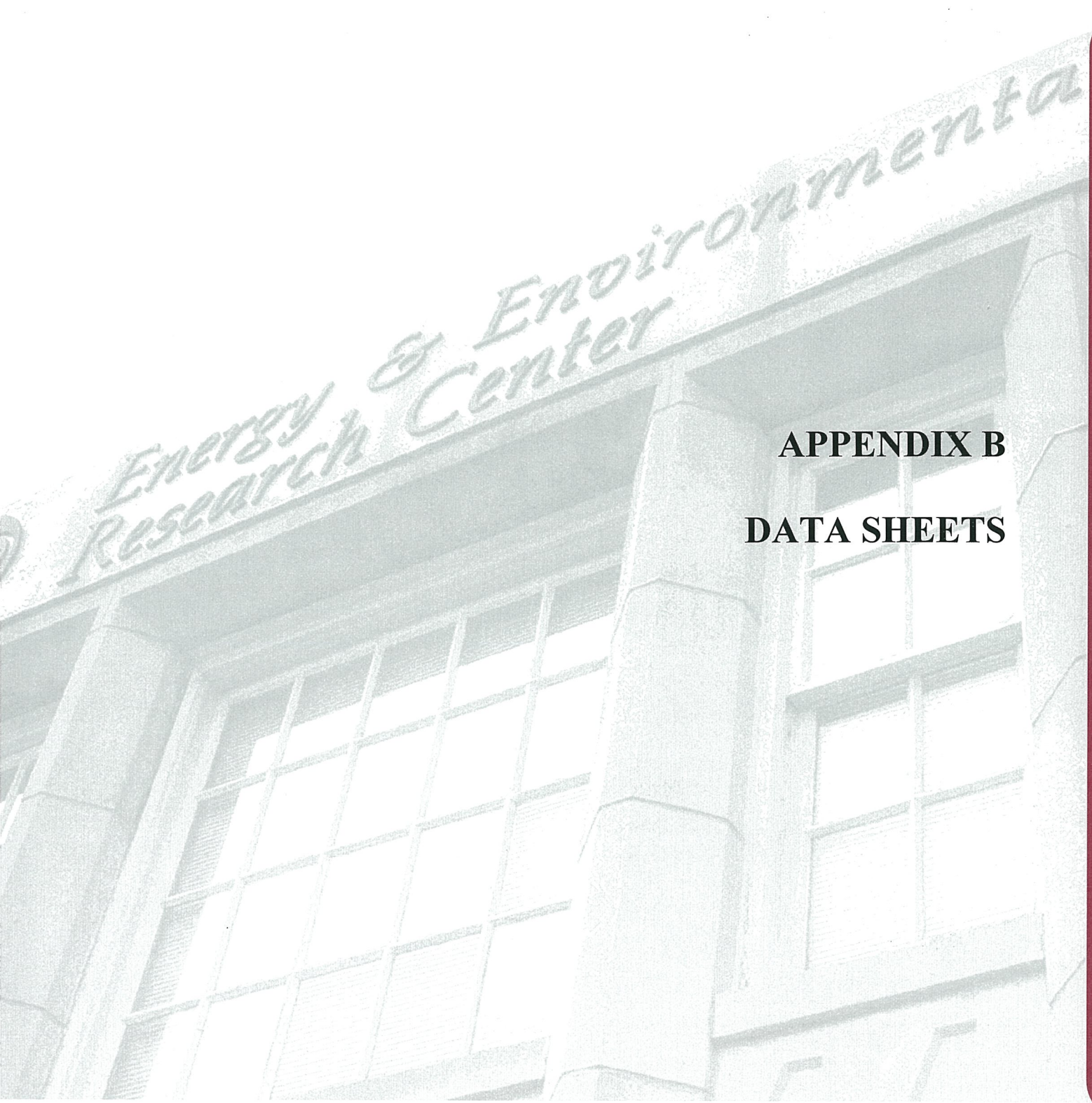
A JEOL 5800LV scanning electron microscope (SEM) equipped with high-speed silicon drift detectors and the accompanying INCA Energy software from Oxford Instruments was used to determine the chemical composition of specific minerals and to generate x-ray mineral maps of the samples. A typical analysis process involves collecting a large number of x-ray counts (50,000–100,000) from the sample at a point for a specific single grain or feature analysis or over a selected area if mineral maps are desired. The quantified elemental composition obtained from specific grain types or feature types is used to determine the type of mineral present based on known standards, with minor adjustments to account for sample-specific variations and/or surface topography effects. Hence, the SEM technique is used to build the mineralogy of a sample from its chemical composition as opposed to standard bulk mineralogy approaches like XRD, which utilize structural features of the different minerals and how these structures diffract x-rays. The SEM technique is particularly attractive because it allows the possibility to use both high-resolution, high-magnification backscatter electron images and x-ray quantitative energy-dispersive spectrometry to collect chemical information on the samples that can be used to build the mineralogy. The SEM technique is advantageous in that it allows for the identification of amorphous substances, such as glauconite, without defined crystals that cannot be characterized using standard XRD techniques.

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# APPENDIX B

# DATA SHEETS

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| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

## SAMPLE PHOTOGRAPH



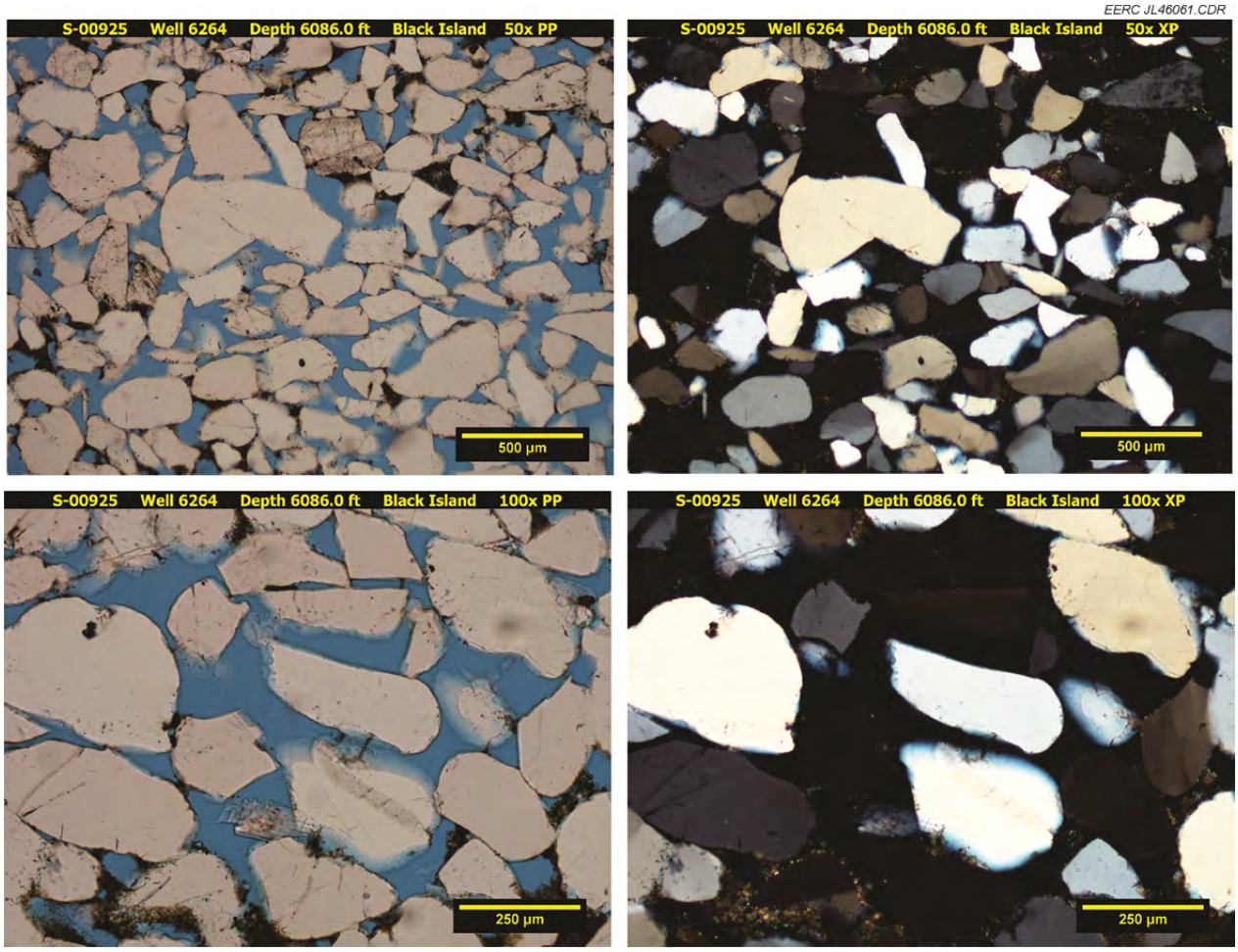

## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT* | NT | NT |

* Not tested. This laboratory technique was not utilized because of sample geometry.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

**PHOTOMICROGRAPHS**




This sample is a clean, fine-grained quartz arenite sandstone displaying no fractures or fossilization. Primary porosity is intergranular while secondary porosity is primarily caused by cement dissolution and small amounts of quartz dissolution. Quartz is weakly cemented, angular to well-rounded, and predominantly monocrystalline. Some quartz overgrowth and compaction are present. Potassium-rich feldspar (K-feldspar), pyrite, clays, and muscovite are minor components.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz and Feldspars | 75.4 | Very weakly cemented, quartz abundantly monocrystalline |
| Clays | 3.6 | |
| Porosity | 21.0 | |

### Texture

| Category | Classification |
|---|---|
| Grain Size, µm | 62–500 |
| Grain-Size Distribution | Very fine to coarse |
| Sorting | Moderately sorted |
| Roundness | Angular to well-rounded |

### Fabric

| Category | Classification |
|---|---|
| Orientation | Weakly |
| Support | Grain, very weakly cemented |
| Packing | Moderate |

### Contacts

| Category | Occurrence |
|---|---|
| Point | Abundant |
| Long | Common |
| Concave–Convex | Rare |
| Sutured | Rare |
| Floating | Very Rare |

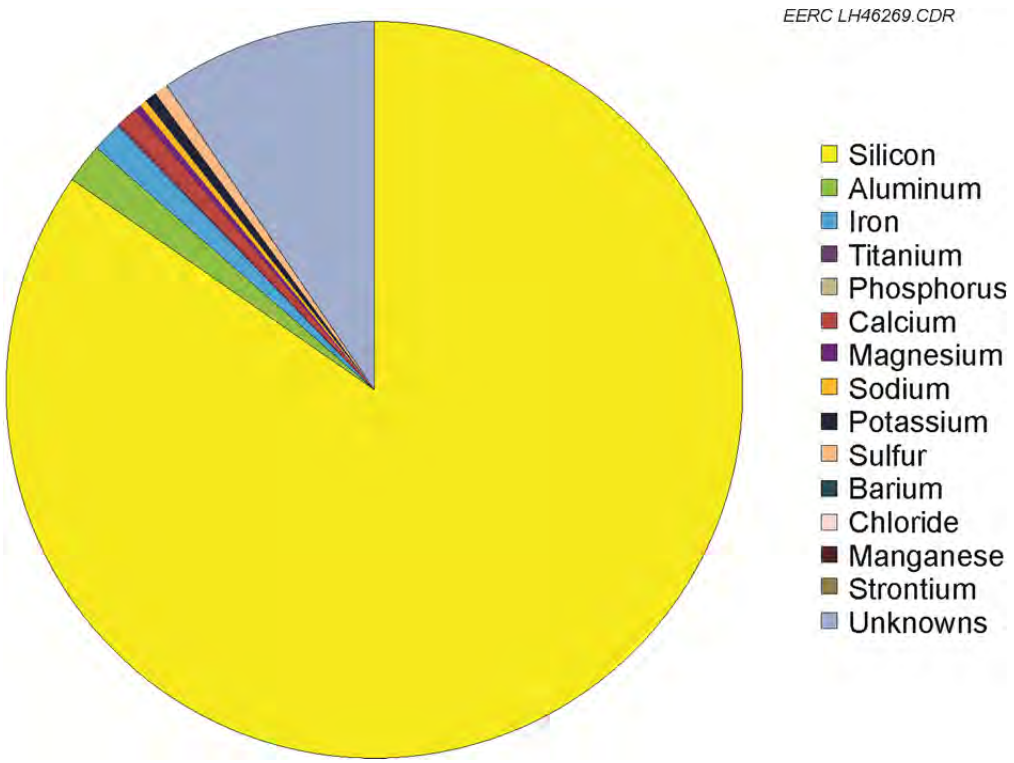
### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Beach |
| Energy Environment | High |
| Dott Classification | Quartz arenite sandstone |
| Dunham Classification | NA* |

* Not applicable.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

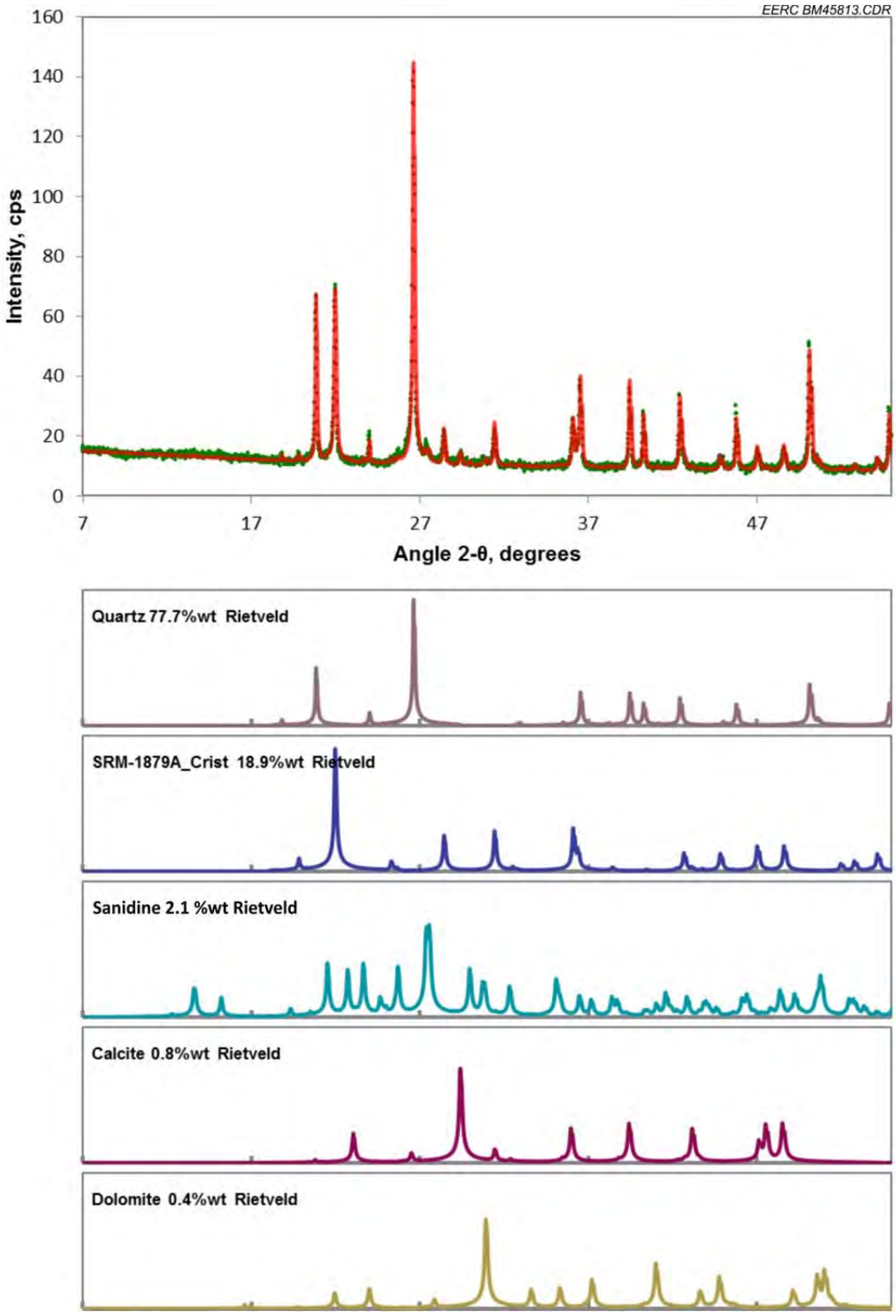
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 84.67 |
| Al (aluminum) | $Al_2O_3$ | 1.74 |
| Fe (iron) | $Fe_2O_3$ | 1.30 |
| Ti (titanium) | $TiO_2$ | 0.11 |
| P (phosphorus) | $P_2O_5$ | 0.00 |
| Ca (calcium) | CaO | 0.91 |
| Mg (magnesium) | MgO | 0.32 |
| Na (sodium) | $Na_2O$ | 0.30 |
| K (potassium) | $K_2O$ | 0.53 |
| S (sulfur) | $SO_3$ | 0.55 |
| Ba (barium) | BaO | 0.01 |
| Cl (chloride) | Cl | 0.03 |
| Mn (manganese) | MnO | 0.00 |
| Sr (strontium) | SrO | 0.01 |
| Unknowns | | 9.52 |
| Total | | 100.00 |

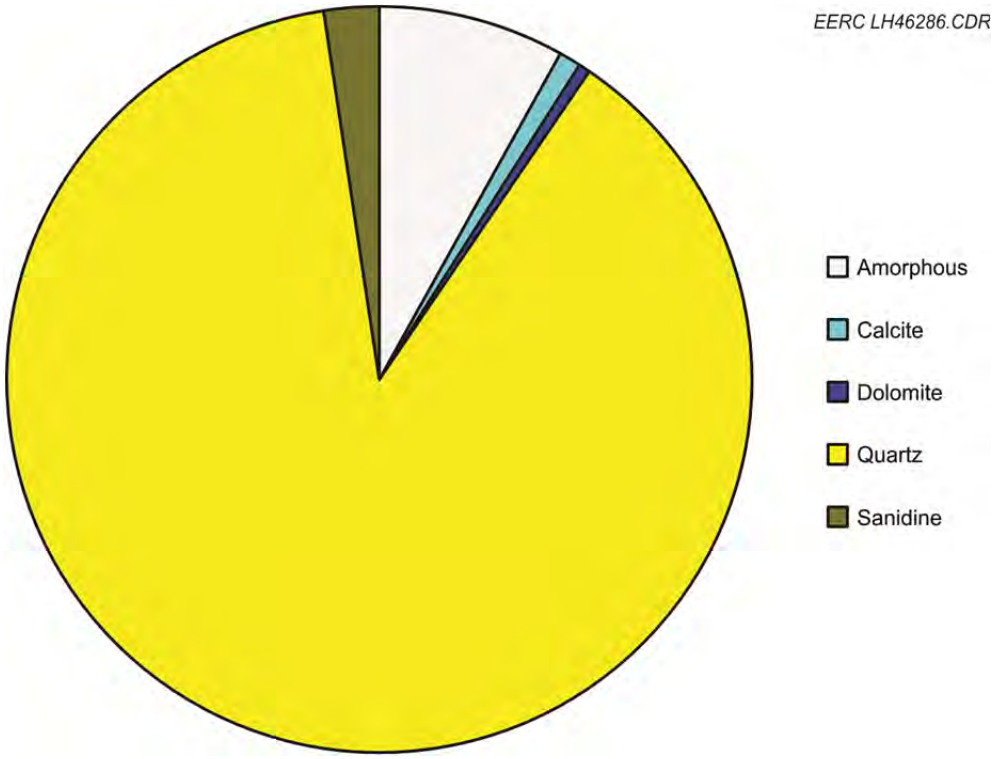
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

**XRD MINERAL ANALYSIS**



| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00926 |
| Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

**XRD Mineral-Phase Distribution**




| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 8.1 | NA* |
| Quartz | $SiO_2$ | 88.1 | 2.65 |
| Sanidine | $NaKAlSi_3O_8$ | 2.4 | 2.55 |
| Calcite | $CaCO_3$ | 1.0 | 2.72 |
| Dolomite | $CaMg(CO_3)_2$ | 0.5 | 2.85 |

* NA indicates not applicable because the amorphous phase is not crystalline.

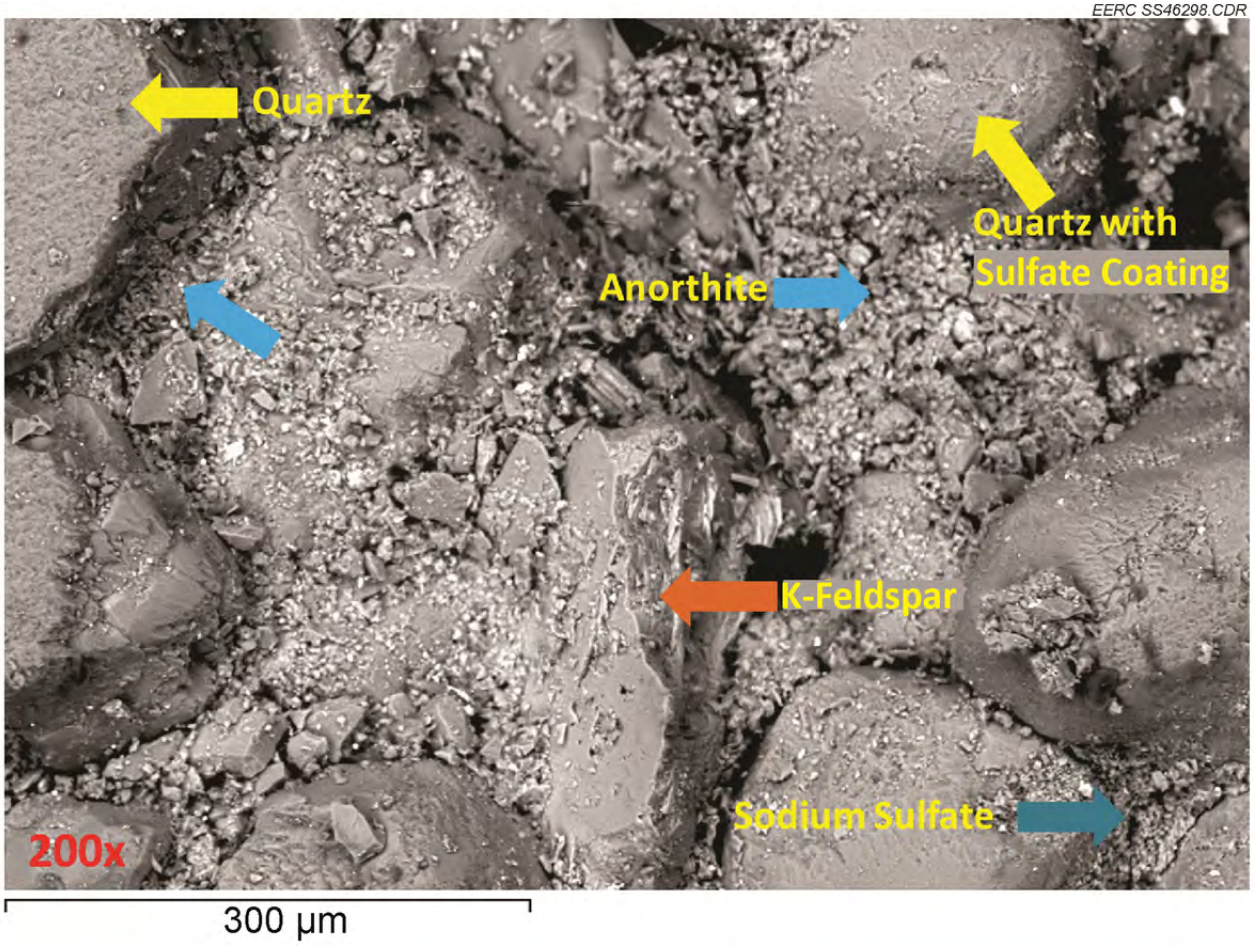
| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

**SCANNING ELECTRON MICROSCOPY (SEM)**

| **Observed Mineral Phases in All SEM Analyses** |
|---|
| Quartz |
| K-Feldspar |
| Pyrite |
| Sodium Sulfate |
| Anorthite |

**Annotated High-Magnification Backscattered Electron (BSE) Image – provides textural and morphological features of the mineral phases observed in the sample**

| | | | |
|---|---|---|---|
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| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |




SEM analysis reveals mixed fine-grain material in the pore spaces, including anorthite and a rare occurrence of sodium sulfate. The major mineral phase found in this sample is quartz, which, in some cases, was found to be coated by sodium sulfate. K-feldspar is also present and consists of large, well-developed grains.

| | | | |
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

## SAMPLE PHOTOGRAPH

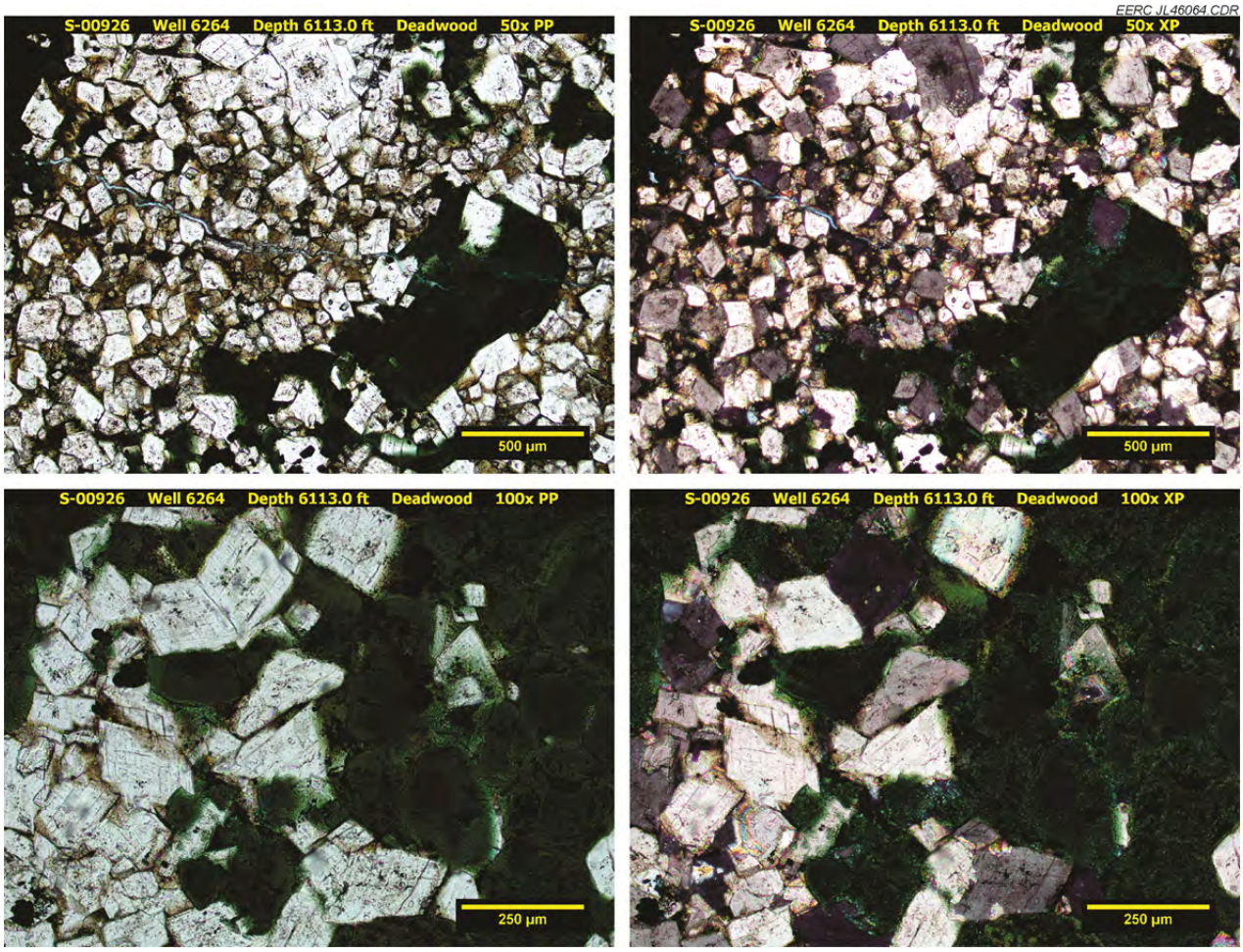



## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

**PHOTOMICROGRAPHS**




This sample is a glauconitic dolostone displaying well-formed dolomite rhombs. Vuggy and fracture porosity types were observed, but porosity is sparse because of the advanced degree of dolomitization. Glauconite concentrations at this well and depth are the greatest of the sample set. No fossils were observed.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

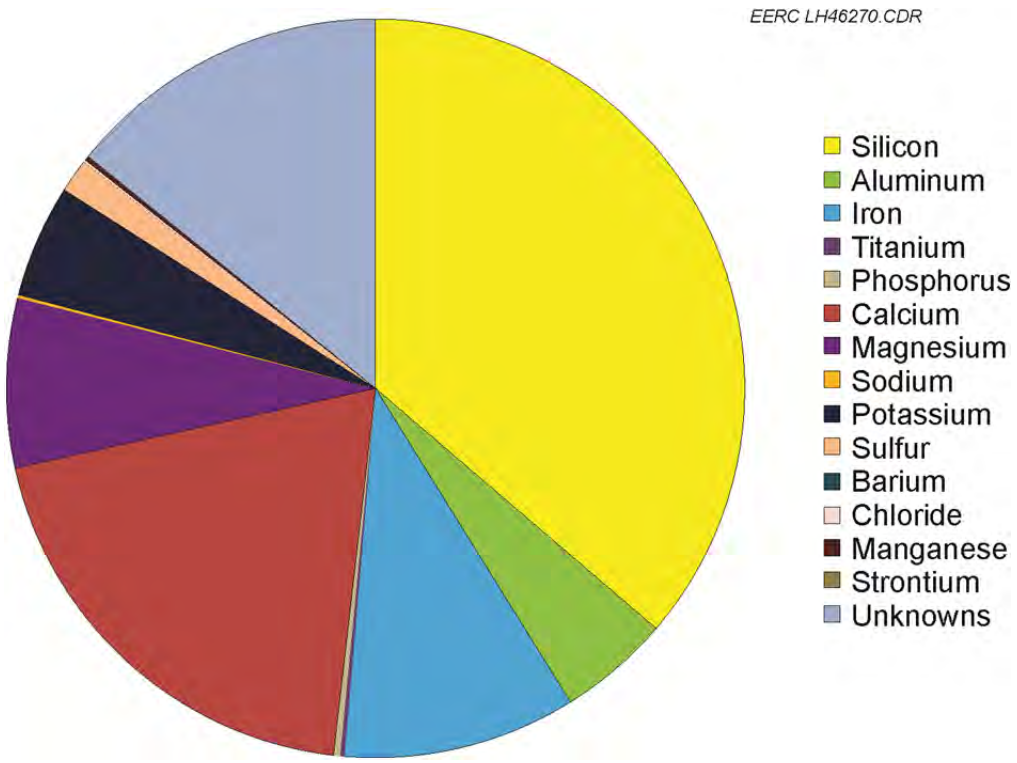
| Assemblage | Percentage | Comments |
|---|---|---|
| Dolomite | 56.4 | Well-formed rhombs |
| Glauconite | 27.2 | Highest concentration |
| Clays | 9.0 | |
| Pyrite | 3.0 | |
| Quartz | 2.4 | |
| Porosity | 2.0 | Vuggy, fracture |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Shallow shelf |
| Energy Environment | Low–medium |
| Dott Classification | NA |
| Dunham Classification | Glauconitic grainstone |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

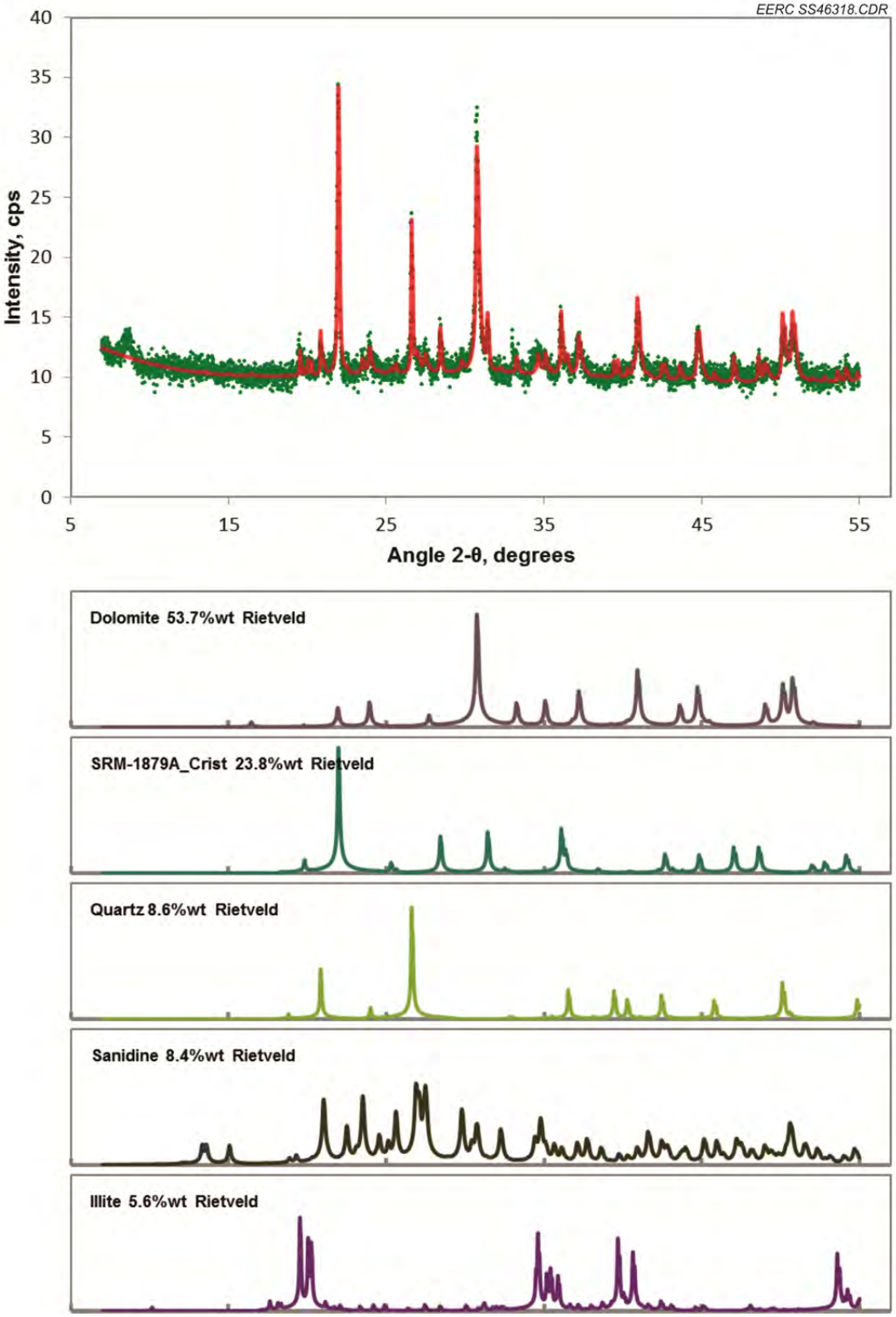
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 36.26 |
| Al (aluminum) | $Al_2O_3$ | 4.89 |
| Fe (iron) | $Fe_2O_3$ | 10.21 |
| Ti (titanium) | $TiO_2$ | 0.19 |
| P (phosphorus) | $P_2O_5$ | 0.28 |
| Ca (calcium) | CaO | 19.71 |
| Mg (magnesium) | MgO | 7.42 |
| Na (sodium) | $Na_2O$ | 0.13 |
| K (potassium) | $K_2O$ | 4.95 |
| S (sulfur) | $SO_3$ | 1.48 |
| Ba (barium) | BaO | 0.01 |
| Cl (chloride) | Cl | 0.08 |
| Mn (manganese) | MnO | 0.19 |
| Sr (strontium) | SrO | 0.01 |
| Unknowns | | 14.20 |
| Total | | 100.00 |

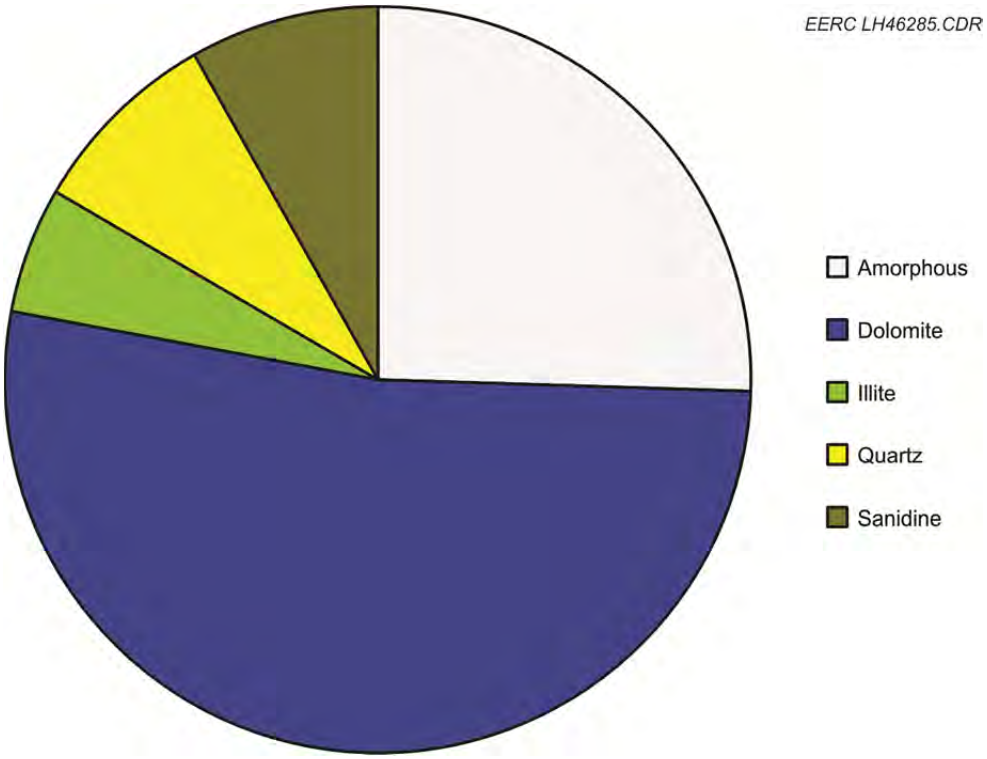
| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00926 |
| Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

## XRD MINERAL ANALYSIS



| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

**XRD Mineral-Phase Distribution**



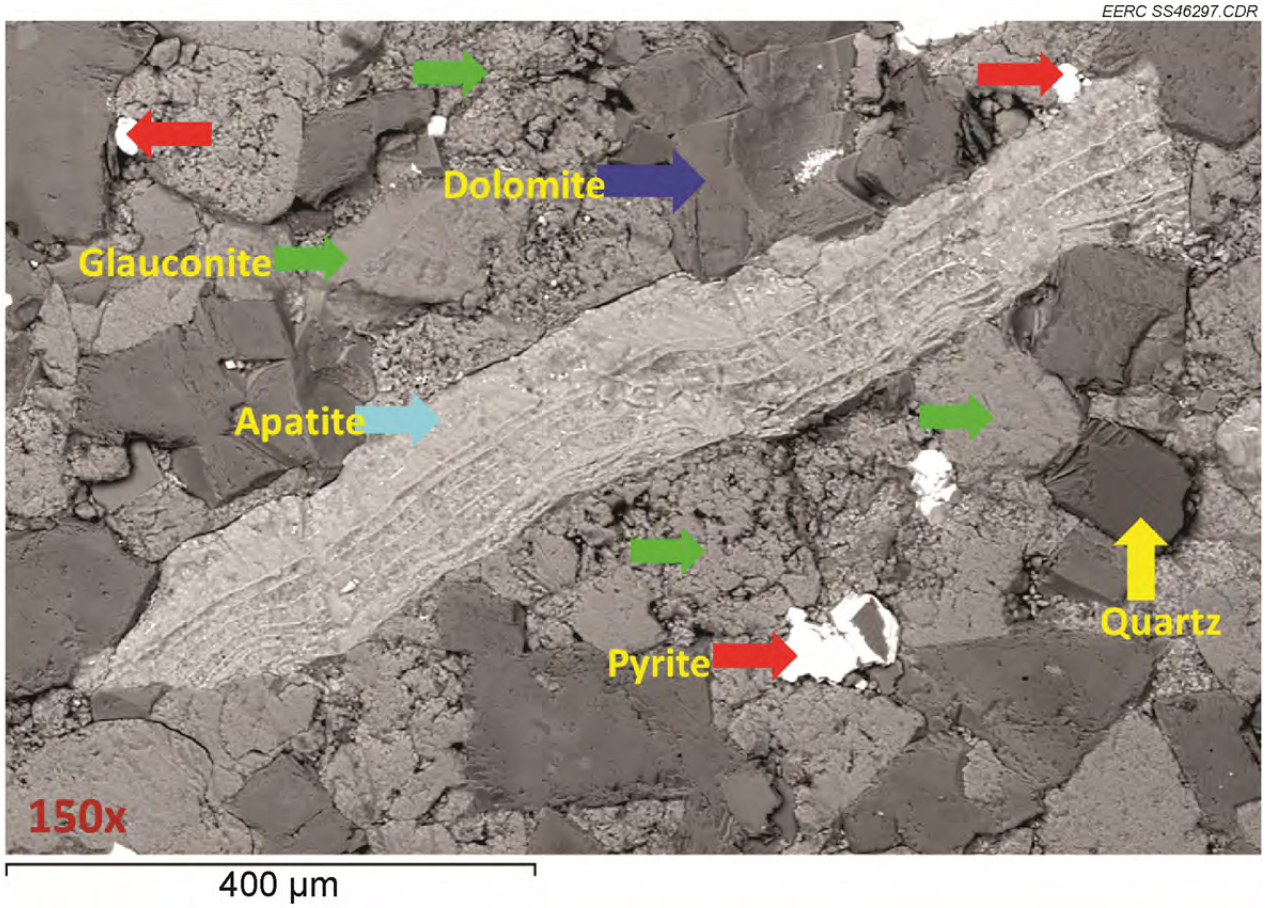

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 25.5 | NA |
| Quartz | $SiO_2$ | 8.4 | 2.65 |
| Dolomite | $CaMg(CO_3)_2$ | 52.4 | 2.82 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 5.5 | 3.27 |
| Sanidine | $NaKAlSi_3O_8$ | 8.2 | 2.54 |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00926 |
| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

**SEM**

| Observed Mineral Phases in All SEM Analyses |
|---|
| Dolomite |
| Glauconite |
| Quartz |
| K-Feldspar |
| Pyrite |
| Apatite |

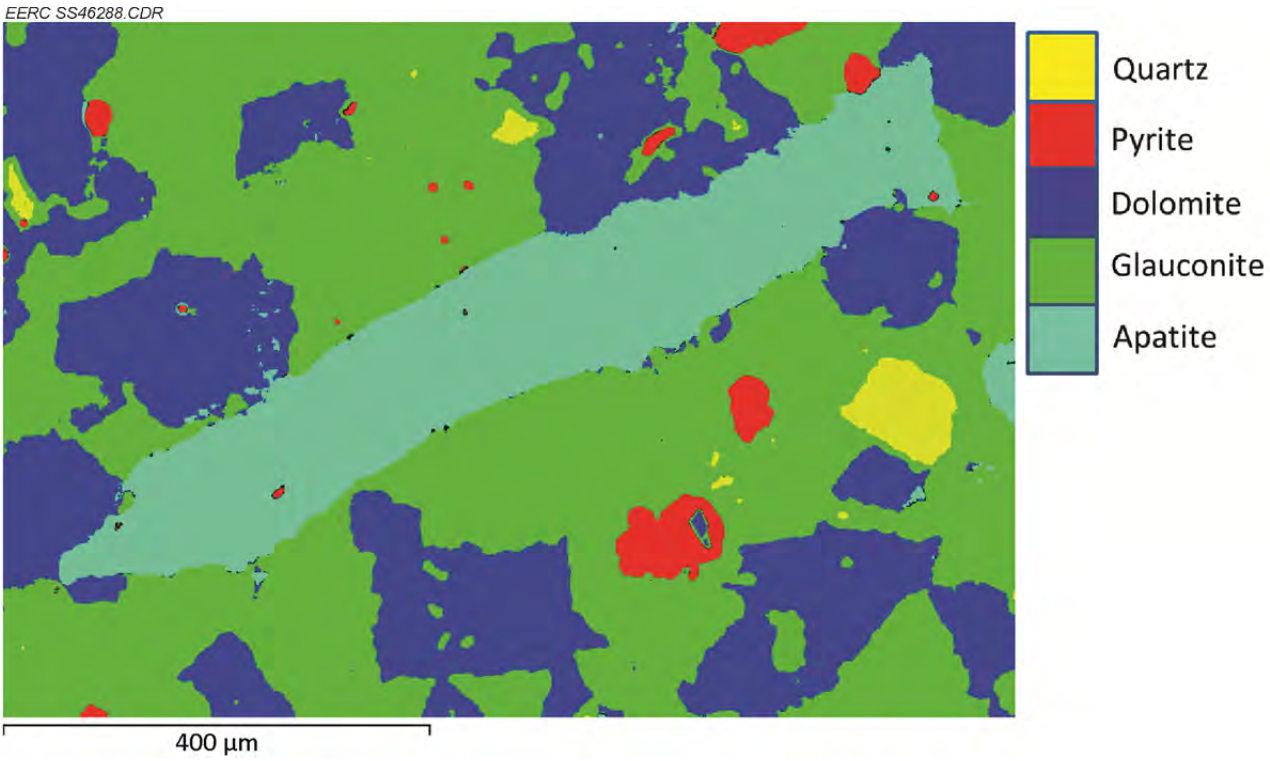
**Annotated High-Magnification BSE Image**




The major phases present include glauconite, dolomite, quartz, apatite, and pyrite. Although a large apatite area is shown in this image, apatite is actually a minor phase in the sample.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00926 |
| Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

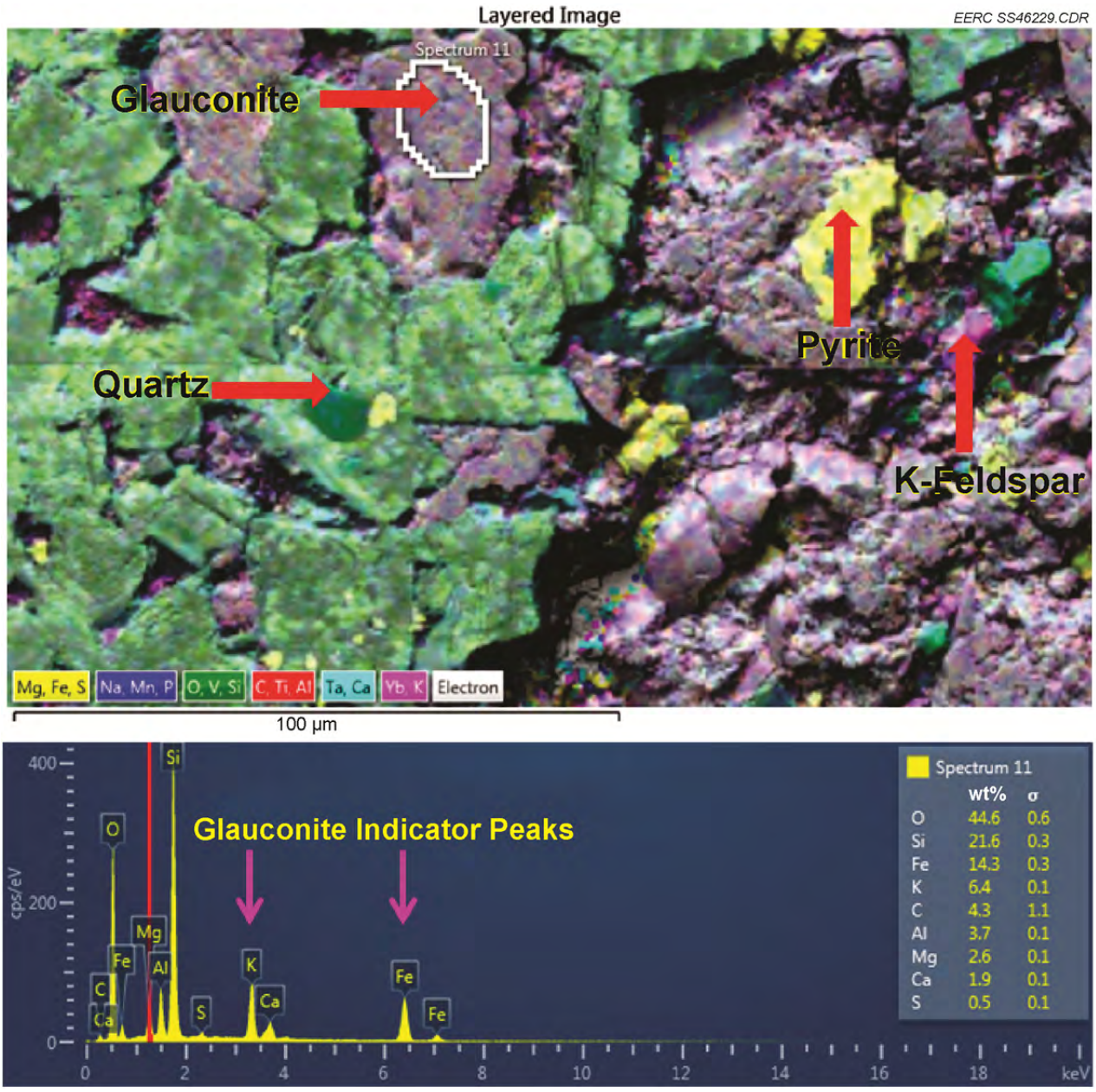
**SEM Digital Mineral Map of a Selected Area on Sample Surface**




The same frame as the BSE image, which provided texture and morphology, is portrayed as a SEM digital mineral map, two-dimensional layout of the mineral phases. The mineral map shows associations and/or inclusions of the phases and quickly conveys information visually about the mineralogy of the sample based on representative areas of the sample.

| | | | |
|---|---|---|---|
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| | Deadwood Formation | Lithology: Dolostone | Depth: 6113.0' |

**Mineral Map Overlain on BSE Image with Spectrum Indicating Glauconite Identification**

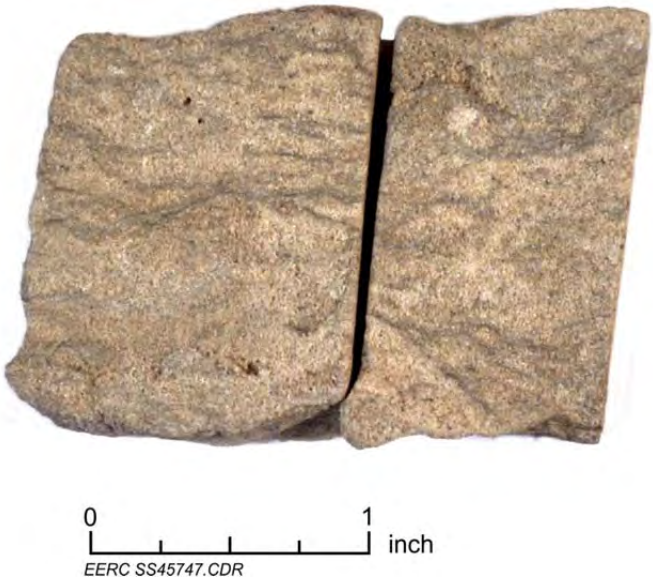



The image shows a mineral map overlain on a BSE image with the different phases observed in this frame. In particular, glauconite (presented as a purplish grey color) is further elucidated by the energy-dispersive spectrum (EDS) shown at the bottom, which displays the characteristic iron and potassium peaks that were used as diagnostic peaks for glauconite identification.

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| | Well Name: NDIC Well 6264 | | ID: S-00927 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |

**SAMPLE PHOTOGRAPH**

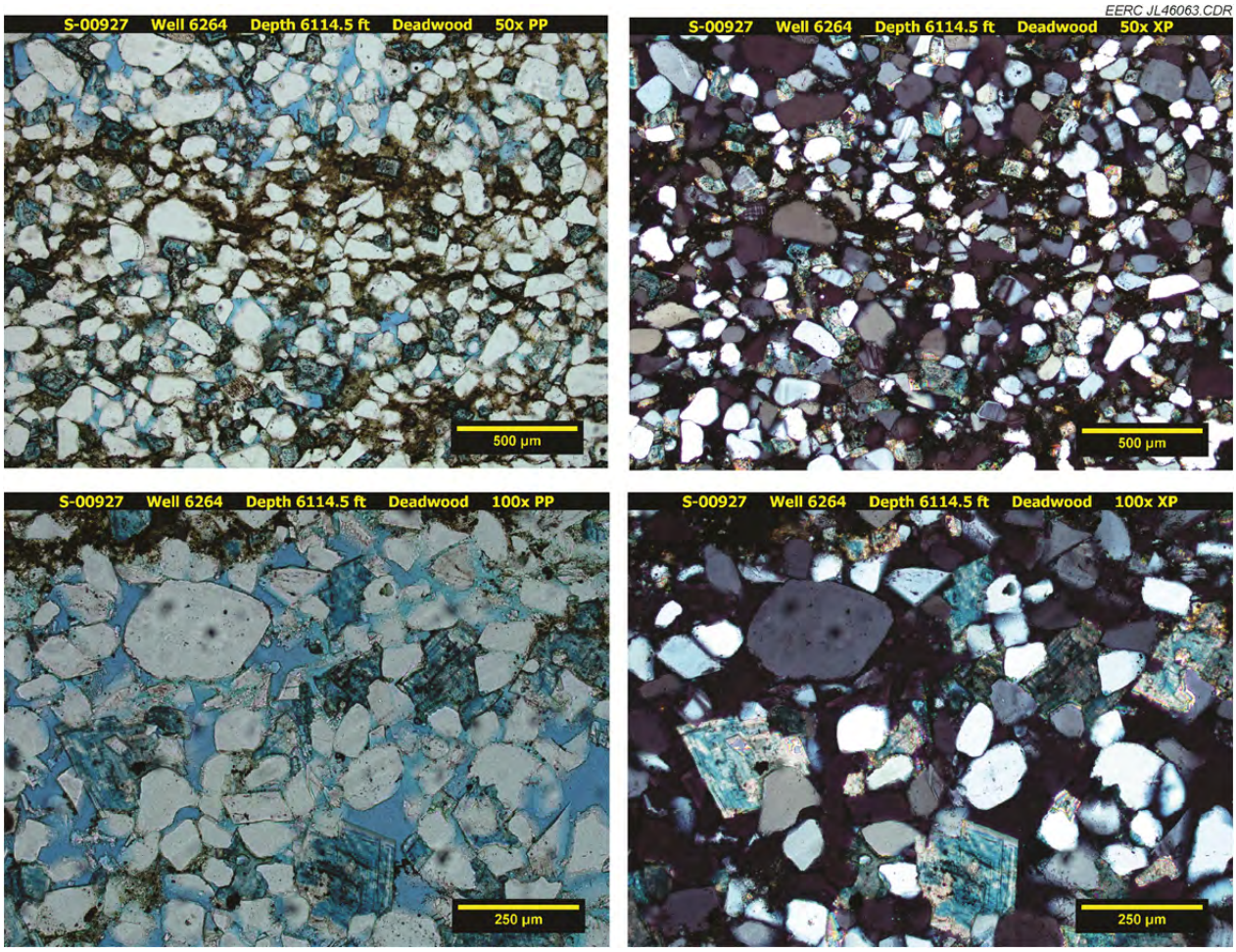



**PHYSICAL PROPERTIES**

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00927 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |

**PHOTOMICROGRAPHS**




This sample is a weakly cemented, fine, dolomitic sandstone displaying ankerite and/or ferroan dolomite. These carbonates have filled in much of the intergranular porosity and secondary cement dissolution porosity. This moderately sorted sample exhibits quartz grains of high and low degrees of grain roundness and sphericity, showing perhaps evidence of different provenance. Evidence of quartz overgrowth and dissolution is present. The clay/cement portion of the sample is charcterized as wavy and erratic oriented laminations. Trace amounts of feldspar and pyrite are observed. No fossils or fractures are observed.

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|---|---|---|---|
| | Well Name: NDIC Well 6264 | | ID: S-00927 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz and Feldspars | 59.0 | Quartz abundantly monocrystalline |
| Dolomite | 12.0 | Rhombohedral |
| Clay | 14.4 | Wavy laminations |
| Pyrite | 0.6 | |
| Porosity | 14.0 | Intergranular, cement dissolution |

### Texture

| Category | Classification |
|---|---|
| Grain Size, µm | 62–500 |
| Grain-Size Distribution | Very fine to coarse |
| Sorting | Moderately sorted |
| Roundness | Angular to well-rounded |

### Fabric

| Category | Classification |
|---|---|
| Orientation | Weakly |
| Support | Grain, very weakly cemented |
| Packing | Moderate |

### Contacts

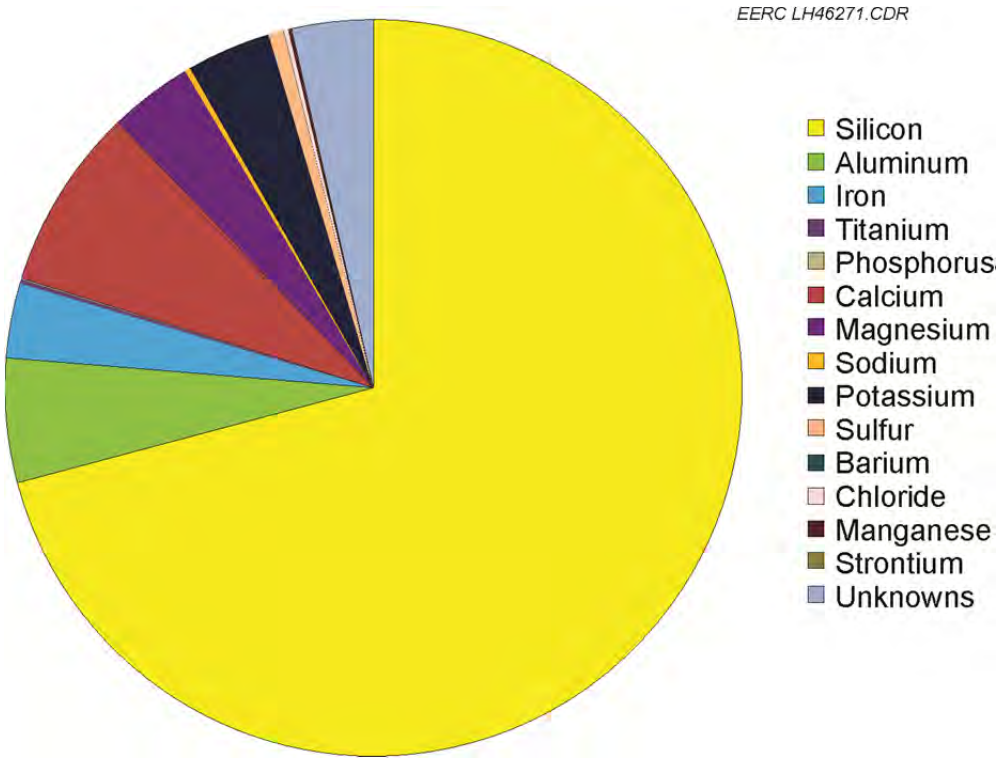
| Category | Occurrence |
|---|---|
| Point | Abundant |
| Long | Common |
| Concave–Convex | Rare |
| Sutured | Rare |
| Floating | Very rare |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Beach |
| Energy Environment | Low–medium |
| Dott Classification | Dolomitic sandstone |
| Dunham Classification | N/A |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00927 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |

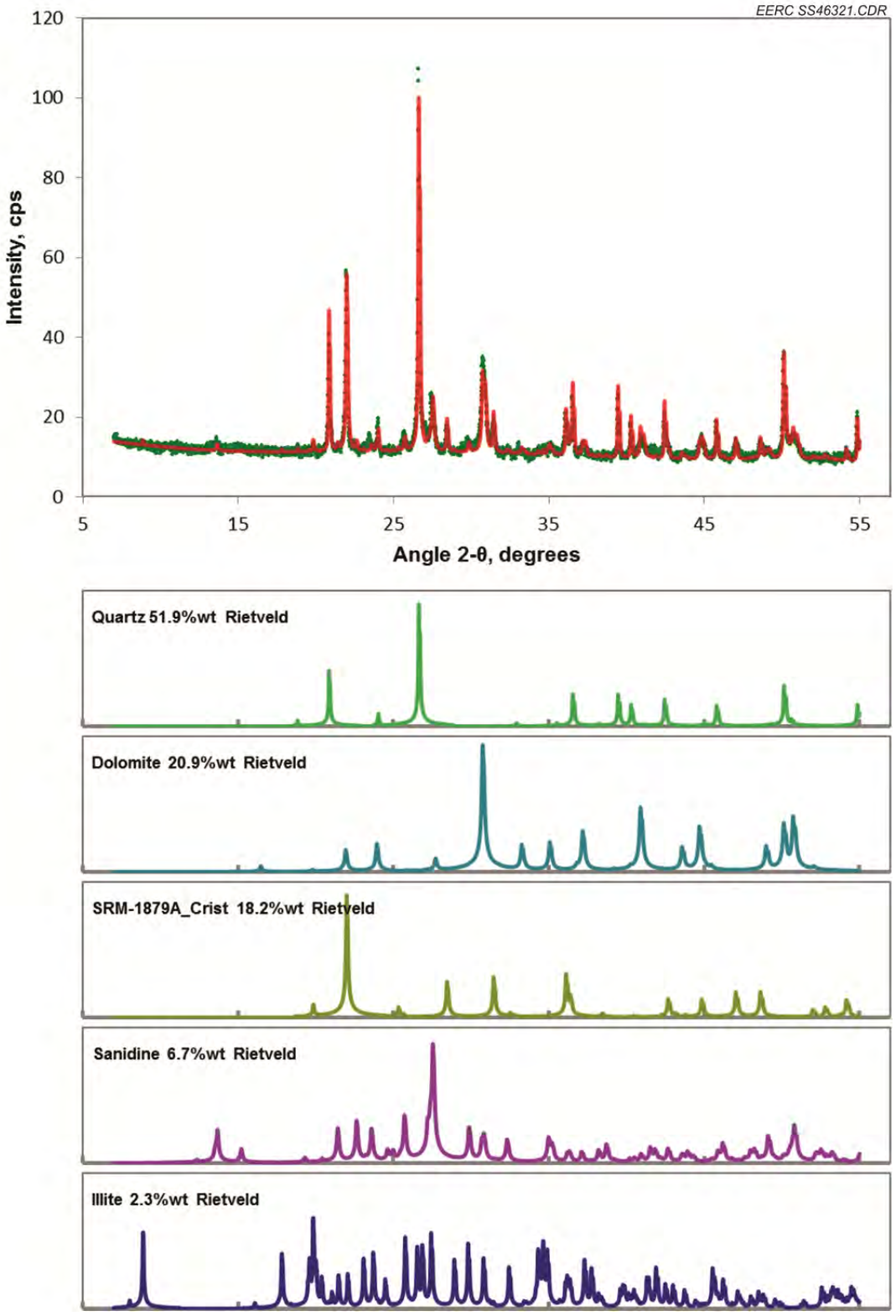
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 70.84 |
| Al (aluminum) | $Al_2O_3$ | 5.45 |
| Fe (iron) | $Fe_2O_3$ | 3.29 |
| Ti (titanium) | $TiO_2$ | 0.19 |
| P (phosphorus) | $P_2O_5$ | 0.03 |
| Ca (calcium) | CaO | 8.00 |
| Mg (magnesium) | MgO | 3.66 |
| Na (sodium) | $Na_2O$ | 0.25 |
| K (potassium) | $K_2O$ | 3.70 |
| S (sulfur) | $SO_3$ | 0.66 |
| Ba (barium) | BaO | 0.03 |
| Cl (chloride) | Cl | 0.19 |
| Mn (manganese) | MnO | 0.13 |
| Sr (strontium) | SrO | 0.01 |
| Unknowns | | 3.57 |
| Total | | 99.99 |

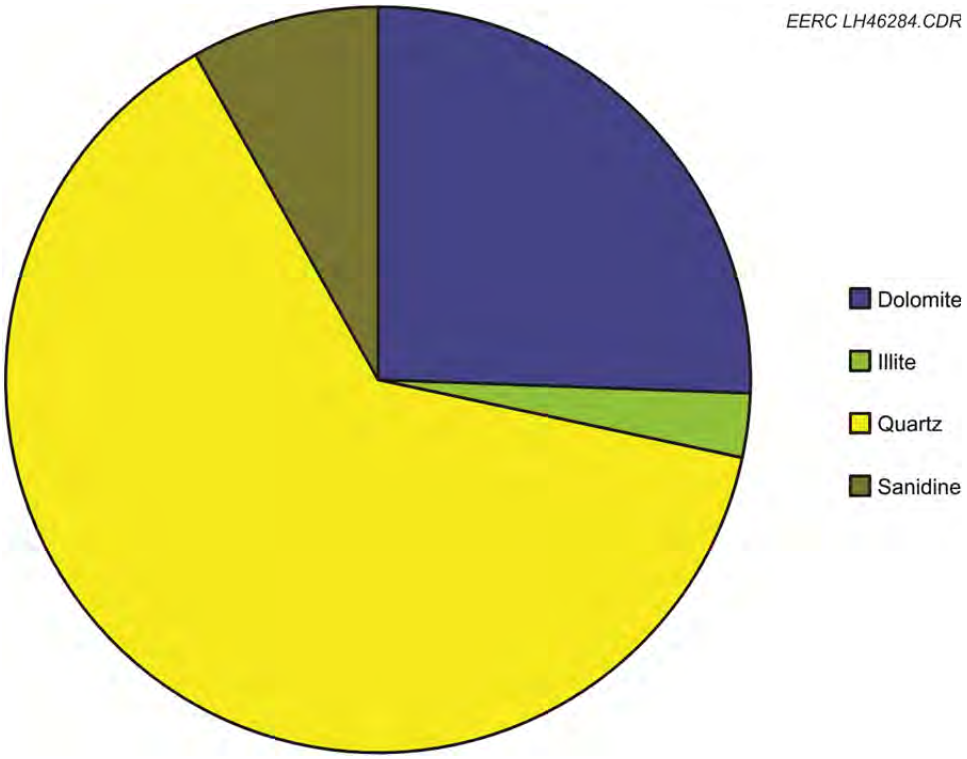
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| | Well Name: NDIC Well 6264 | | ID: S-00927 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |

**XRD MINERAL ANALYSIS**



| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00927 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |

**XRD Mineral-Phase Distribution**



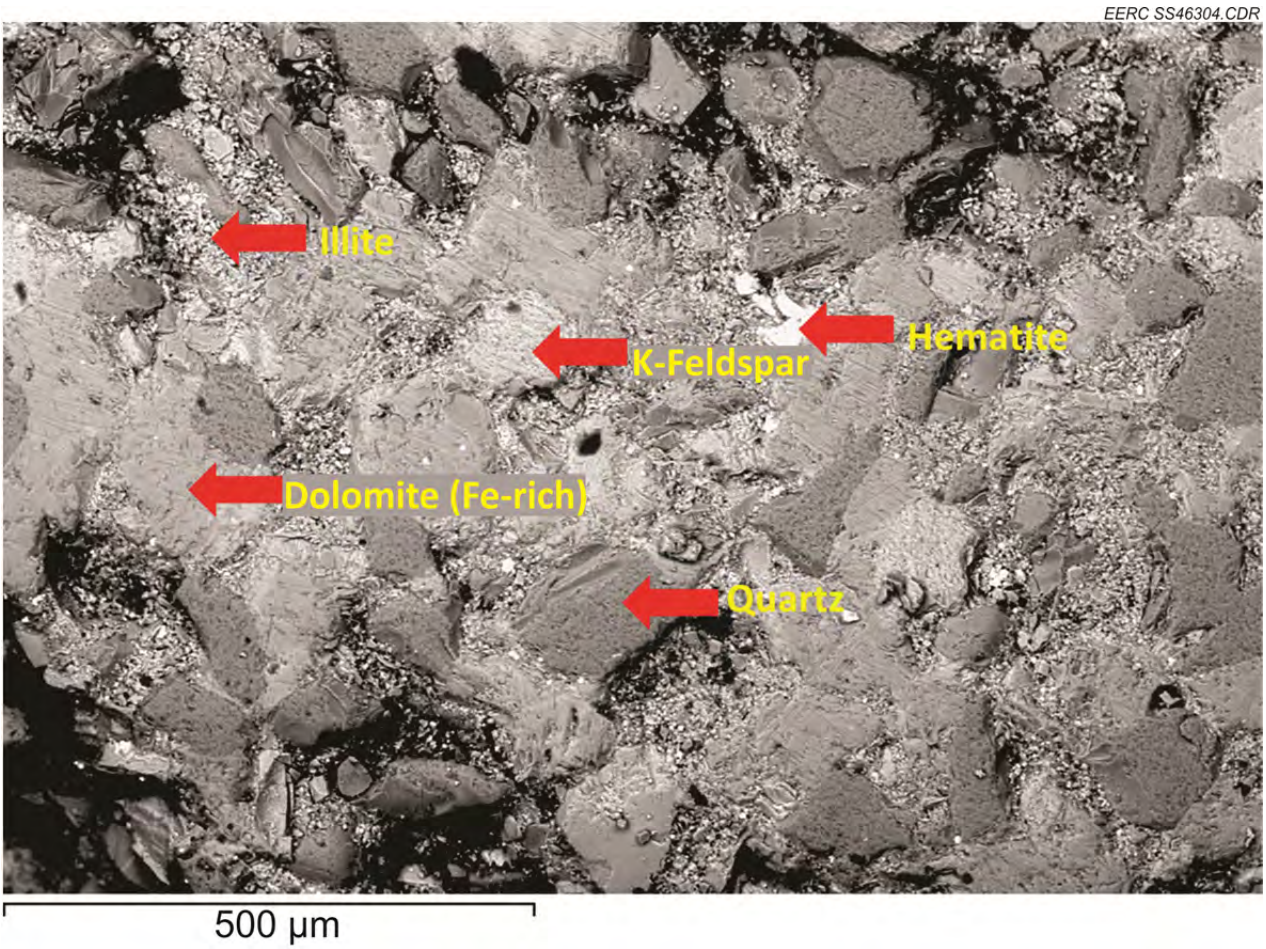

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Quartz | $SiO_2$ | 63.5 | 2.65 |
| Dolomite | $CaMg(CO_3)_2$ | 25.6 | 2.81 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 2.8 | 2.77 |
| Sanidine | $NaKAlSi_3O_8$ | 8.2 | 2.53 |

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00927 |
| Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |

**SEM**

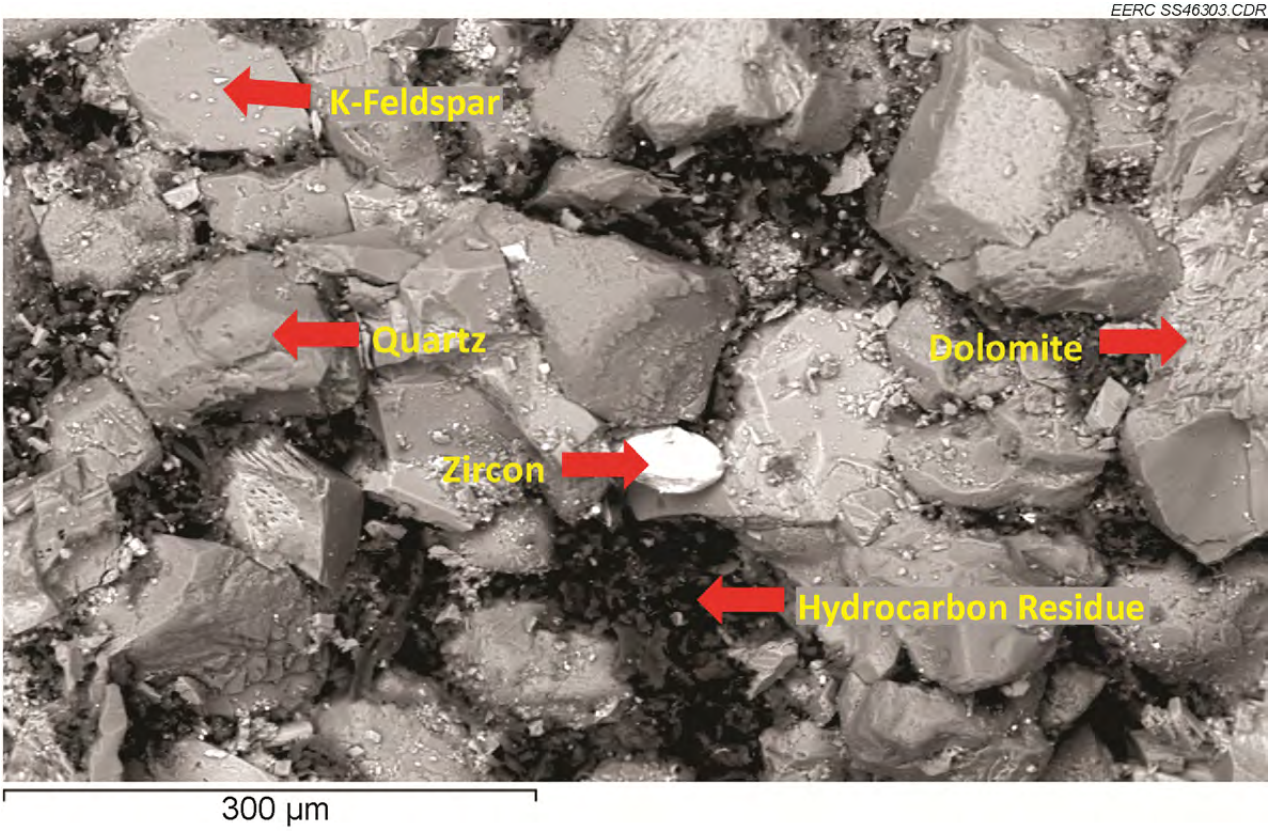
| Observed Mineral Phases in All SEM Analyses |
|---|
| Quartz |
| Anhydrite |
| Dolomite (iron [Fe]-rich) |
| Zircon |
| K-Feldspar |
| Illite |
| Iron Oxide (hematite) |

**Annotated High-Magnification BSE Images**




The BSE image shows quartz, dolomite, and K-feldspar as the major mineral grains. Illite is present in minor amounts and occurs predominantly in the pore spaces. Hematite is also in the rock sample but is expected to be in trace quantities only.

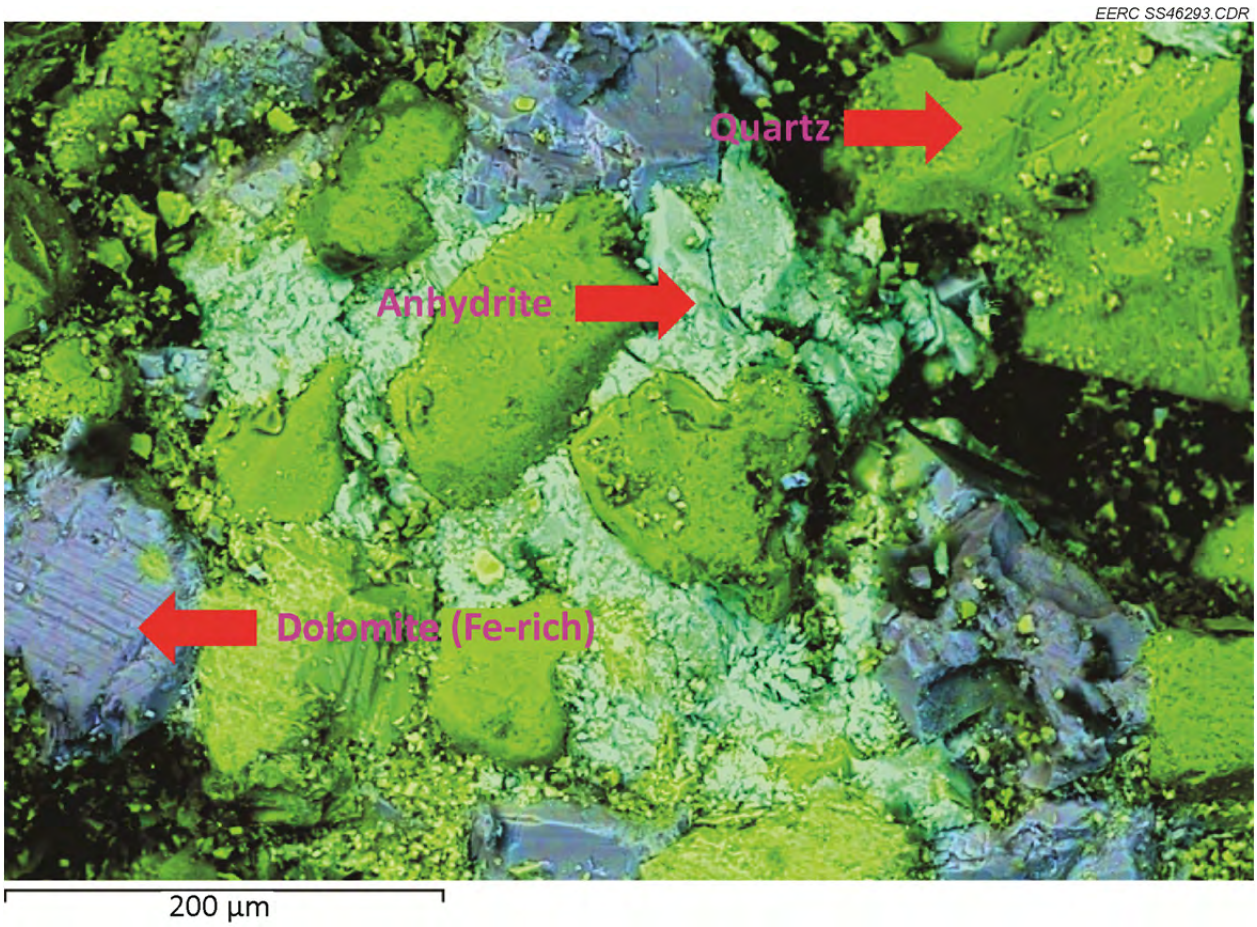
| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00927 |
| Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |




A high-magnification SEM BSE image of the sample shows dried flakes of hydrocarbon (organic) residue in the pore space, which is likely due to residual oil trapped in the sample when it was collected. In addition, this image shows the presence of zircon, which was found to be a common accessory mineral in most of the samples.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00927 |
| Deadwood Formation | Lithology: Sandstone | Depth: 6114.5' |

**Mineral Map Overlain on BSE Image**




The mineral map overlain on the BSE image provides textural and morphological information as well as mineral associations. For example, anhydrite was found to occur mainly in the intergranular spaces of the quartz and dolomite grains.

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| | Well Name: NDIC Well 6264 | | ID: S-00928 |
| | Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |

**SAMPLE PHOTOGRAPH**

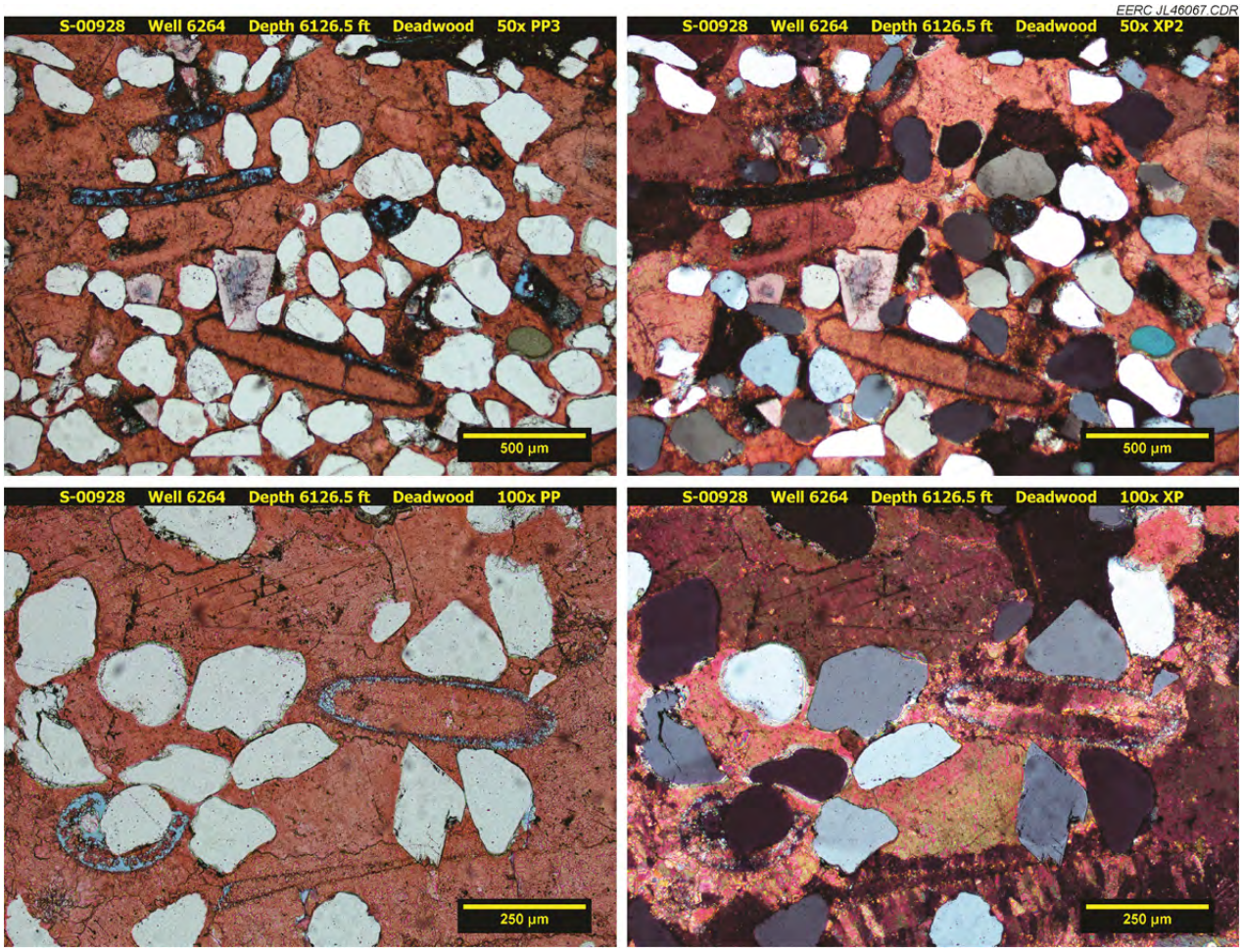



**PHYSICAL PROPERTIES**

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00928 |
| | Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |

**PHOTOMICROGRAPHS**




This sample is fine-grained, calcareous wackestone. The micritic matrix (dyed with Alizarin red) encompasses predominantly quartz, rhombohedral zoned ferroan dolomite (dyed with potassium ferricyanide), and feldspars. Small zones of clay matrices also having small fractures and rhombohedral-zoned ferroan dolomite are found sporadically throughout. Quartz exhibits a higher degree of grain sphericity and roundness than other depths in this well. Trace amounts of metals and no glauconite are present. Porosity is the result of dissolution of micrite, clays, and fossil grains (moldic porosity). Echinoderms, crinoids, algae, and trilobites are observed.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00928 |
| | Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |

**PETROGRAPHIC DESCRIPTIONS**

**Mineral Assemblages**

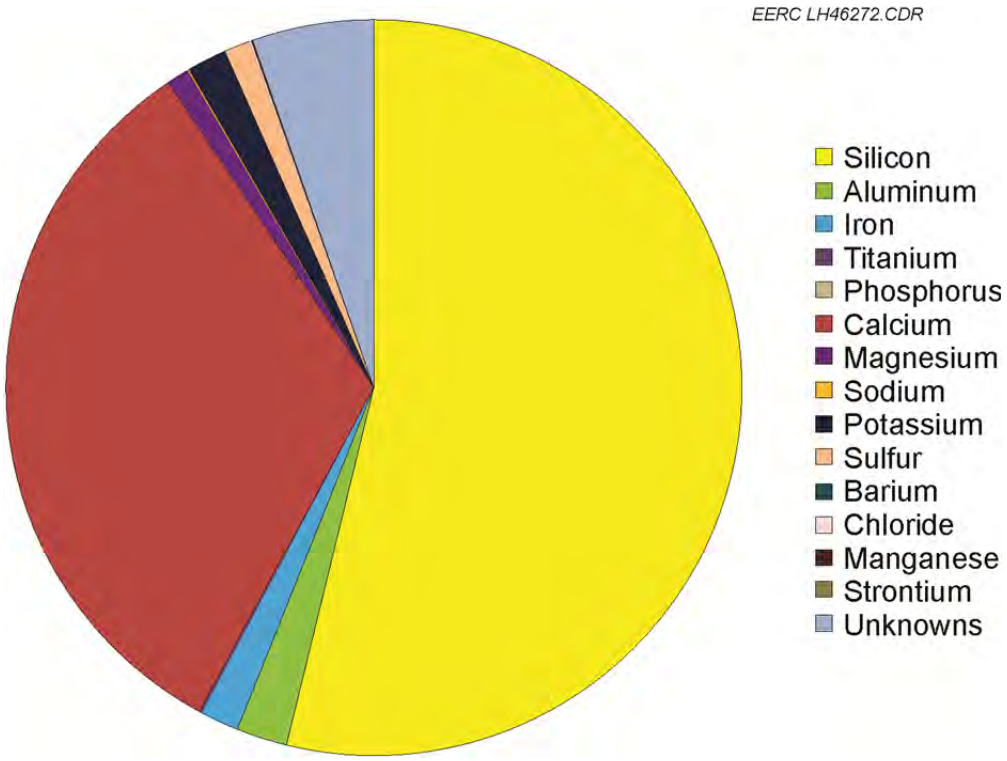
| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz and Feldspars | 49.2 | Quartz monocrystalline |
| Micrite | 36.6 | Calcite matrix |
| Dolomite | 4.6 | Ferroan, rhombs |
| Pyrite | 1.0 | |
| Clays | 5.6 | |
| Porosity | 3.0 | Intergranular, cement dissolution, moldic |

**Classification**

| Category | Classification |
|---|---|
| Depositional Environment | Lagoonal |
| Energy Environment | Low–medium |
| Dott Classification | Calcareous sandstone |
| Dunham Classification | Wackestone |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00928 |
| | Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |

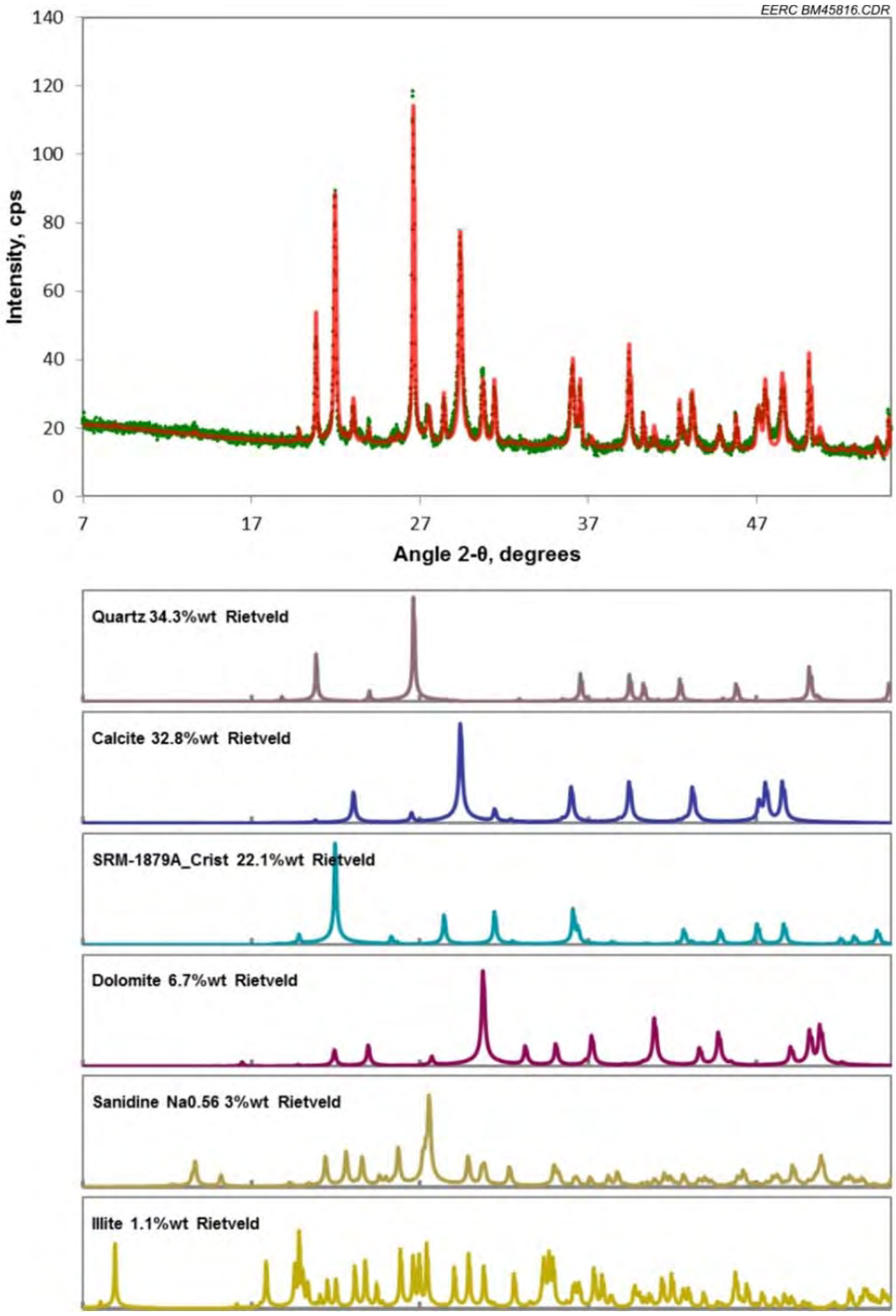
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 53.82 |
| Al (aluminum) | $Al_2O_3$ | 2.23 |
| Fe (iron) | $Fe_2O_3$ | 1.71 |
| Ti (titanium) | $TiO_2$ | 0.11 |
| P (phosphorus) | $P_2O_5$ | 0.00 |
| Ca (calcium) | CaO | 32.70 |
| Mg (magnesium) | MgO | 1.01 |
| Na (sodium) | $Na_2O$ | 0.06 |
| K (potassium) | $K_2O$ | 1.74 |
| S (sulfur) | $SO_3$ | 1.15 |
| Ba (barium) | BaO | 0.01 |
| Cl (chloride) | Cl | 0.07 |
| Mn (manganese) | MnO | 0.06 |
| Sr (strontium) | SrO | 0.01 |
| Unknowns | | 5.34 |
| Total | | 100.00 |

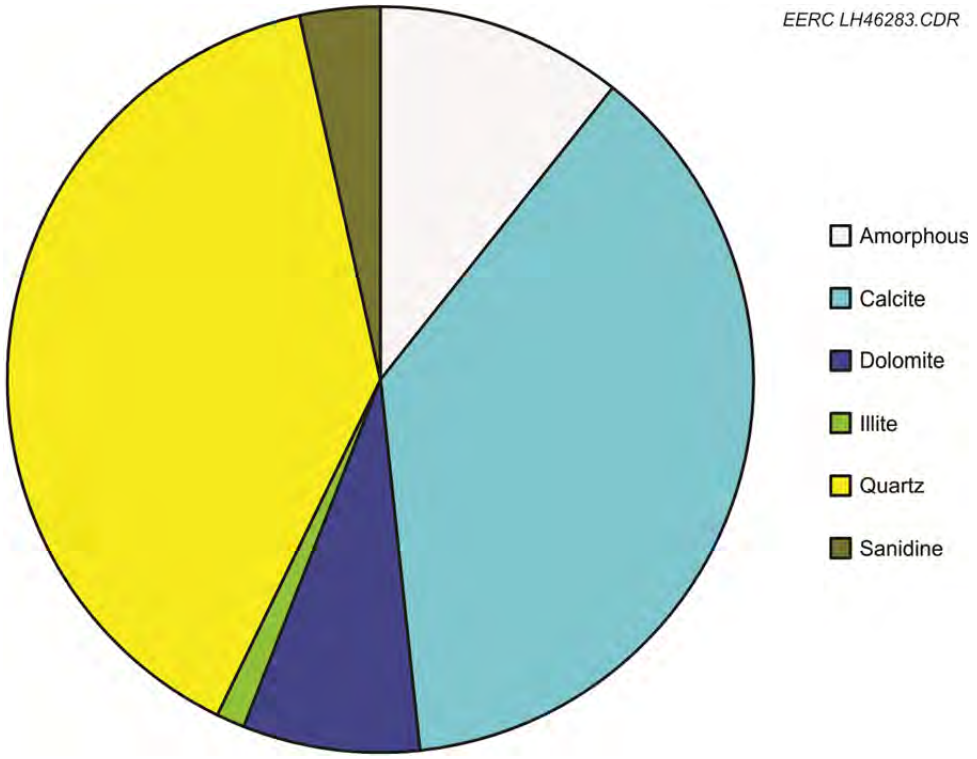
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00928 |
| | Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |

**XRD MINERAL ANALYSIS**



| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00928 |
| | Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |

**XRD Mineral-Phase Distribution**



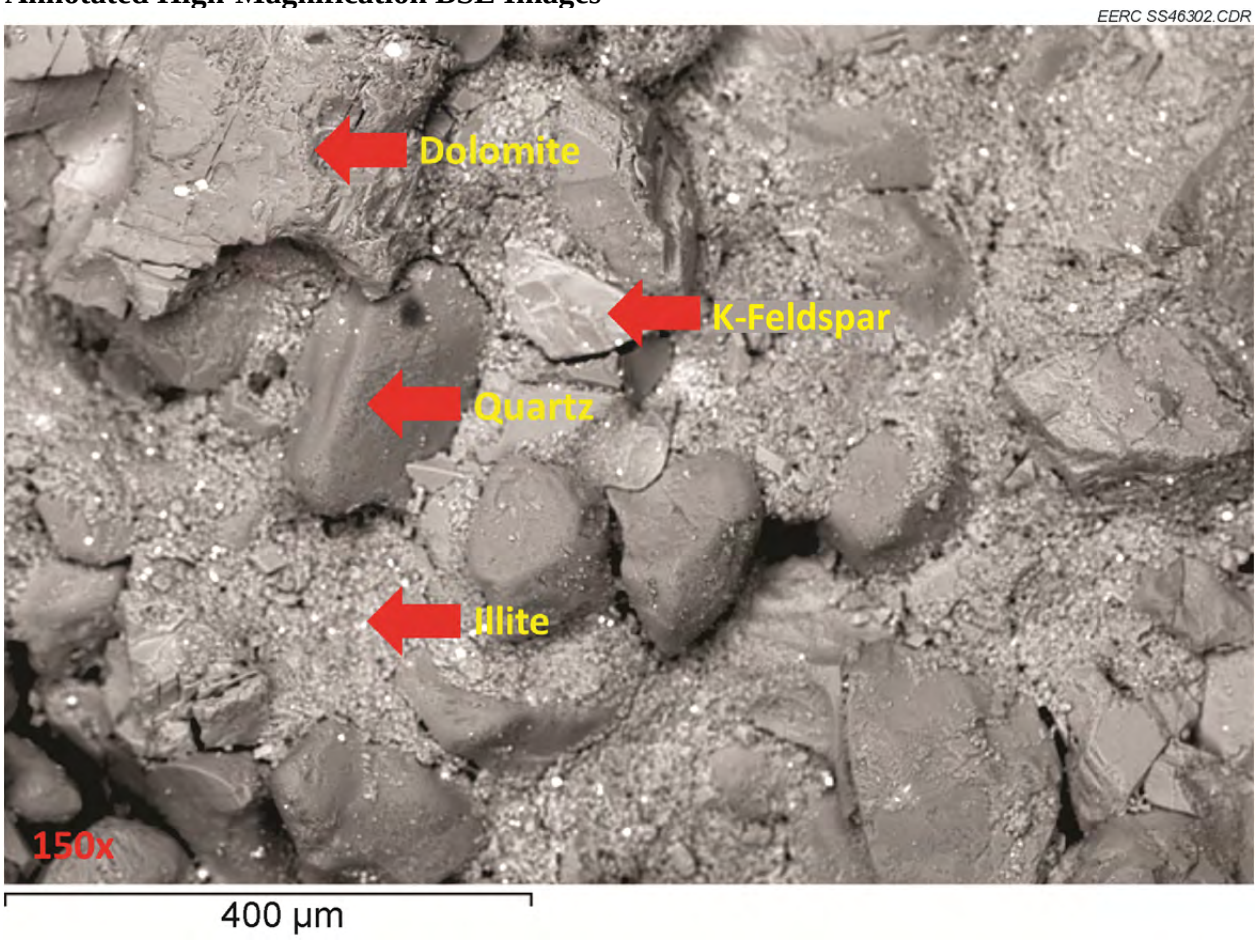

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 10.7 | NA |
| Quartz | $SiO_2$ | 39.3 | 2.65 |
| Calcite | $CaCO_3$ | 37.6 | 2.72 |
| Dolomite | $CaMg(CO_3)_2$ | 7.7 | 2.82 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 1.2 | 2.79 |
| Sanidine | $NaKAlSi_3O_8$ | 3.5 | 2.53 |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00928 |
| | Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |

**SEM**

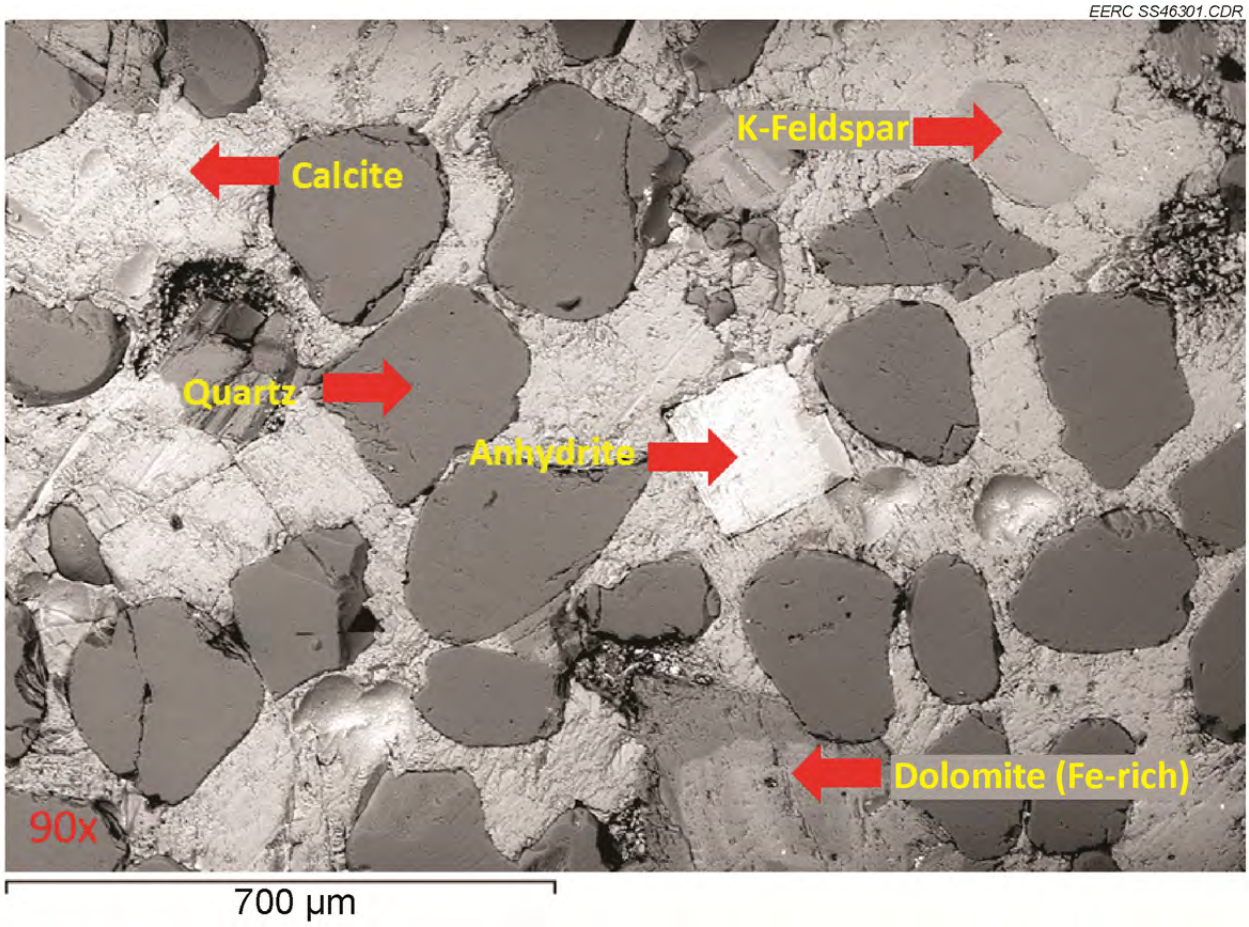
| Observed Mineral Phases in All SEM Analyses |
|---|
| Calcite |
| Quartz |
| Pyrite |
| Dolomite |
| K-Feldspar |
| Illite |
| Anhydrite |

**Annotated High-Magnification BSE Images**




The SEM BSE image shows illite in the pore space and quartz, dolomite, and K-feldspar as major mineral grains. K-feldspar is distinctly different from illite based on the grain texture and structure, although they both have the same chemistry. These structural attributes, coupled with quantitative differences in the amounts of potassium, are essential in delineating illite from K-feldspars in rock samples.

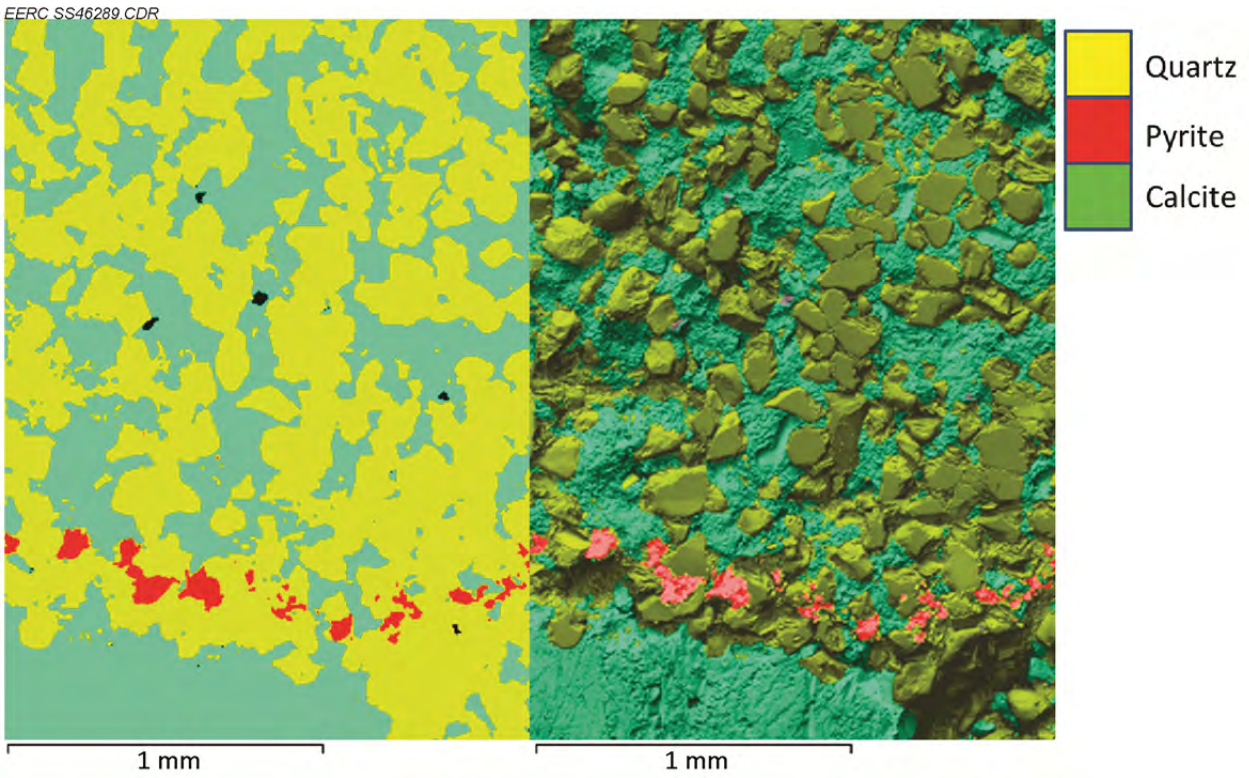
| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00928 |
| Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |




This SEM BSE image of another area of the sample shows calcite cement as the main matrix material, with quartz, dolomite, anhydrite, and K-feldspar grains emerging distinctly from the cementation's calcite matrix phase.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 6264 | | ID: S-00928 |
| | Deadwood Formation | Lithology: Wackestone | Depth: 6126.5' |

**Mineral Map and Mineral Map Overlain on BSE Image (same frame)**




A mineral map (left) and a layered image (right) of the same frame are displayed together and show the major minerals found, the associations, and the texture of the grains of the various phases. In particular, pyrite was observed to lie along a line, which may suggest a bedding plane of the rock.

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| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00929 |
| Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

## SAMPLE PHOTOGRAPH

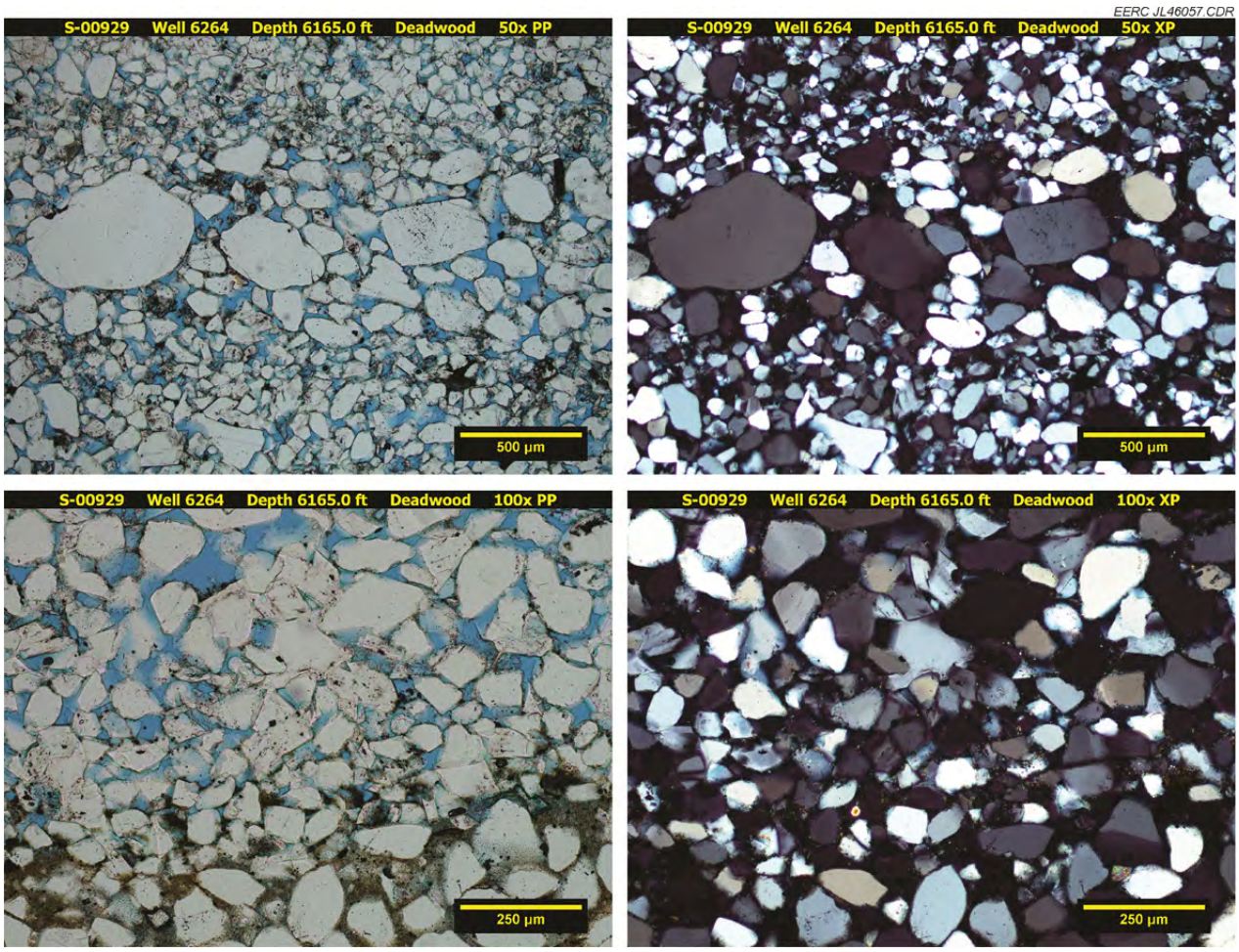



## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00929 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

**PHOTOMICROGRAPHS**




This poorly sorted, friable sample consists primarily of quartz with uneven cementation. Inconsistent cementation and graded bedding provide fluctuating porosities. Porosity is the result of intergranular voids created by variable grain texture and cement dissolution. Grain roundness varies from angular to subrounded. Lithic minerals include feldspars, micas, dolomite, and pyrite. No presence of glauconite or fossils was discovered.

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00929 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

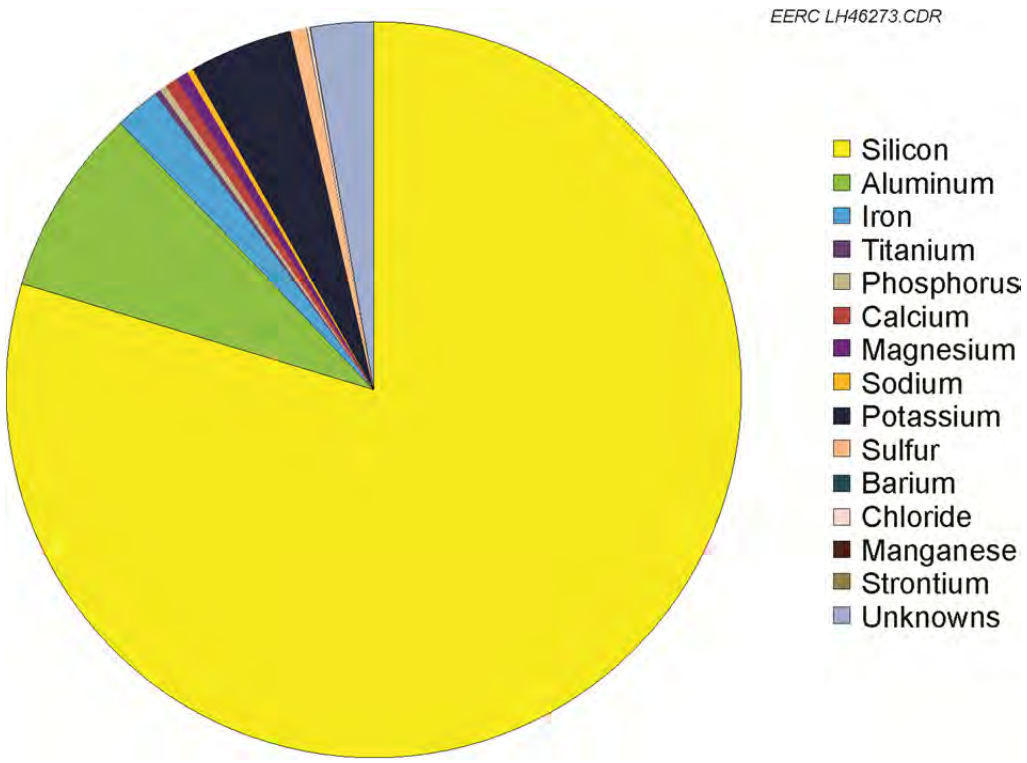
| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz and Feldspars | 74.2 | Quartz monocrystalline |
| Biotite | 0.6 | |
| Clays | 9.4 | Laminations |
| Dolomite | 2.4 | Subhedral |
| Pyrite | 0.6 | |
| Porosity | 12.8 | Intergranular |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Beach |
| Energy Environment | Low–medium |
| Dott Classification | Quartz arenite sandstone |
| Dunham Classification | N/A |

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00929 |
| Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

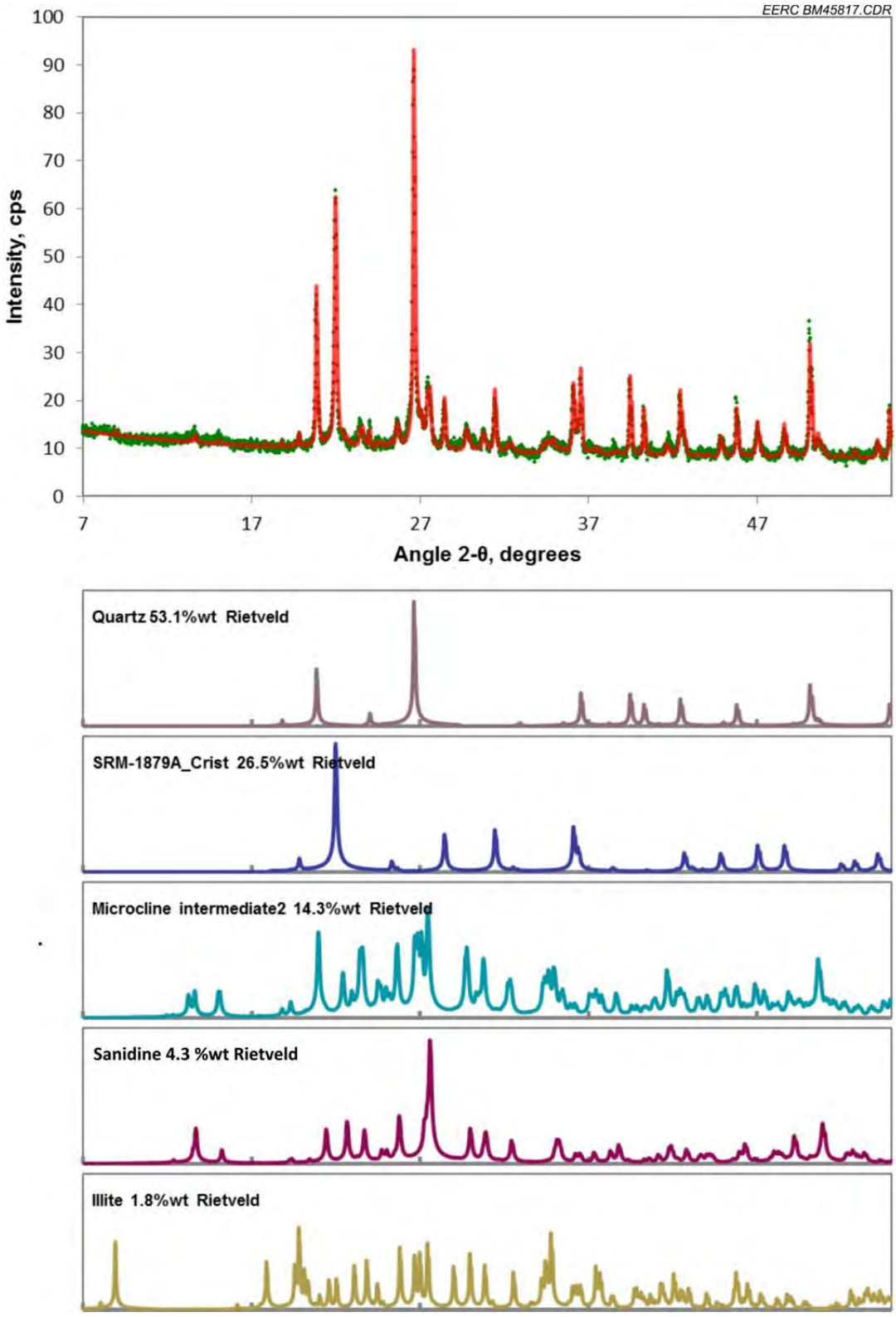
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 79.66 |
| Al (aluminum) | $Al_2O_3$ | 8.23 |
| Fe (iron) | $Fe_2O_3$ | 1.99 |
| Ti (titanium) | $TiO_2$ | 0.27 |
| P (phosphorus) | $P_2O_5$ | 0.29 |
| Ca (calcium) | CaO | 0.56 |
| Mg (magnesium) | MgO | 0.55 |
| Na (sodium) | $Na_2O$ | 0.27 |
| K (potassium) | $K_2O$ | 4.56 |
| S (sulfur) | $SO_3$ | 0.69 |
| Ba (barium) | BaO | 0.04 |
| Cl (chloride) | Cl | 0.11 |
| Mn (manganese) | MnO | 0.01 |
| Sr (strontium) | SrO | 0.01 |
| Unknowns | | 2.76 |
| Total | | 100.00 |

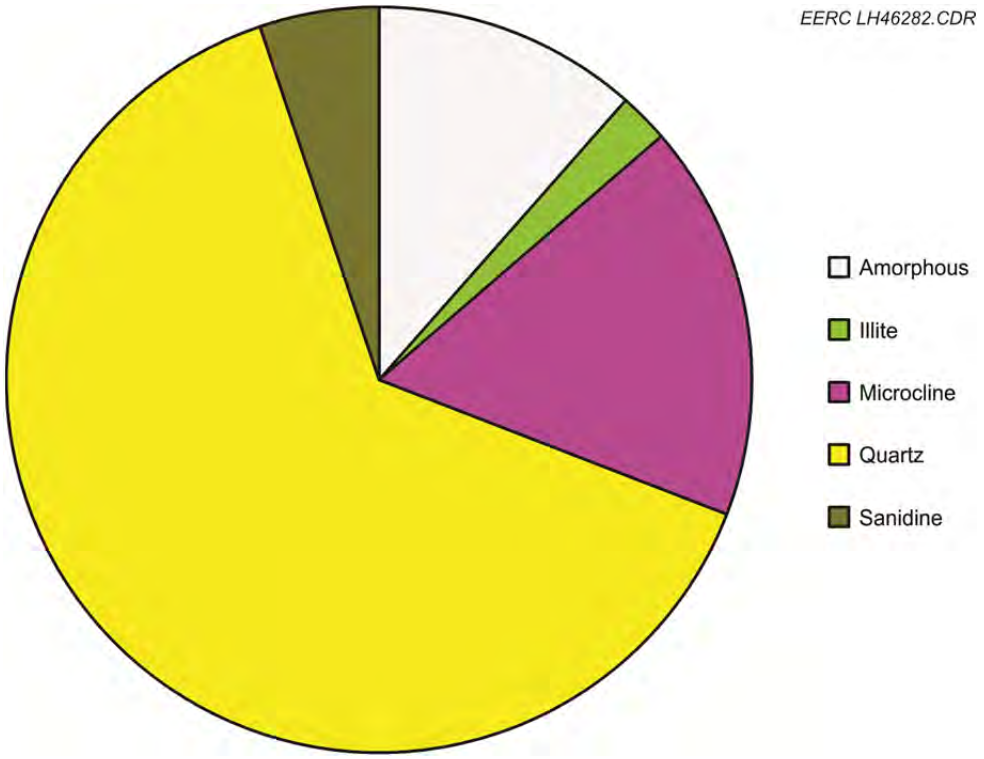
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00929 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

**XRD MINERAL ANALYSIS**



| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 6264 | | ID: S-00929 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

**XRD Mineral-Phase Distribution**



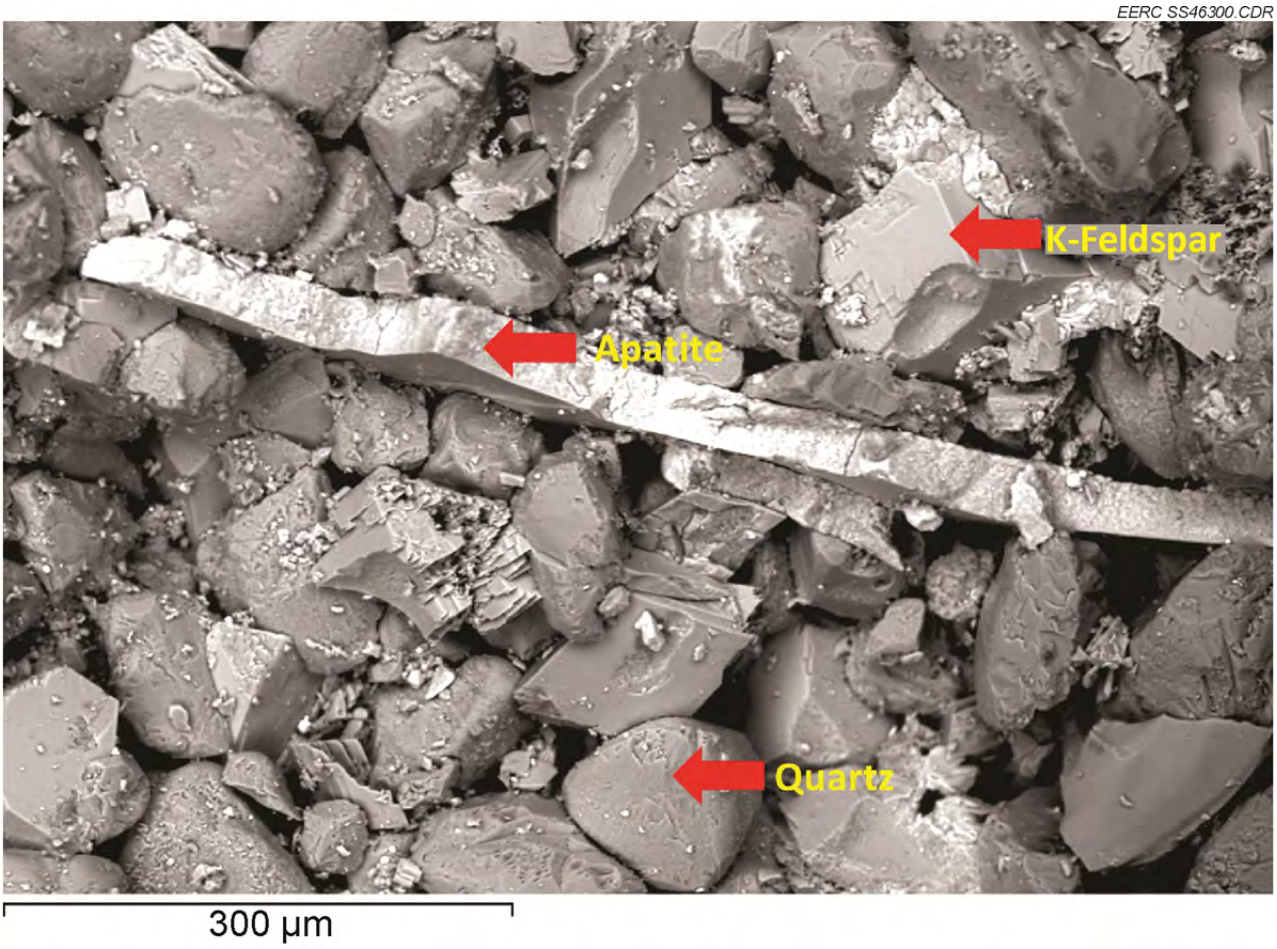

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 11.5 | NA |
| Quartz | $SiO_2$ | 63.9 | 2.65 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 2.2 | 2.79 |
| Microcline | $KAlSi_3O_8$ | 17.2 | 2.55 |
| Sanidine | $NaKAlSi_3O_8$ | 5.2 | 2.55 |

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00929 |
| Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

**SEM**

| Observed Mineral Phases in All SEM Analyses |
|---|
| Quartz |
| Apatite |
| K-Feldspar |
| Zircon |

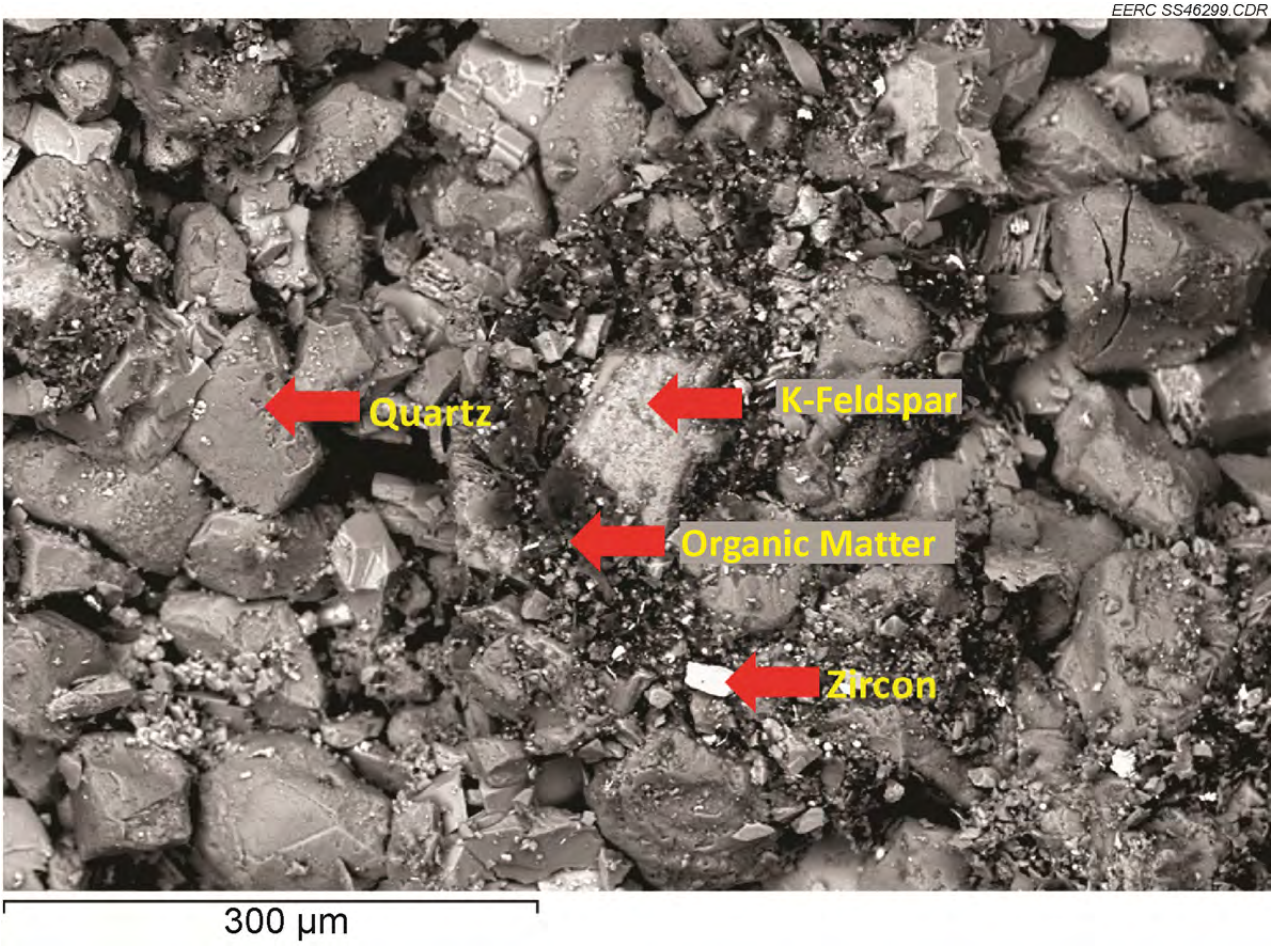
**Annotated High-Magnification BSE Images**




The SEM BSE image shows large quartz and K-feldspar grains with an apatite sheet embedded in the rock. Apatite clearly displays a softer texture than quartz or K-feldspar.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00929 |
| Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

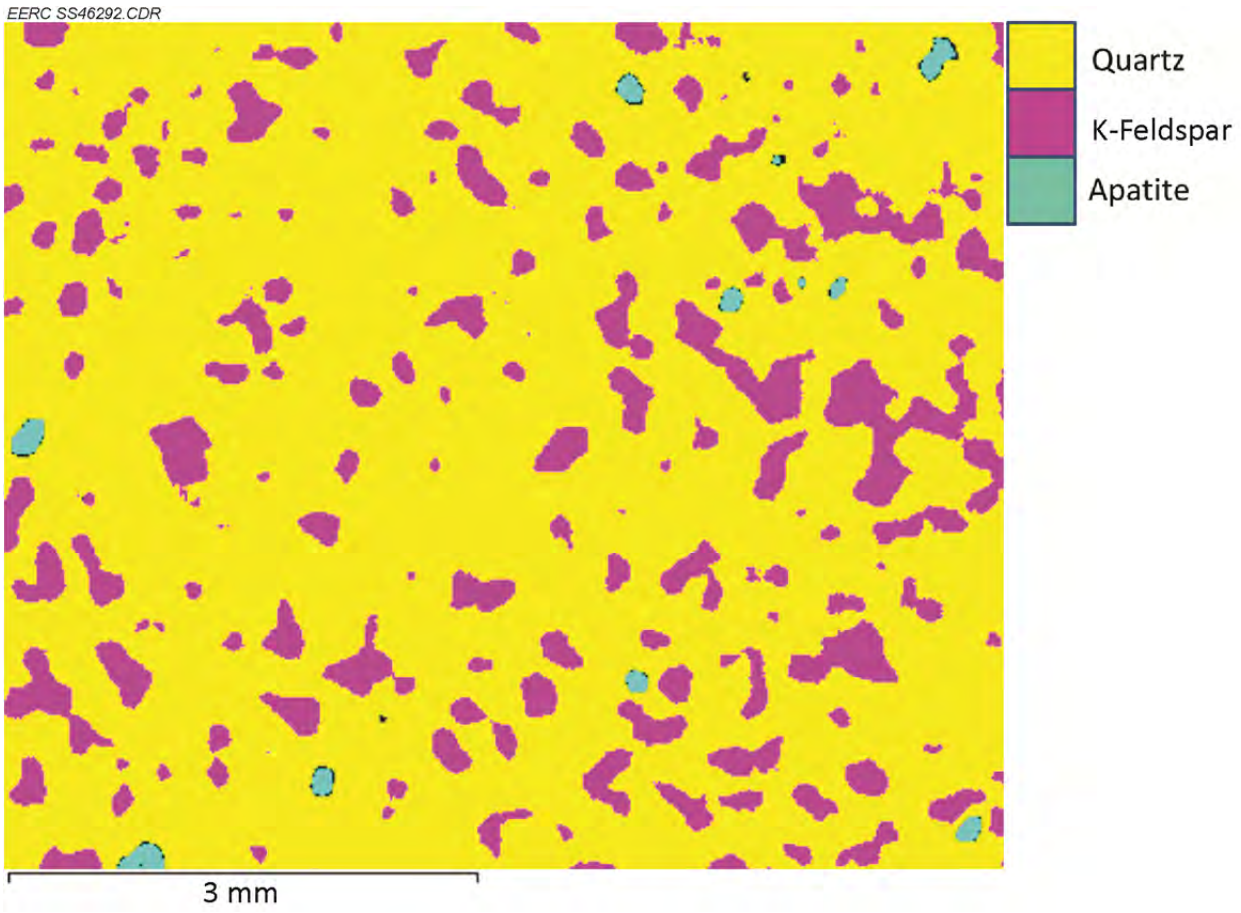
EERC SS46299.CDR




The BSE image shows organic material found in the sample as well as the accessory mineral zircon. Both are present in the pore spaces between quartz and K-feldspar grains.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 6264 | | ID: S-00929 |
| Deadwood Formation | Lithology: Sandstone | Depth: 6165.0' |

**Mineral Map**




The mineral map shows three main phases in the sample: quartz, K-feldspar, and apatite.

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| | Well Name: NDIC Well 17467 | | ID: S-00768 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9440.1' |

**SAMPLE PHOTOGRAPH**

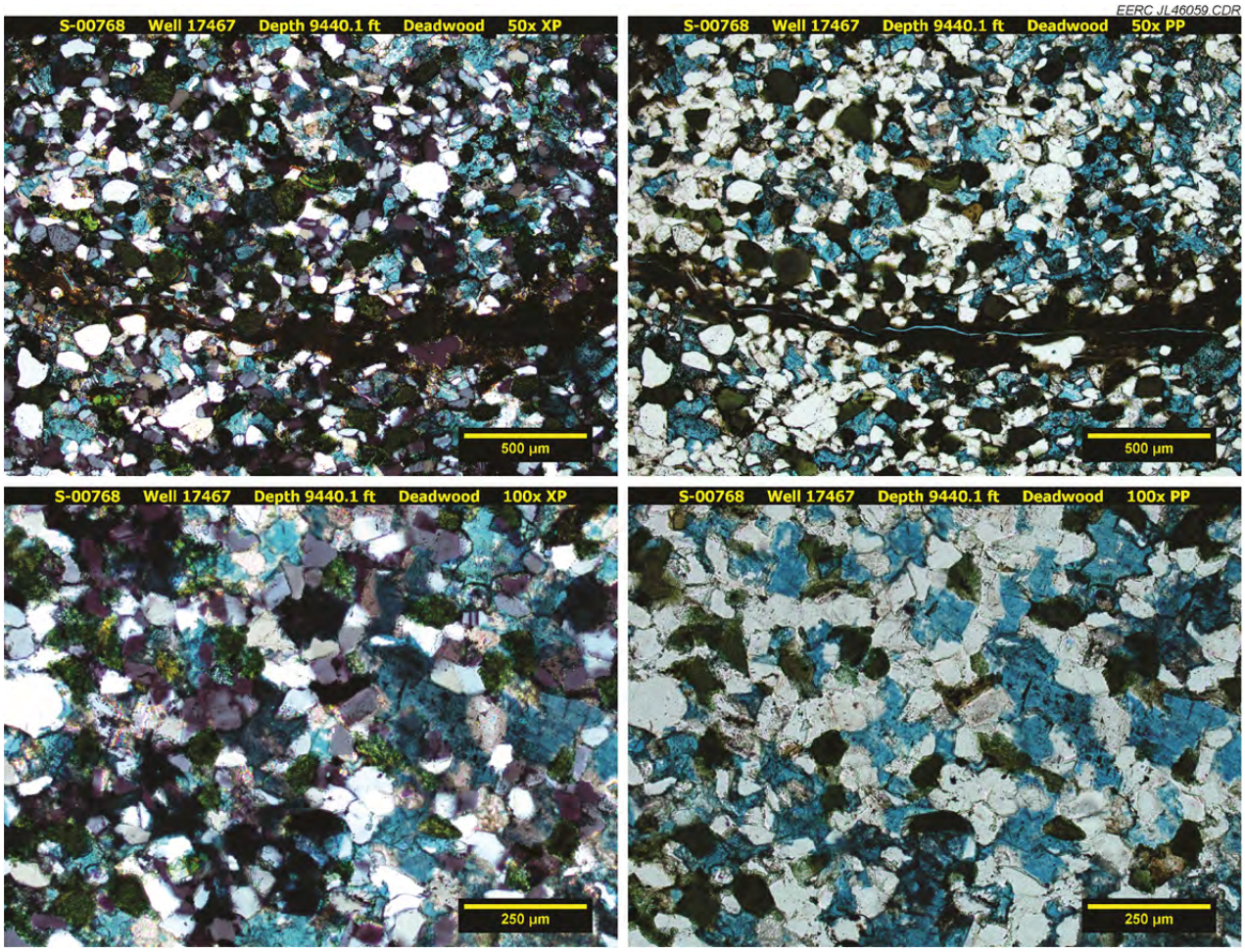



**PHYSICAL PROPERTIES**

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| 3.71 | 2.63 | 0.009 |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00768 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9440.1' |

**PHOTOMICROGRAPHS**




This sample is tight dolomitic sandstone having no visible porosity except for small fractures as shown in the photomicrograph. The moderately well sorted sample exhibits many postdepositional features: glauconite grains, dolomitization (blue minerals), and quartz overgrowths. Each of these diagenetic features reduces primary porosity. Small amounts of feldspars, biotite, pyrite, and muscovite are present. No presence of fossils is detected.

| | | | |
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| | Well Name: NDIC Well 17467 | | ID: S-00768 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9440.1' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

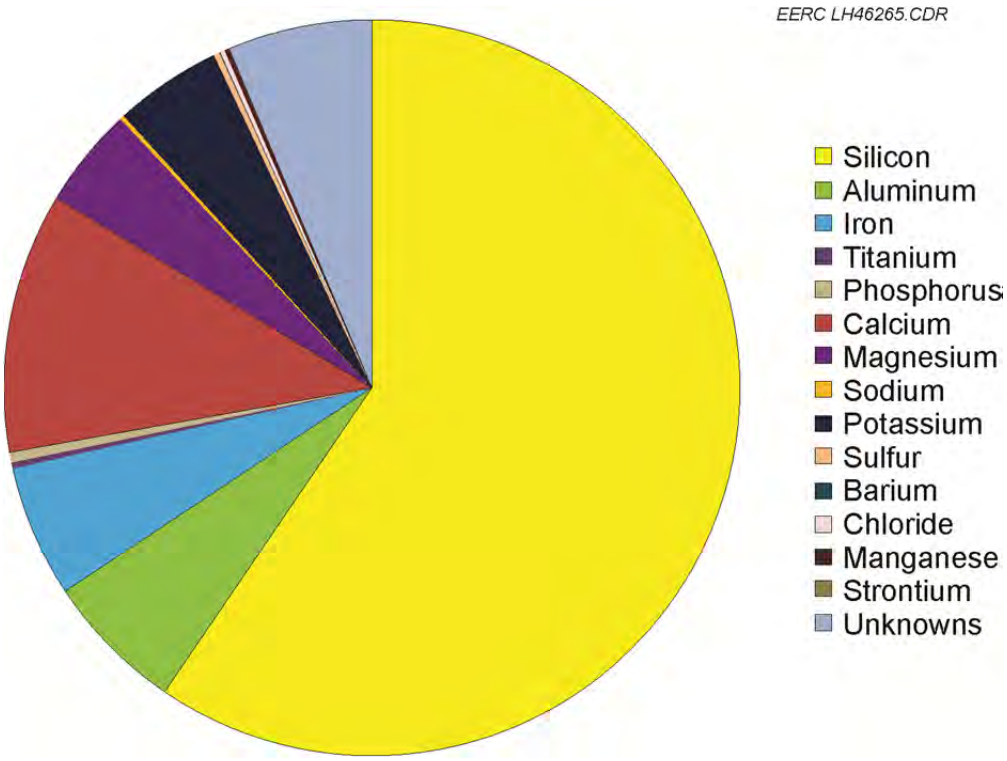
| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 53.0 | Monocrystalline |
| Glauconite | 18.2 | |
| Dolomite | 21.8 | Anhedral |
| Clay | 3.8 | Laminations |
| Pyrite | 0.8 | |
| Biotite | 2.4 | |
| Porosity | 0.0 | Fractures |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Shallow shelf/beach |
| Energy Environment | Medium |
| Dott Classification | Dolomitic sandstone |
| Dunham Classification | N/A |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00768 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9440.1' |

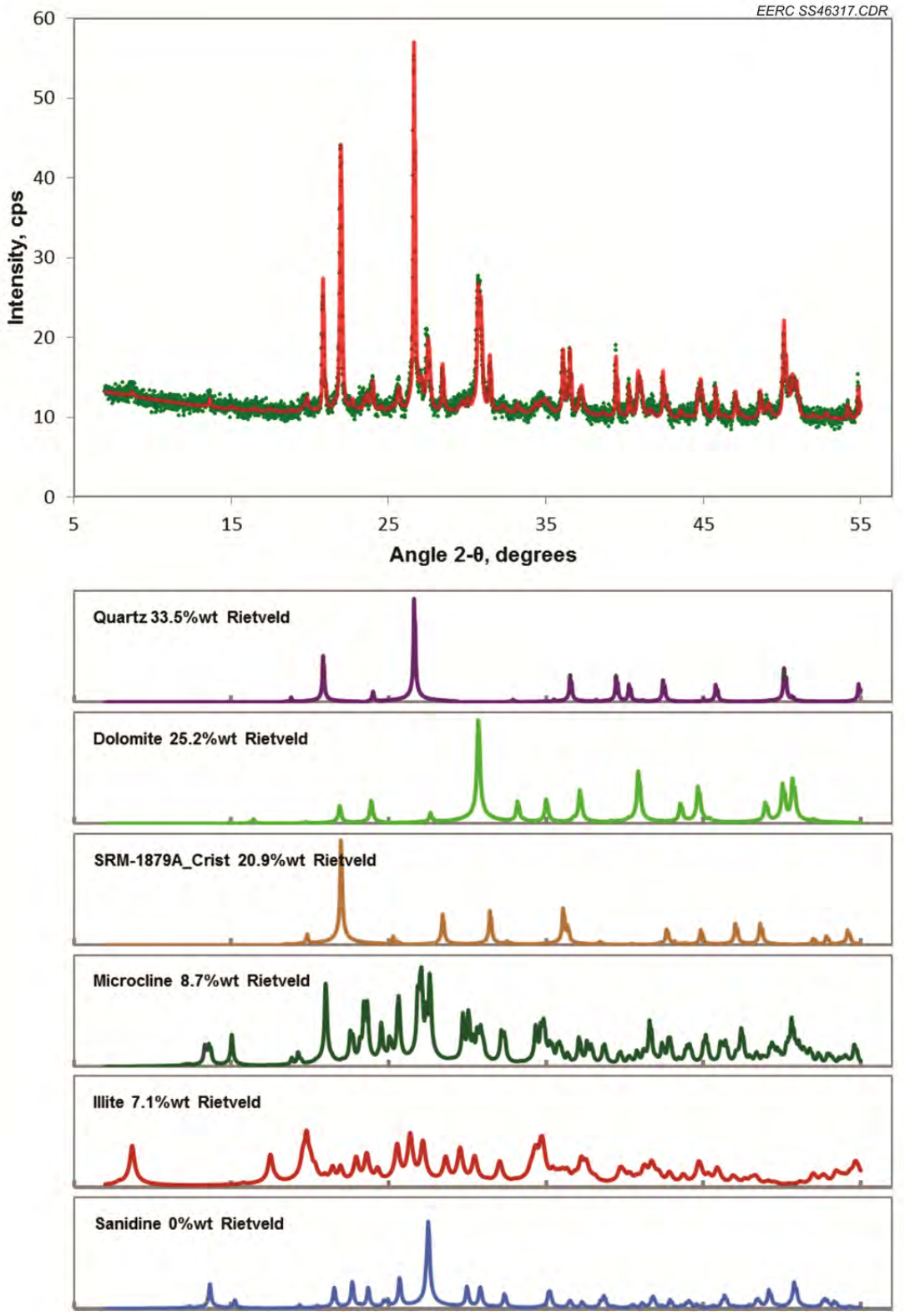
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 59.52 |
| Al (aluminum) | $Al_2O_3$ | 6.16 |
| Fe (iron) | $Fe_2O_3$ | 5.80 |
| Ti (titanium) | $TiO_2$ | 0.27 |
| P (phosphorus) | $P_2O_5$ | 0.44 |
| Ca (calcium) | CaO | 11.44 |
| Mg (magnesium) | MgO | 4.42 |
| Na (sodium) | $Na_2O$ | 0.19 |
| K (potassium) | $K_2O$ | 4.72 |
| S (sulfur) | $SO_3$ | 0.25 |
| Ba (barium) | BaO | 0.05 |
| Cl (chloride) | Cl | 0.20 |
| Mn (manganese) | MnO | 0.19 |
| Sr (strontium) | SrO | 0.01 |
| Unknowns | | 6.34 |
| Total | | 100.00 |

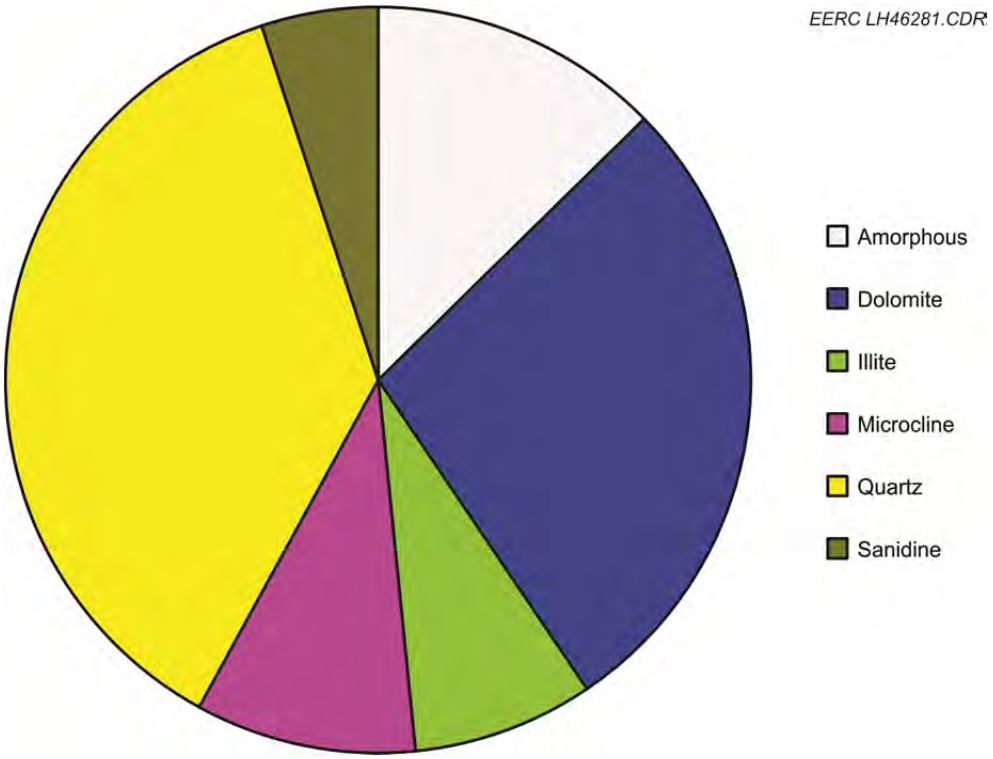
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 17467 | | ID: S-00768 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9440.1' |

**XRD MINERAL ANALYSIS**



| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00768 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9440.1' |

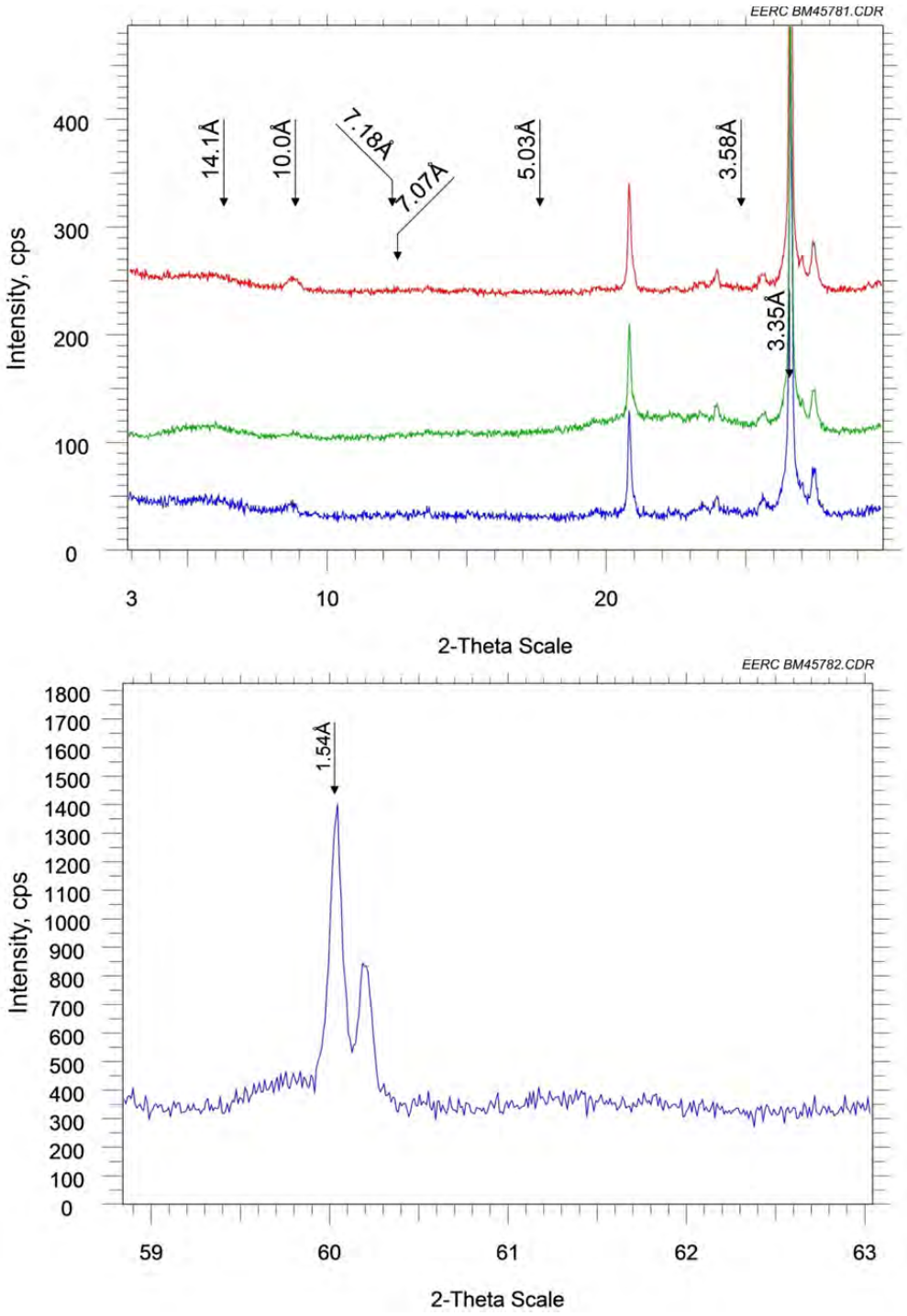
**XRD Mineral-Phase Distribution**




| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 12.7 | NA |
| Quartz | $SiO_2$ | 37.0 | 2.65 |
| Dolomite | $CaMg(CO_3)_2$ | 27.9 | 2.81 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 7.9 | 2.73 |
| Microcline | $KAlSi_3O_8$ | 9.6 | 2.57 |
| Sanidine | $NaKAlSi_3O_8$ | 5.1 | 2.56 |

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 17467 | | ID: S-00768 |
| Deadwood Formation | Lithology: Sandstone | Depth: 9440.1' |

**XRD Clay Typing**




The analyzed clay fraction contained an insignificant amount of illitelike clay structure.

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| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 17467 | | ID: S-00769 |
| Deadwood Formation | Lithology: Silty Dolostone | Depth: 9443.1' |

**SAMPLE PHOTOGRAPH**

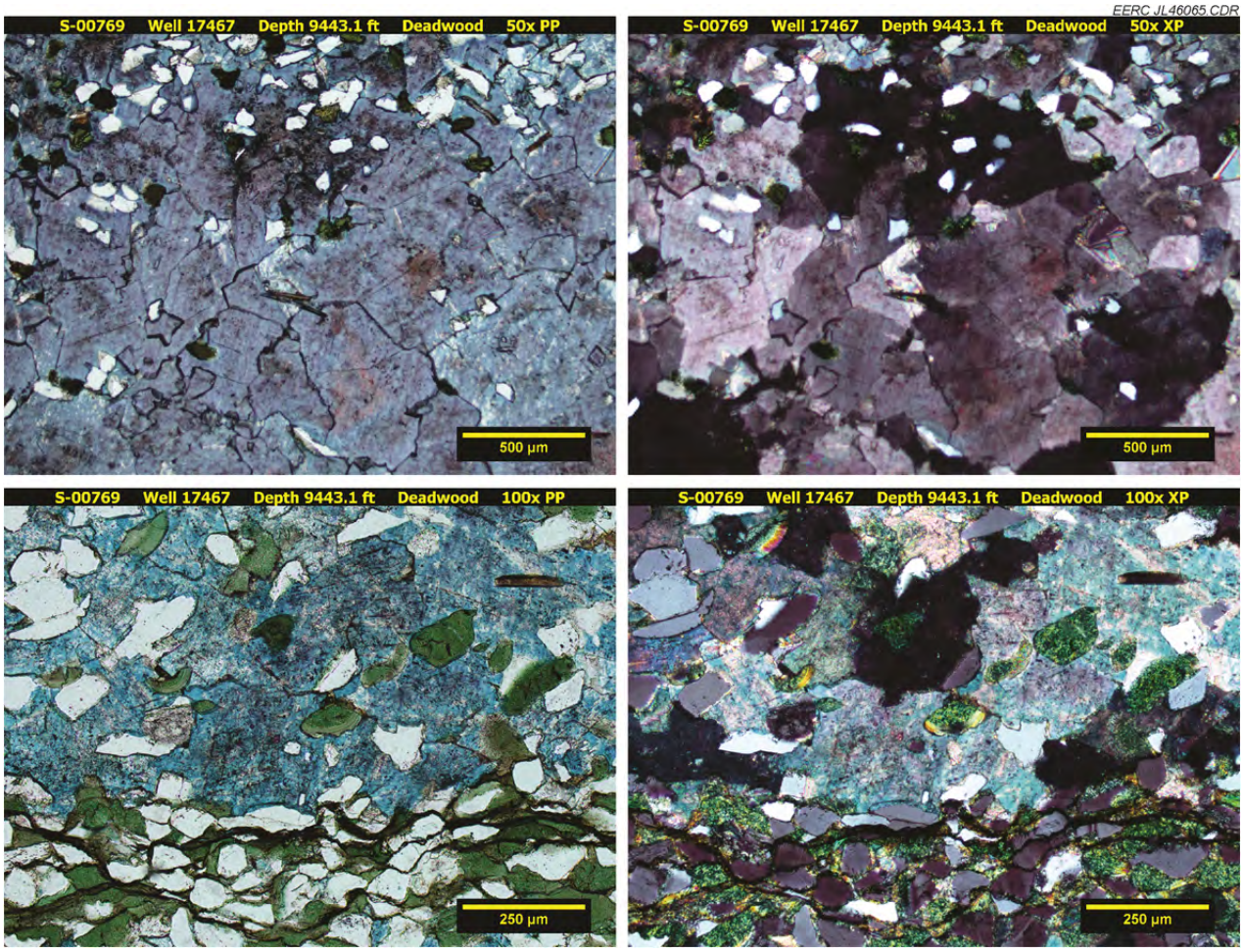



**PHYSICAL PROPERTIES**

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| 3.24 | 2.76 | 0.021 |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 17467 | | ID: S-00769 |
| | Deadwood Formation | Lithology: Silty Dolostone | Depth: 9443.1' |

**PHOTOMICROGRAPHS**




This sample is a finely bedded silty dolostone with fair amounts of glauconite. Dolomite is characterized as nonplanar having irregular or curved crystal boundaries. Quartz is inconsistently concentrated and is typically subangular to subrounded with some overgrowth present. Porosity is not detectible because of extensive dolomitization. Small amounts of feldspars and biotite are present. No fractures or fossils are observed.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00769 |
| | Deadwood Formation | Lithology: Silty Dolostone | Depth: 9443.1' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

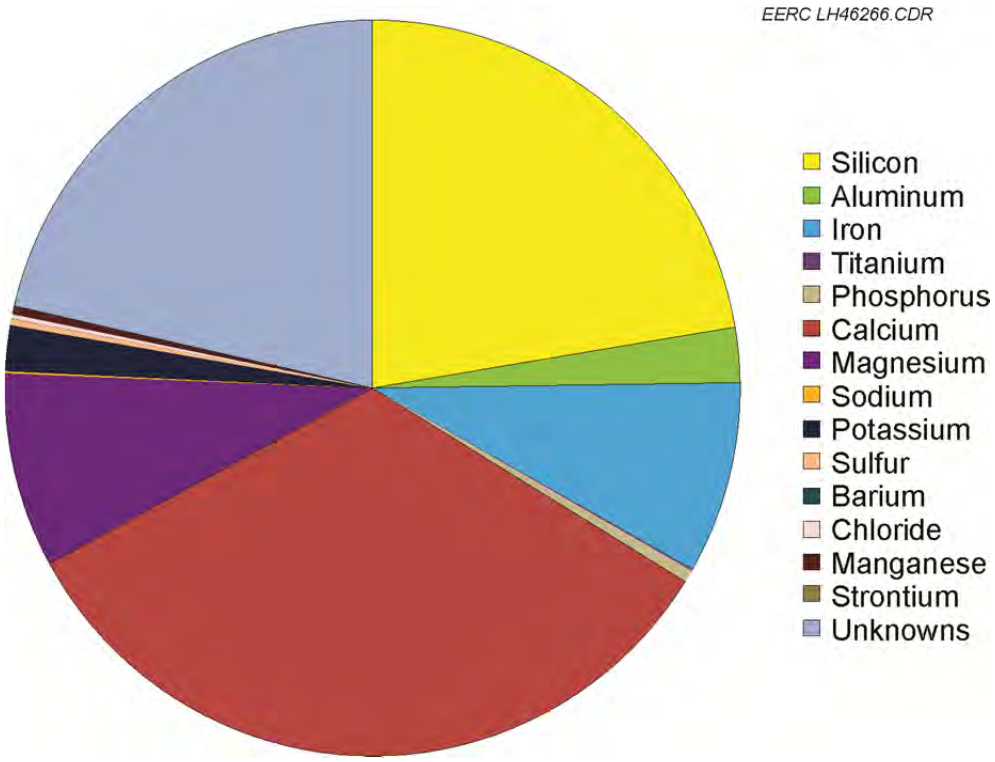
| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 28.8 | Monocrystalline |
| Glauconite | 13.4 | |
| Dolomite | 56.4 | Anhedral |
| Biotite | 0.8 | |
| Clays | 0.6 | Laminations |
| Porosity | 0.0 | None observed |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Lagoonal/peritidal |
| Energy Environment | Low–medium |
| Dott Classification | N/A |
| Dunham Classification | Dolomitic grainstone |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 17467 | | ID: S-00769 |
| | Deadwood Formation | Lithology: Silty Dolostone | Depth: 9443.1' |

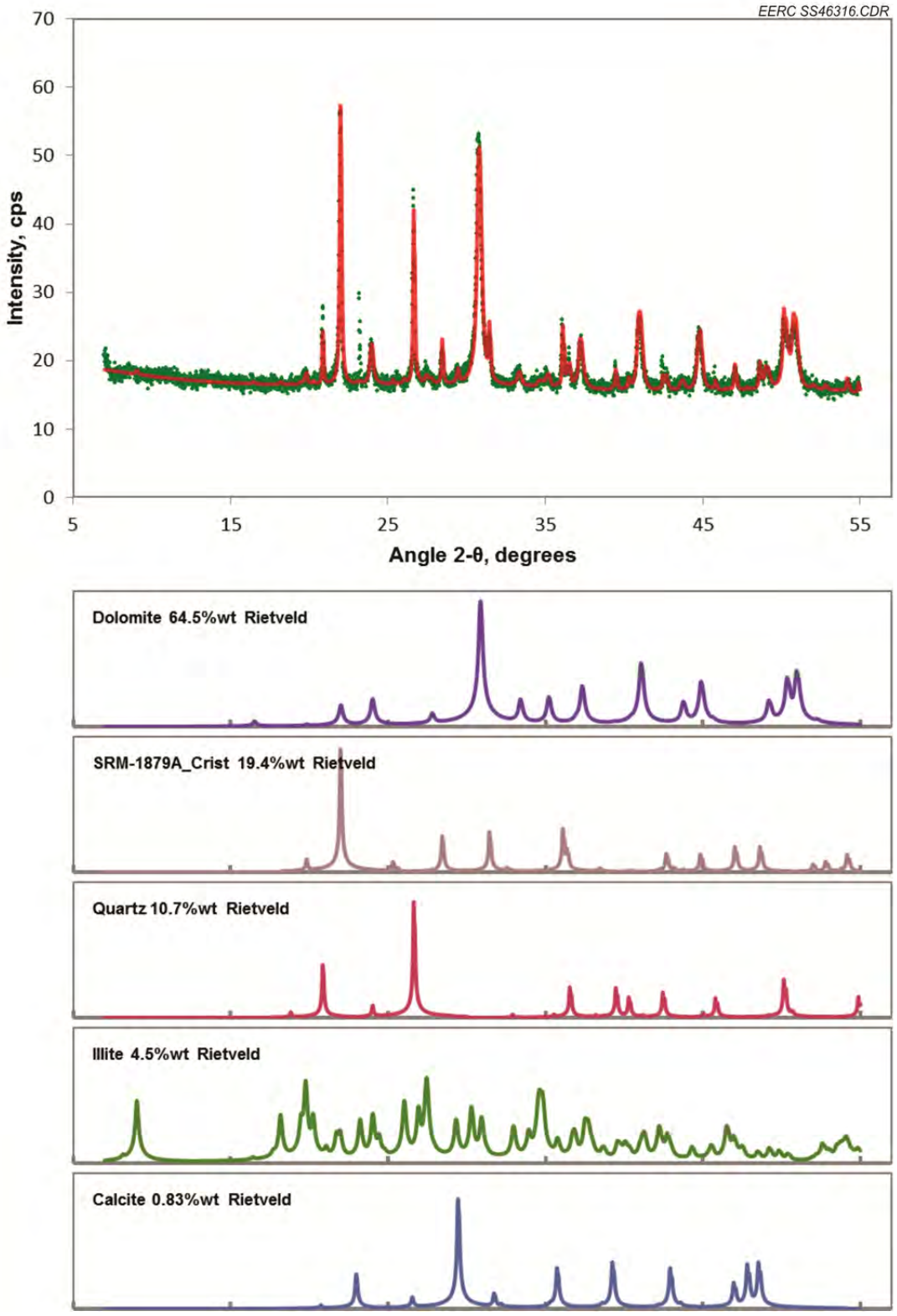
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 22.35 |
| Al (aluminum) | $Al_2O_3$ | 2.42 |
| Fe (iron) | $Fe_2O_3$ | 8.42 |
| Ti (titanium) | $TiO_2$ | 0.09 |
| P (phosphorus) | $P_2O_5$ | 0.53 |
| Ca (calcium) | CaO | 33.27 |
| Mg (magnesium) | MgO | 8.57 |
| Na (sodium) | $Na_2O$ | 0.09 |
| K (potassium) | $K_2O$ | 2.01 |
| S (sulfur) | $SO_3$ | 0.27 |
| Ba (barium) | BaO | 0.02 |
| Cl (chloride) | Cl | 0.19 |
| Mn (manganese) | MnO | 0.35 |
| Sr (strontium) | SrO | 0.01 |
| Unknowns | | 21.41 |
| Total | | 99.99 |

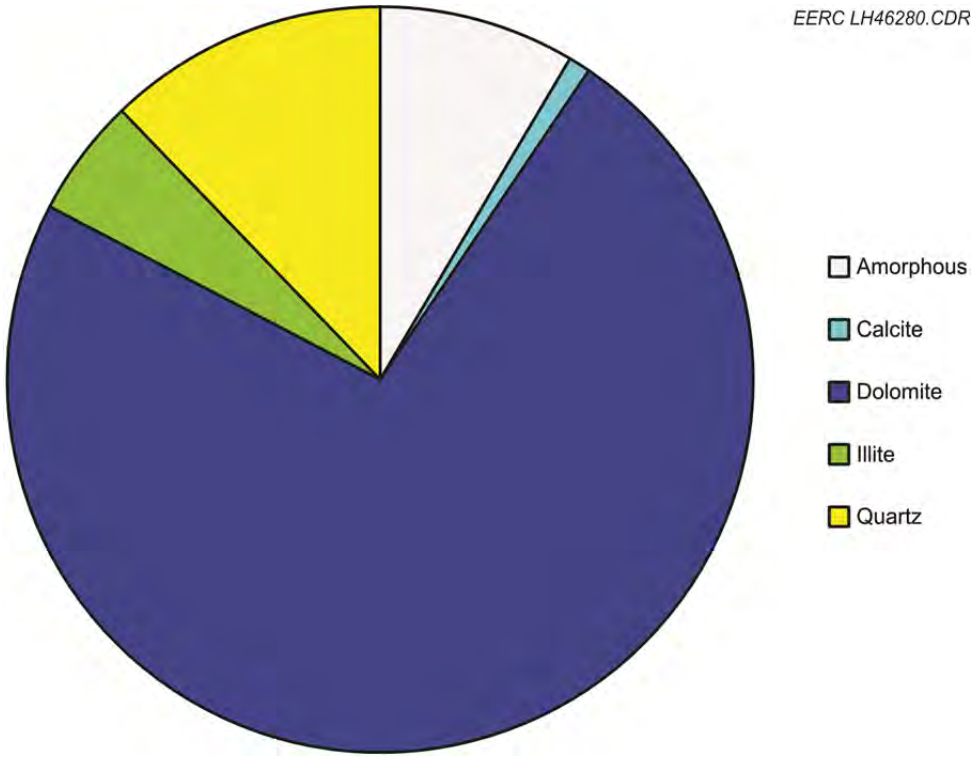
| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00769 |
| | Deadwood Formation | Lithology: Silty Dolostone | Depth: 9443.1' |

**XRD MINERAL ANALYSIS**



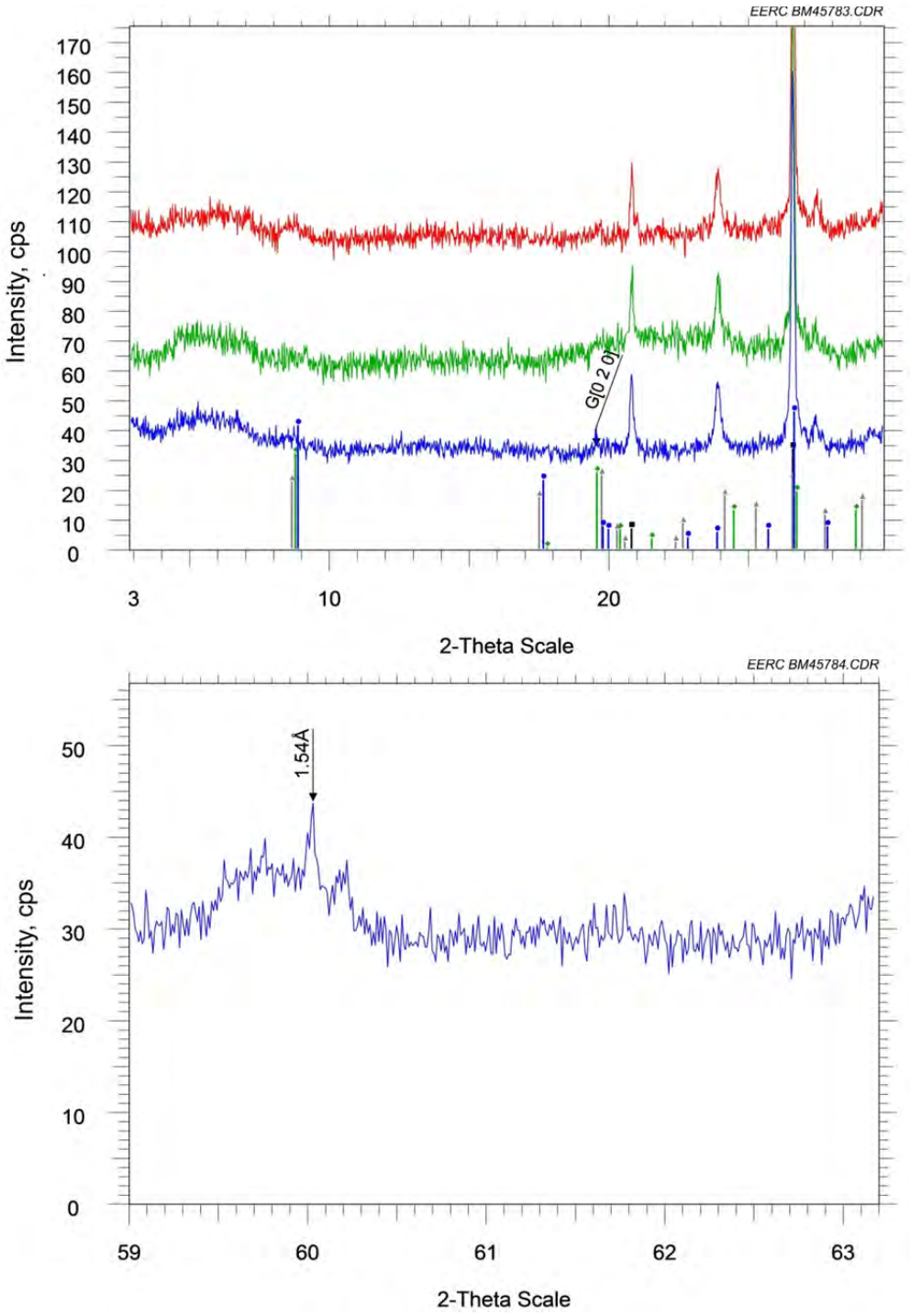
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 17467 | | ID: S-00769 |
| | Deadwood Formation | Lithology: Silty Dolostone | Depth: 9443.1' |

**XRD Mineral-Phase Distribution**




| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 8.5 | NA |
| Quartz | $SiO_2$ | 12.2 | 2.65 |
| Calcite | $CaCO_3$ | 0.9 | 2.70 |
| Dolomite | $CaMg(CO_3)_2$ | 73.2 | 2.85 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 5.1 | 2.83 |

**XRD Clay Typing**




The analyzed clay fraction contained an insignificant amount of an illitelike clay structure or any other clay. A weak peak indicates the possible presence of glauconite ([0 2 0] peak).

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| | Well Name: NDIC Well 17467 | | ID: S-00773 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9450.3' |

**SAMPLE PHOTOGRAPH**

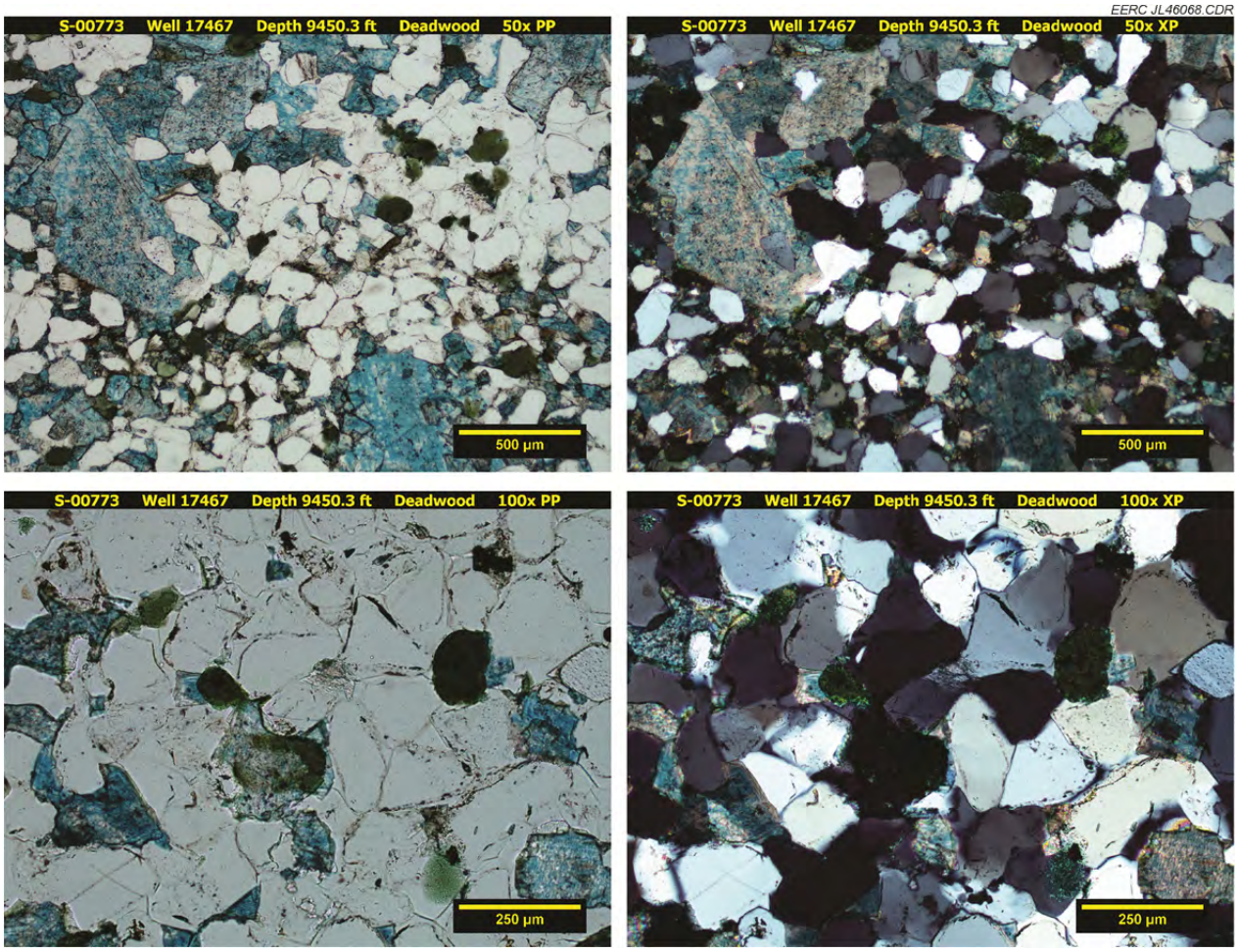



**PHYSICAL PROPERTIES**

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| 4.81 | 2.62 | 0.024 |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00773 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9450.3' |

**PHOTOMICROGRAPHS**




This sample is a moderately sorted sandstone having largely nonplanar, iron-rich dolomite. Porosity is not observed in the sample because of dolomitization and substantial quartz overgrowth. Fossils and fractures are not present within the sample.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00773 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9450.3' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 72.8 | Heavy overgrowth |
| Glauconite | 8.2 | |
| Dolomite | 18.2 | Anhedral |
| Biotite | 0.8 | |
| Porosity | 0.0 | None observed |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Shallow shelf/beach |
| Energy Environment | Medium |
| Dott Classification | Dolomitic sandstone |
| Dunham Classification | N/A |

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| | Well Name: NDIC Well 17467 | | ID: S-00772 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9459.3' |

## SAMPLE PHOTOGRAPH

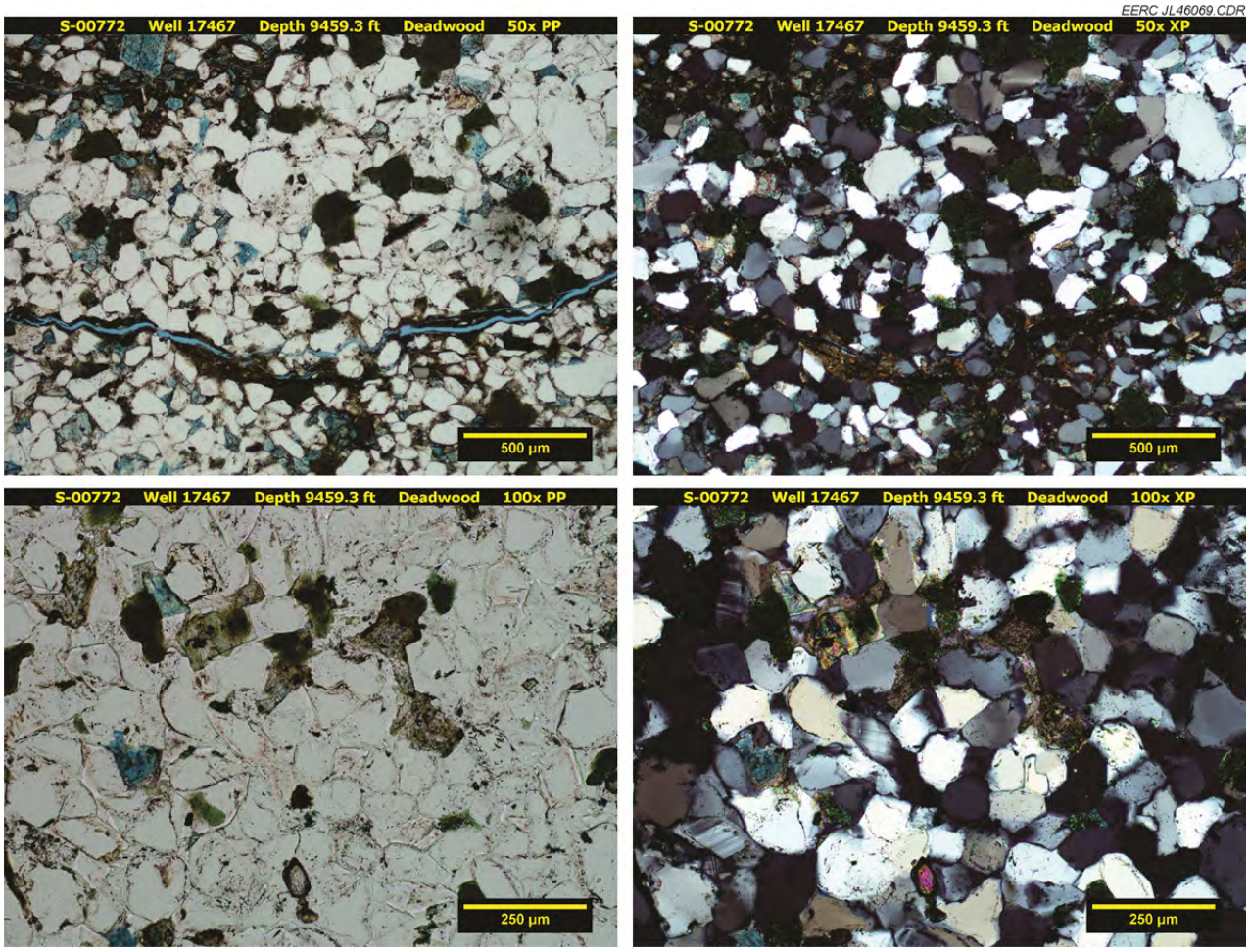



## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| 4.36 | 2.56 | 0.069 |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00772 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9459.3' |

**PHOTOMICROGRAPHS**




This sample is a fairly well sorted sandstone representing wavy to erratic clay laminations throughout the sample. Porosity is limited to fractures located within clay portions. Porosity has been replaced throughout the sample by iron-rich, nonplanar dolomite. Within the clay matrix reside rhombohedral iron-rich dolomite, silt, and pyrite. No fossils are present.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00772 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9459.3' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 78.0 | Abundant overgrowths |
| Glauconite | 8.0 | |
| Dolomite | 6.8 | Planar and nonplanar |
| Feldspars | Trace | |
| Biotite | 1.0 | |
| Clay | 4.6 | Laminations |
| Porosity | | Fractures |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Beach |
| Energy Environment | Medium |
| Dott Classification | Glauconitic sandstone |
| Dunham Classification | N/A |

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|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00771 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9462.1' |

## SAMPLE PHOTOGRAPH

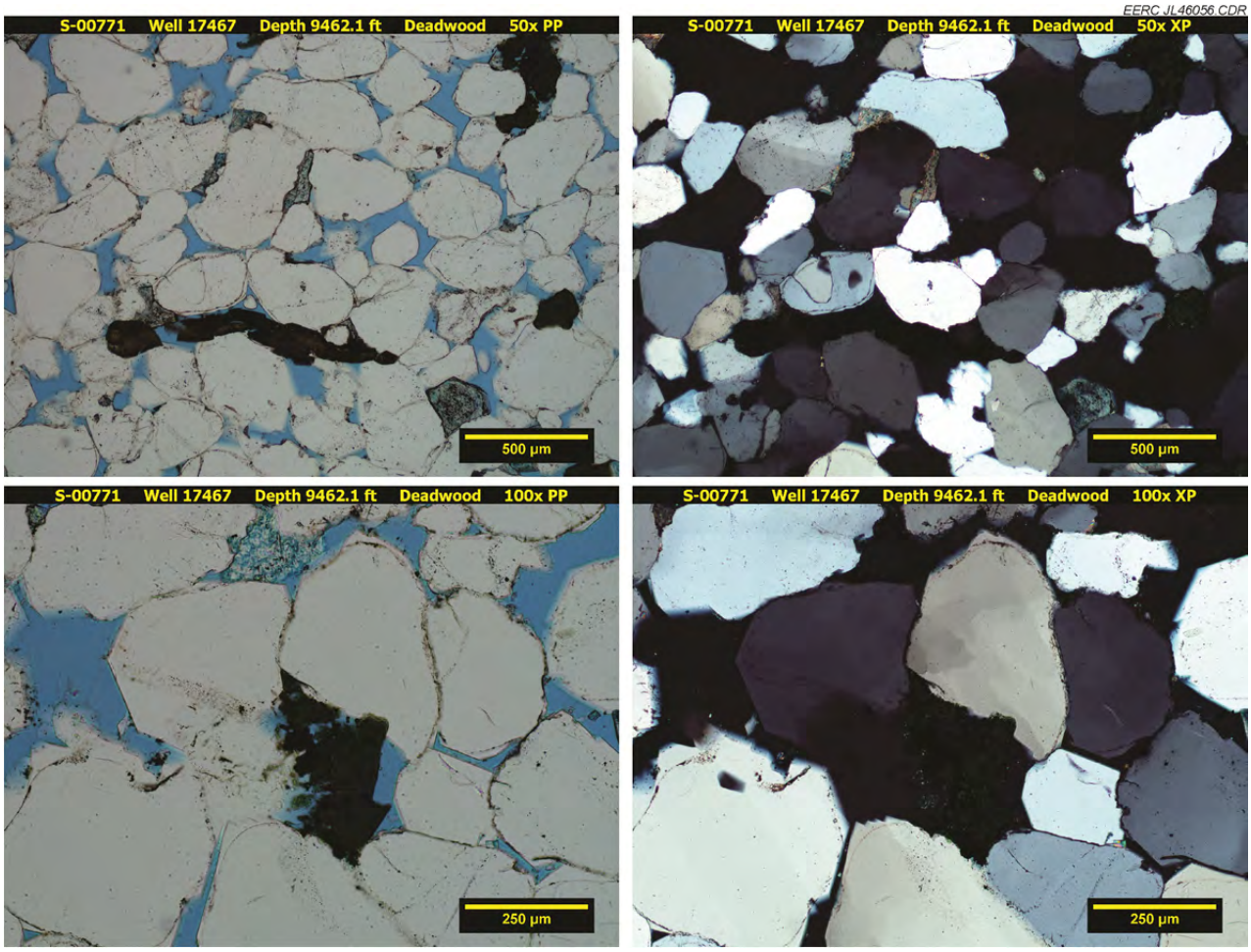



## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| 14.7 | 2.26 | 528.2 |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 17467 | | ID: S-00771 |
| | Deadwood Formation | Lithology: Sandstone | Depth: 9462.1' |

**PHOTOMICROGRAPHS**




This sample is a fine- to coarse-grained lithic arenitic sandstone. This fairly well sorted sample expresses mostly subrounded grains having intergranular porosity. Mineral dissolution is widespread throughout, represented by the partial glauconite grains and the minor amounts of micritic cement still in existence. Compaction is most severe at this interval as shown by the physical alteration (breaking/crushing) of glauconite and biotite grains. Porosity is further reduced by quartz overgrowths and dolomitization. There is no evidence of fractures and fossilization.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 17467 | | ID: S-00771 |
| Deadwood Formation | Lithology: Sandstone | Depth: 9462.1' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 83.8 | Noncemented |
| Glauconite | 2.6 | |
| Dolomite | 3.0 | Well-formed rhombs |
| Biotite | 0.2 | |
| Porosity | 10.4 | Intergranular |

### Texture

| Category | Classification |
|---|---|
| Grain Size, µm | 62–500 |
| Grain-Size Distribution | Very fine to coarse |
| Sorting | Moderately sorted |
| Roundness | Angular to well rounded |

### Fabric

| Category | Classification |
|---|---|
| Orientation | Weakly |
| Support | Grain |
| Packing | Moderate |

### Contacts

| Category | Occurrence |
|---|---|
| Point | Abundant |
| Long | Abundant |
| Concave–Convex | Common |
| Sutured | Occasional |
| Floating | None |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Beach |
| Energy Environment | High |
| Dott Classification | Quartz arenite sandstone |
| Dunham Classification | N/A |

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| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11789.5' |

## SAMPLE PHOTOGRAPH

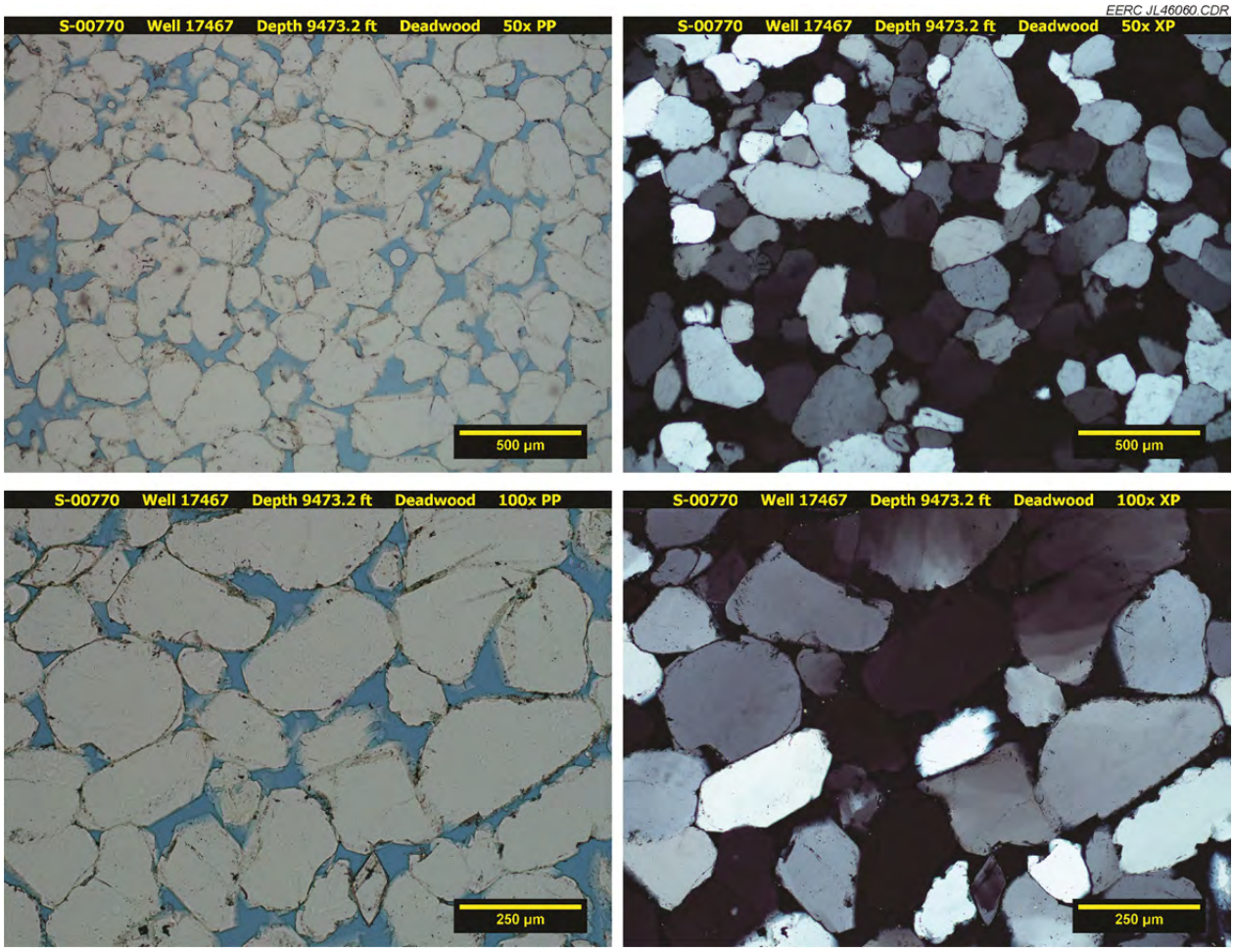



## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| 16.8 | 2.18 | 654.2 |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11789.5' |

**PHOTOMICROGRAPHS**




This sample is a fine-grained arenitic sandstone. This fairly well sorted sample expressing subangular to rounded grains has intergranular porosity. The quartz shows both overgrowths and dissolution. Trace levels of metals and biotite are observed. No evidence of fracturing or fossilization is noted.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11789.5' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 85.6 | Well-sorted |
| Biotite | 0.4 | |
| Feldspars | 0.2 | |
| Pyrite | 0.2 | |
| Porosity | 13.6 | Intergranular |

### Texture

| Category | Classification |
|---|---|
| Grain Size, µm | 62–500 |
| Grain-Size Distribution | Very fine to coarse |
| Sorting | Moderately sorted |
| Roundness | Angular to well rounded |

### Fabric

| Category | Classification |
|---|---|
| Orientation | Weakly |
| Support | Grain |
| Packing | Moderate |

### Contacts

| Category | Occurrence |
|---|---|
| Point | Abundant |
| Long | Abundant |
| Concave–Convex | Common |
| Sutured | Occasional |
| Floating | Rare |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Beach |
| Energy Environment | High |
| Dott Classification | Quartz arenite sandstone |
| Dunham Classification | N/A |

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| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |

## SAMPLE PHOTOGRAPH

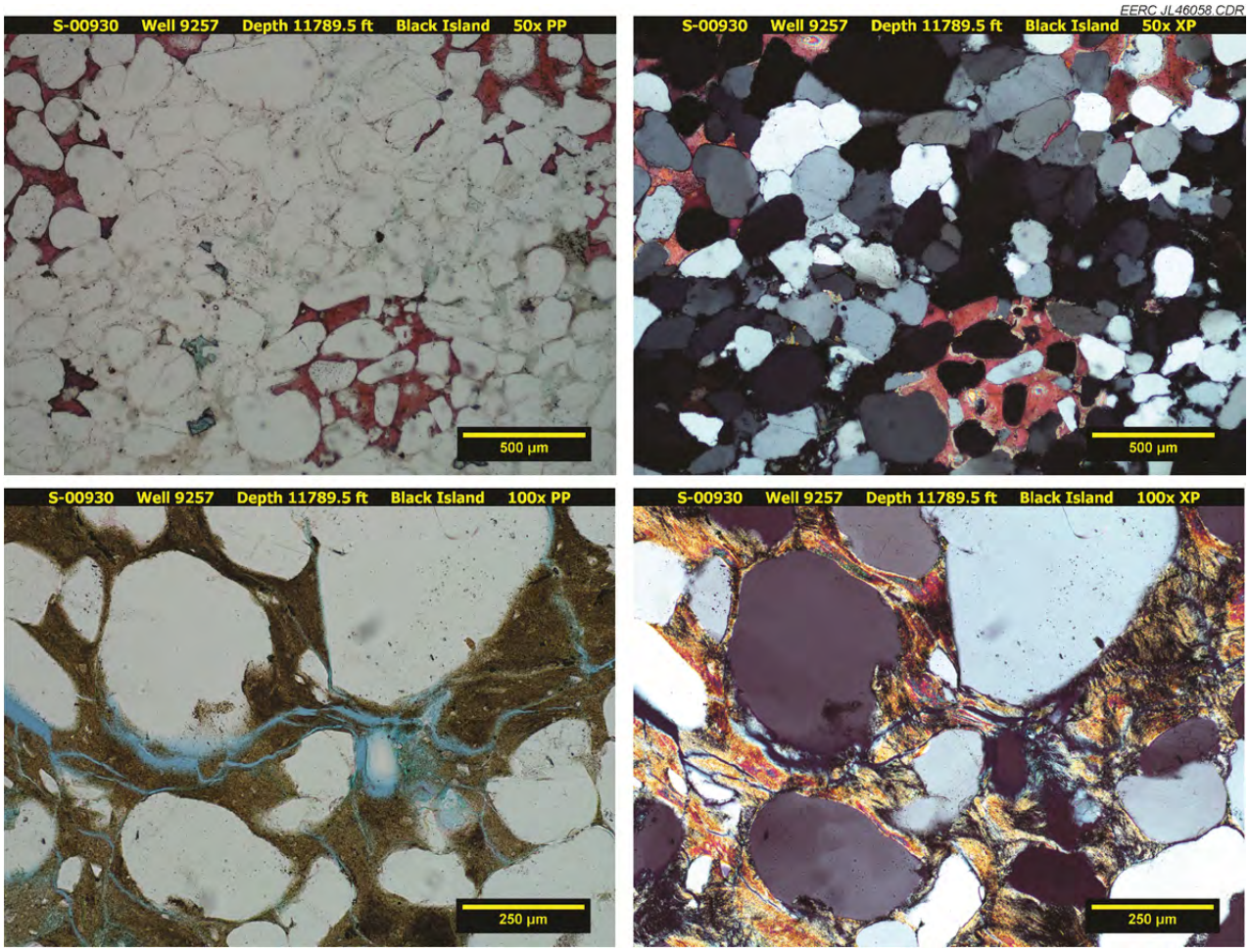



## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |

**PHOTOMICROGRAPHS**




This moderately sorted sample contains predominantly quartz grains cemented by micrite, quartz, and clay. Porosity is preserved as fractures and cement dissolution. Grains display a higher degree of roundness than others in the sample set. Concentrations of quartz overgrowths occur randomly within the sample. Trace amounts of biotite, pyrite, and subplanar iron-rich dolomite are noted. The sample contains no fossils.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

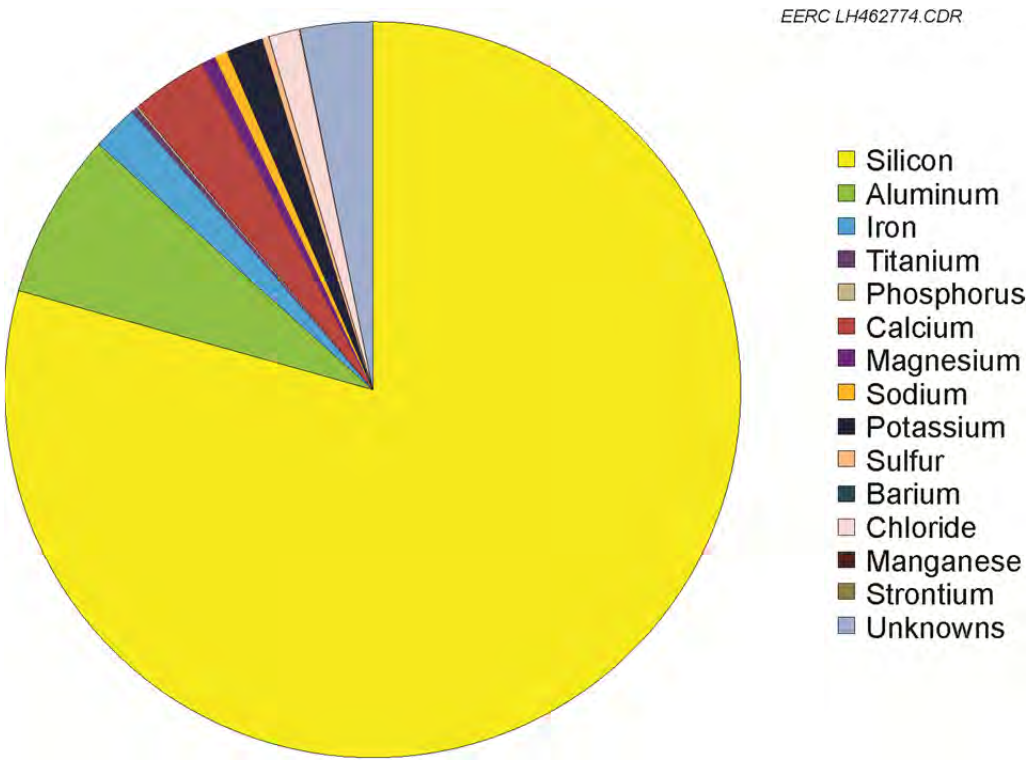
| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 79.8 | Monocrystalline |
| Pyrite | Trace | |
| Calcite | 8.2 | Cement |
| Clay | 7.4 | Cement, laminations |
| Porosity | 4.6 | Fractures, cement dissolution |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Tidal flats |
| Energy Environment | Low–medium |
| Dott Classification | Calcareous sandstone |
| Dunham Classification | N/A |

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 9257 | | ID: S-00930 |
| Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |

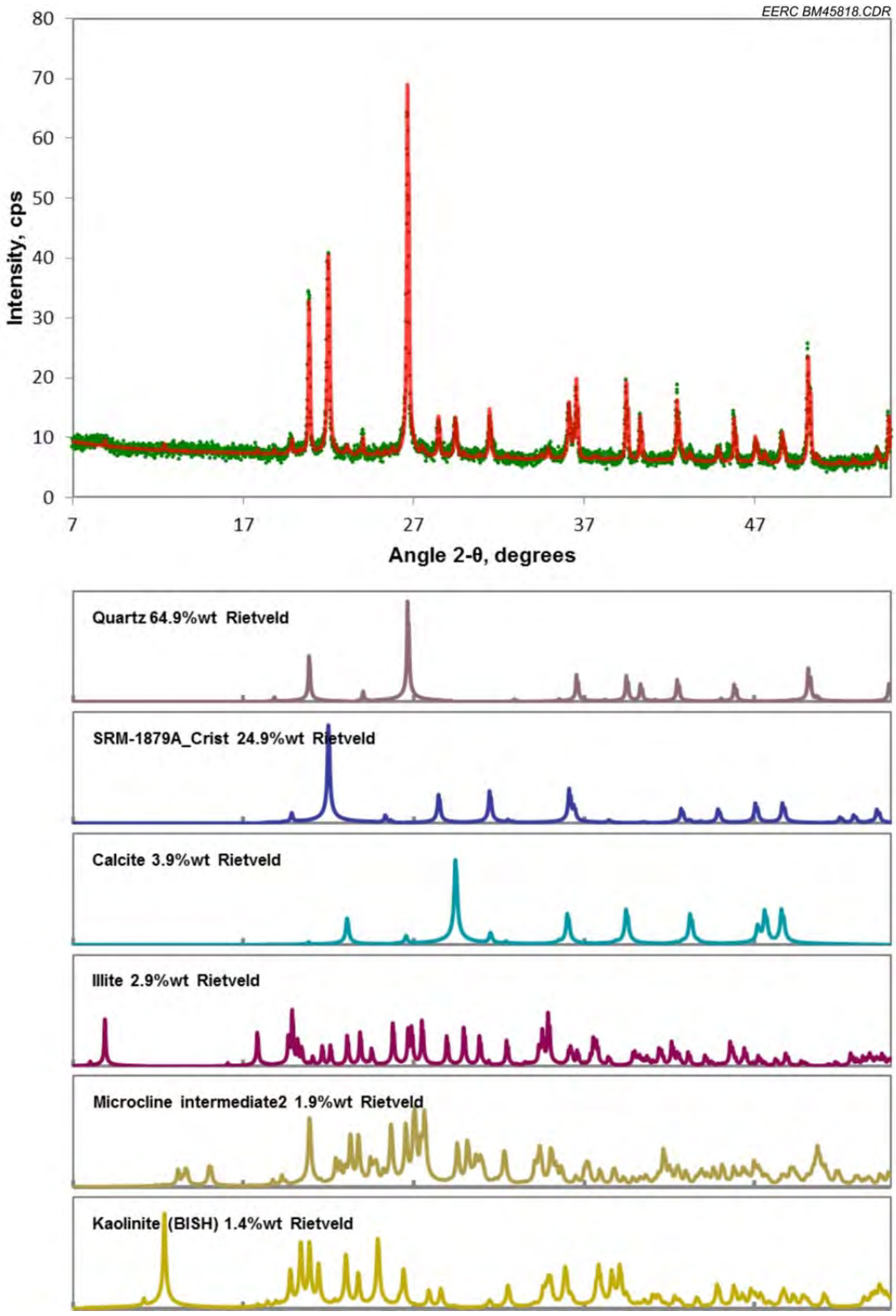
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 79.34 |
| Al (aluminum) | $Al_2O_3$ | 7.28 |
| Fe (iron) | $Fe_2O_3$ | 2.02 |
| Ti (titanium) | $TiO_2$ | 0.28 |
| P (phosphorus) | $P_2O_5$ | 0.07 |
| Ca (calcium) | CaO | 3.34 |
| Mg (magnesium) | MgO | 0.63 |
| Na (sodium) | $Na_2O$ | 0.57 |
| K (potassium) | $K_2O$ | 1.64 |
| S (sulfur) | $SO_3$ | 0.27 |
| Ba (barium) | BaO | 0.01 |
| Cl (chloride) | Cl | 1.34 |
| Mn (manganese) | MnO | 0.02 |
| Sr (strontium) | SrO | 0.02 |
| Unknowns | | 3.18 |
| Total | | 100.00 |

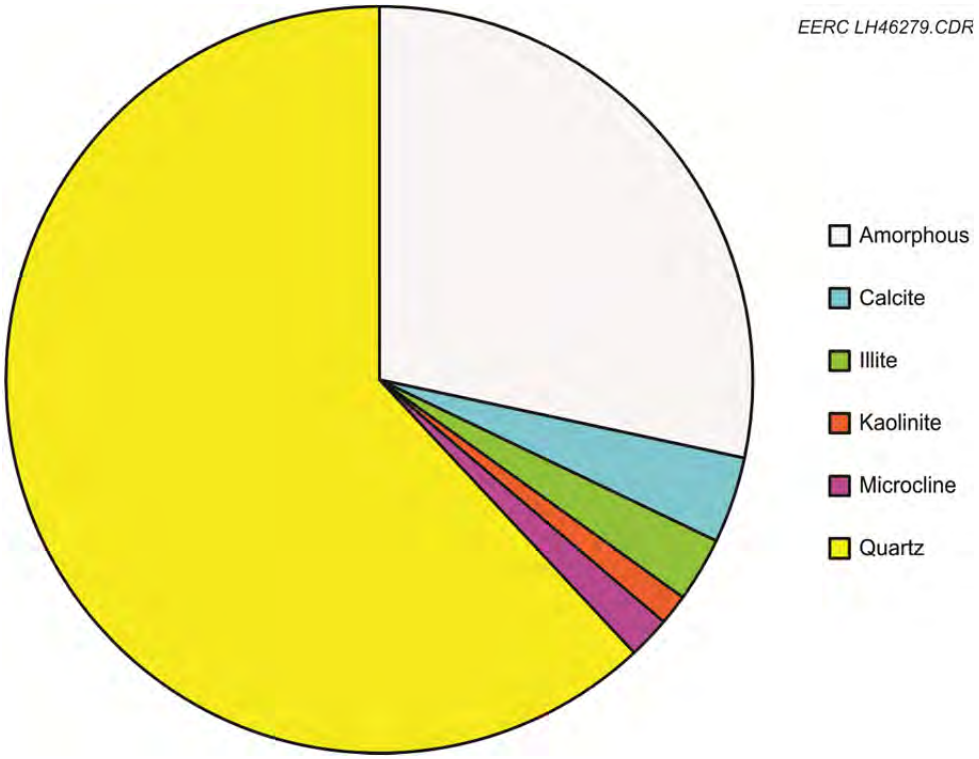
| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |

**XRD MINERAL ANALYSIS**



| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |

**XRD Mineral-Phase Distribution**



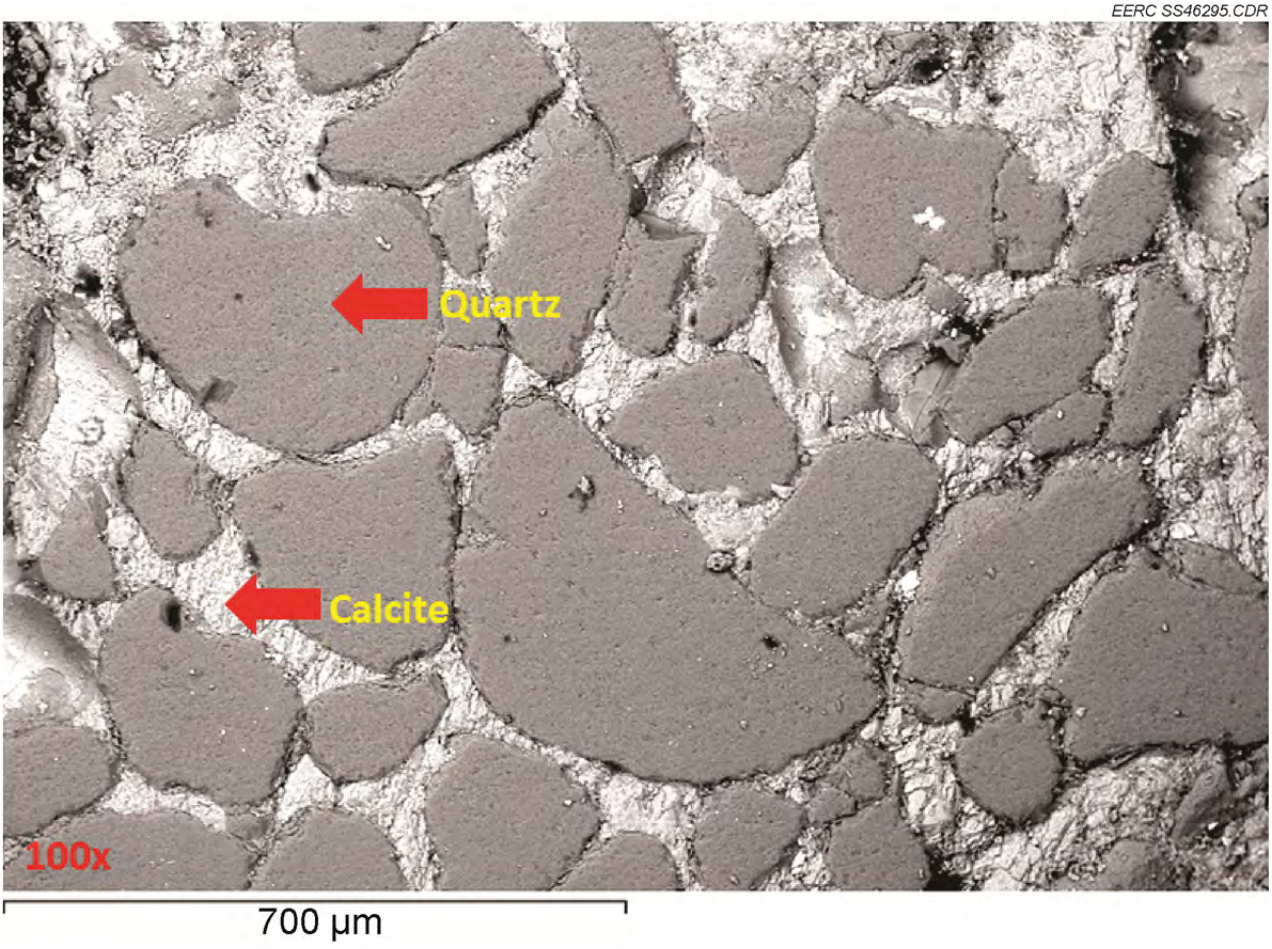

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 28.4 | NA |
| Quartz | $SiO_2$ | 61.9 | 2.65 |
| Calcite | $CaCO_3$ | 3.7 | 2.72 |
| Kaolinite | $Al_2Si_2O_6(OH)_4$ | 1.3 | 2.53 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 2.8 | 2.80 |
| Microcline | $KAlSi_3O_8$ | 1.8 | 2.55 |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |

**SEM**

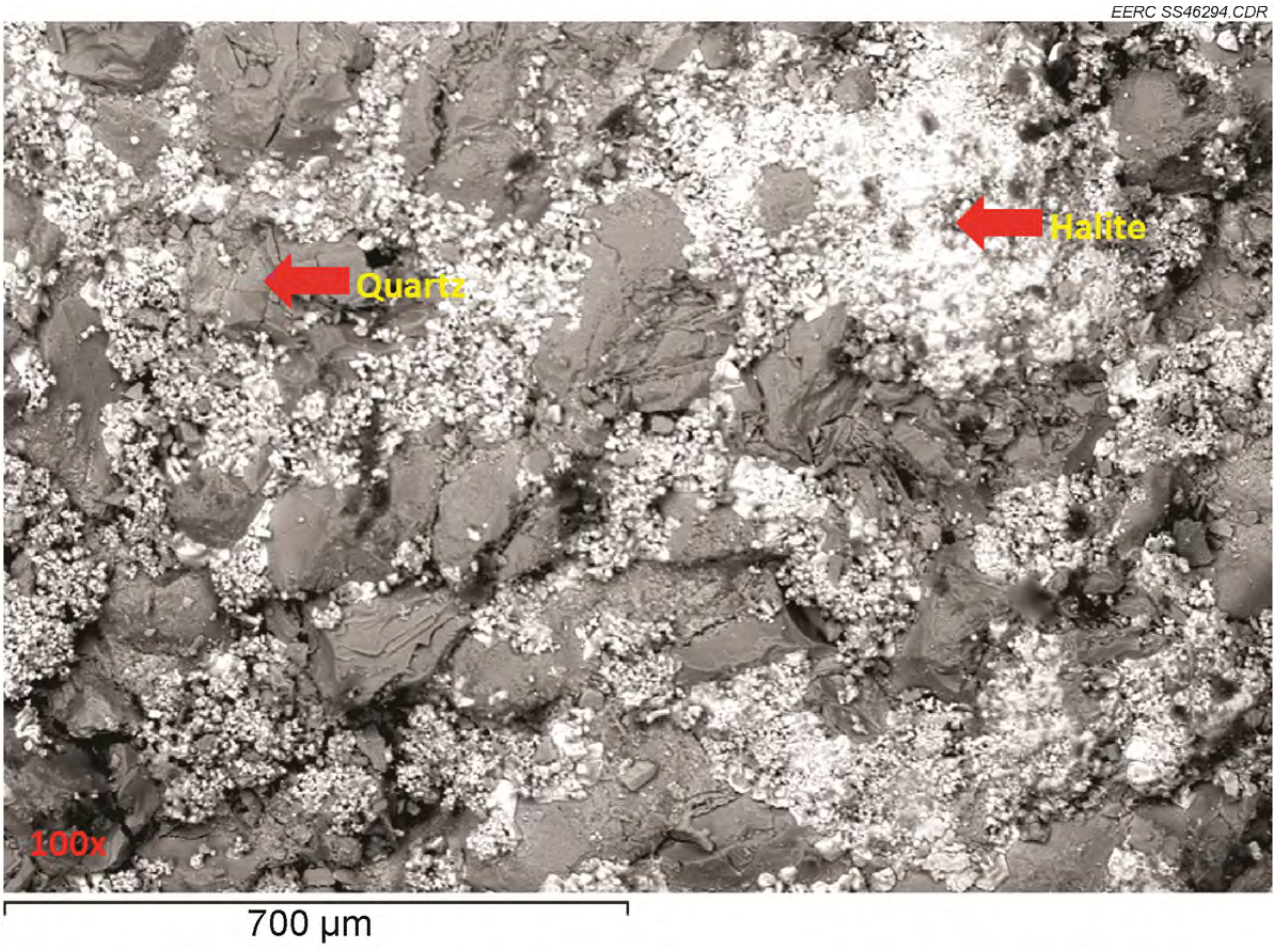
| Observed Mineral Phases in All SEM Analyses |
|---|
| Illite |
| Quartz |
| Halite |
| Calcite |
| Pyrite |
| Rutile |

**Annotated High-Magnification BSE Images**




The BSE image shows calcite cement as the matrix material in a predominantly sandstone rock sample.

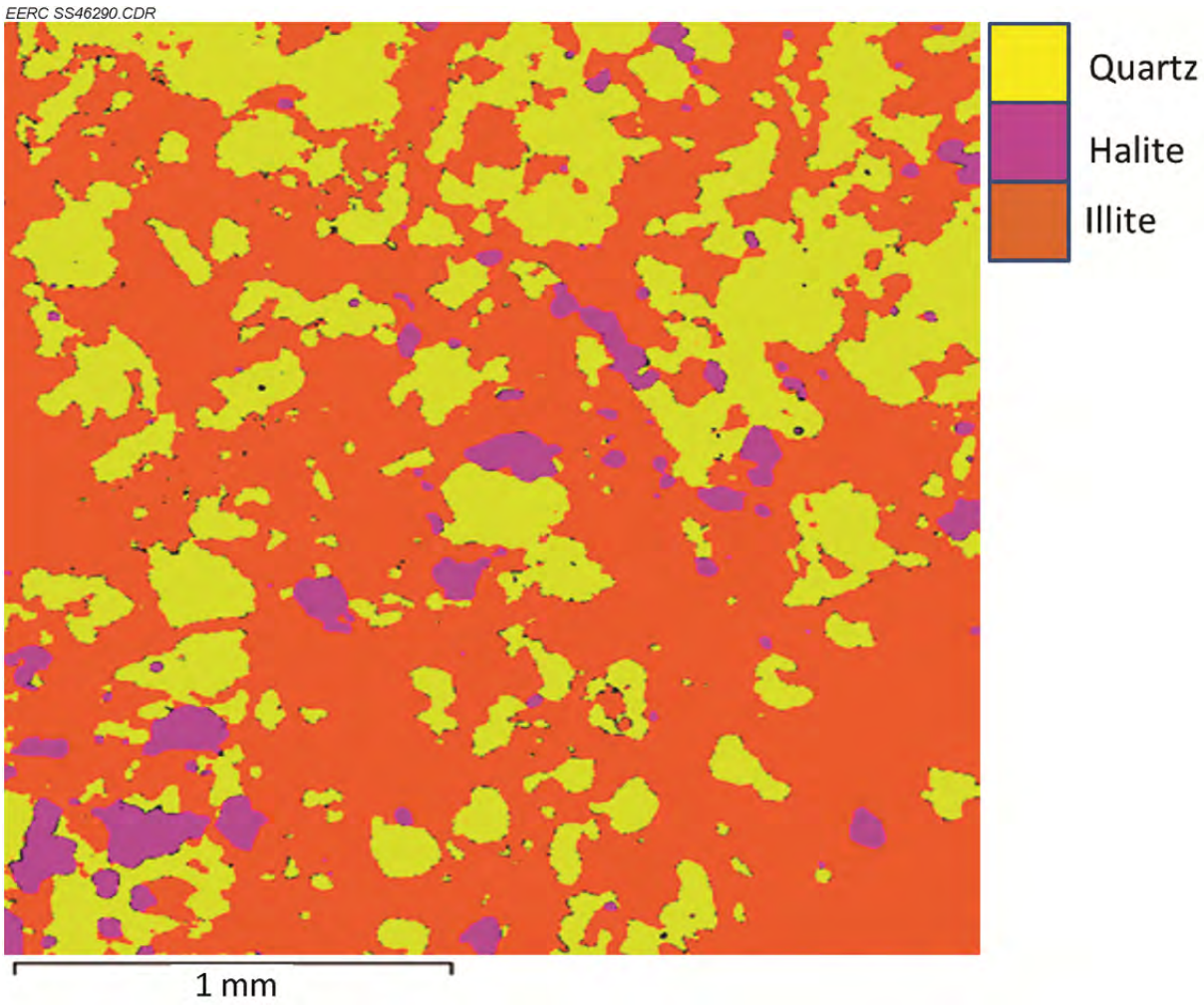
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00930 |
| | Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |




This image shows another view of the sample in an area that has halite mineral phase as the major matrix material.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 9257 | | ID: S-00930 |
| Black Island Formation | Lithology: Sandstone | Depth: 11,789.5' |

**Mineral Map**




The mineral map shows halite present in a predominantly quartz and clay (illite) rock sample.

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| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**SAMPLE PHOTOGRAPH**

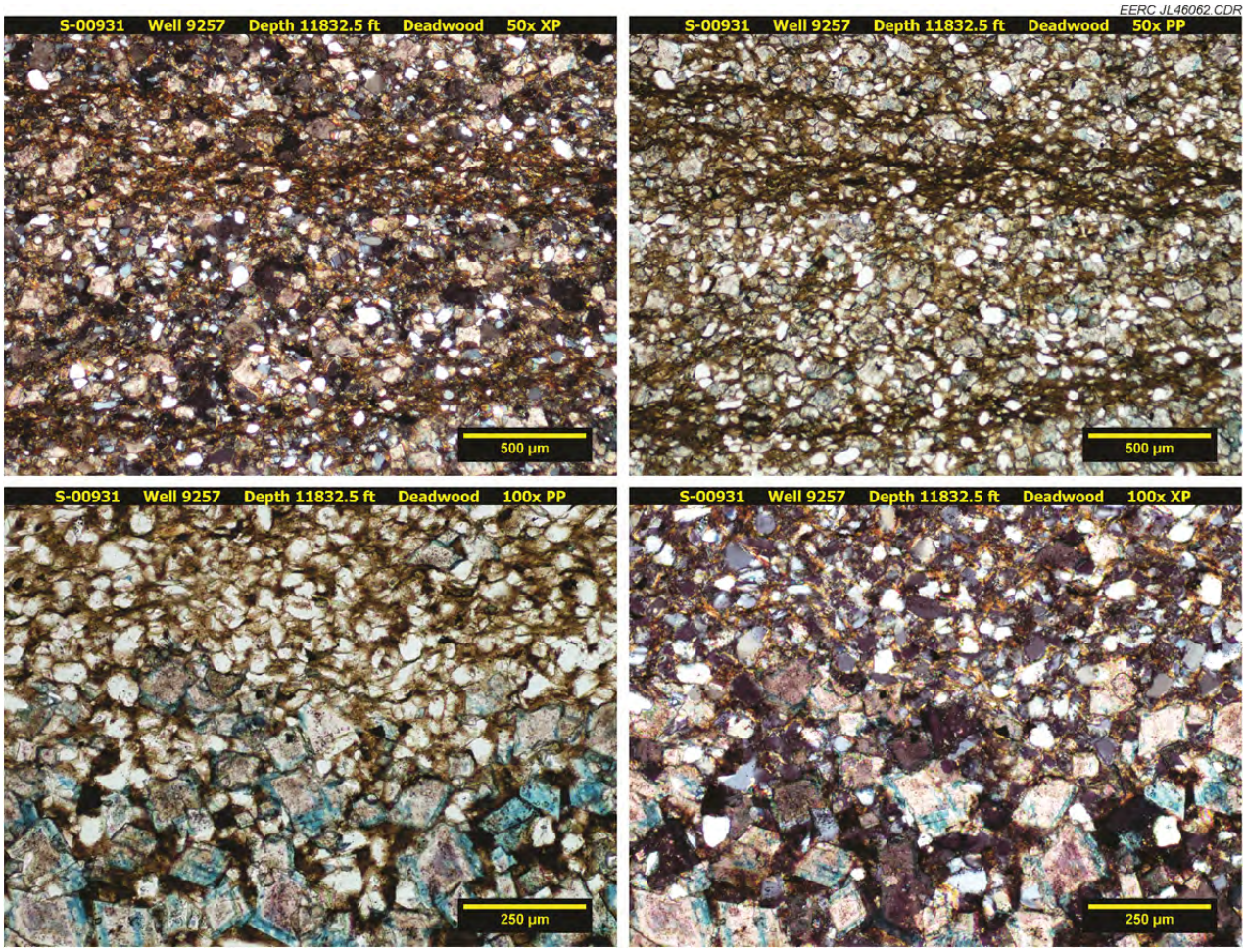



**PHYSICAL PROPERTIES**

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | Applied Geology Laboratory | | |
|---|---|---|---|
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**PHOTOMICROGRAPHS**




This sample is a fine-grained mix of predominantly quartz, subhedral dolomite, and clays. This moderately well sorted rock has quartz displaying varying degrees of grain sphericity and roundness residing within a clay matrix. Dolomite is noninterlocking and has a small degree of iron staining. Trace amounts of muscovite, biotite, pyrite, and feldspars are detected. No fossils are observed in this thin section.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

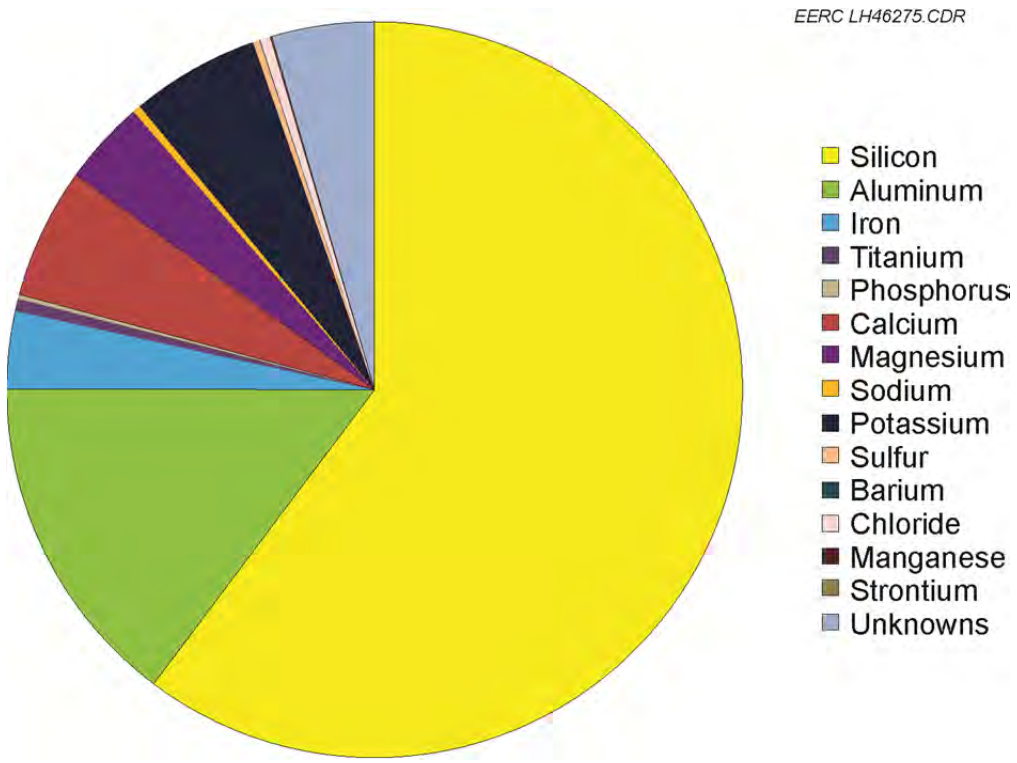
| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 31.0 | Abundantly monocrystalline |
| Dolomite | 26.8 | Subhedral–rhombohedral |
| Pyrite | 0.6 | |
| Biotite | 2.0 | |
| Clay | 39.0 | Laminations |
| Porosity | 0.4 | Fractures |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Lagoonal |
| Energy Environment | Low |
| Dott Classification | N/A |
| Dunham Classification | Dolomitic grainstone |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

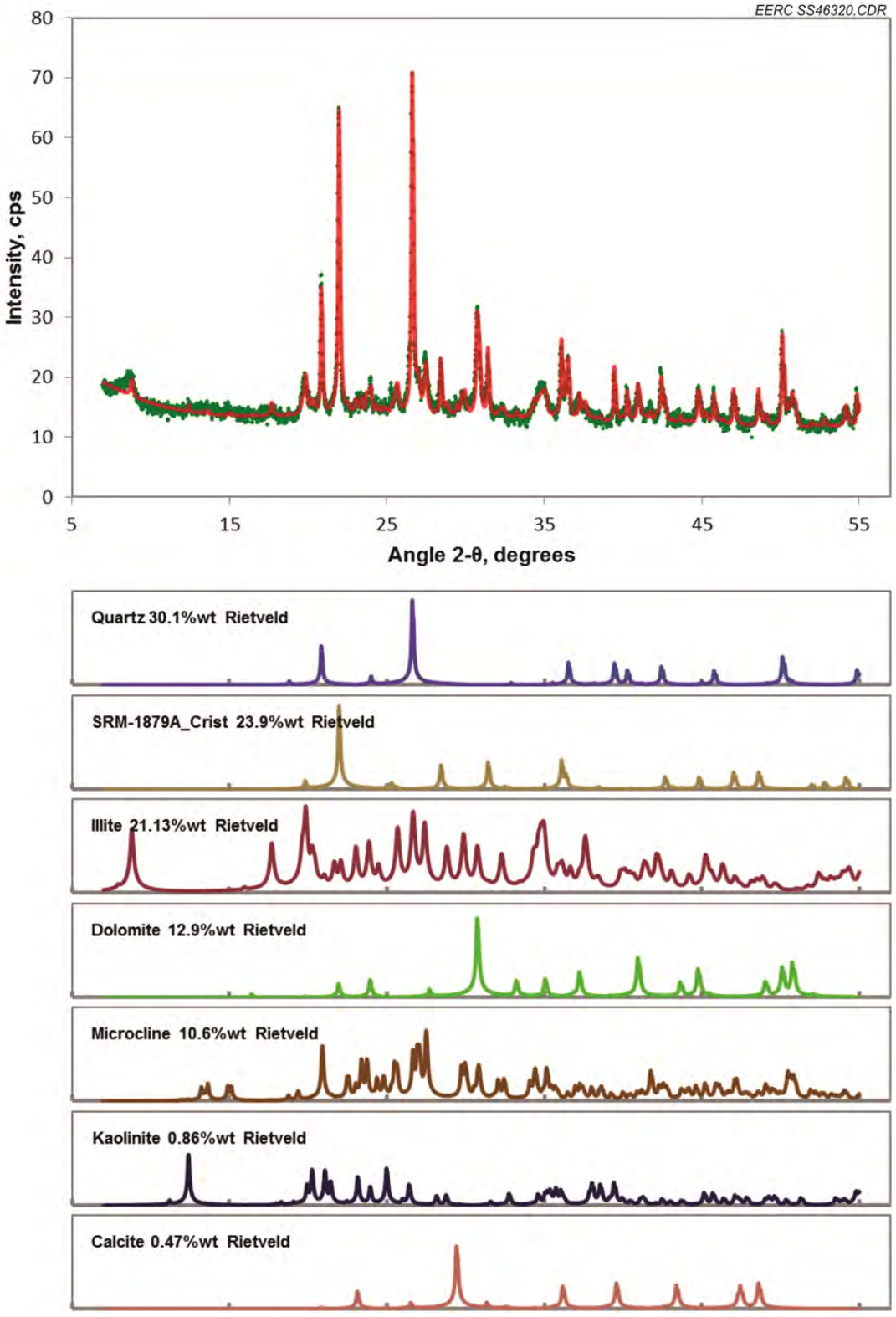
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 60.25 |
| Al (aluminum) | $Al_2O_3$ | 14.78 |
| Fe (iron) | $Fe_2O_3$ | 3.42 |
| Ti (titanium) | $TiO_2$ | 0.55 |
| P (phosphorus) | $P_2O_5$ | 0.17 |
| Ca (calcium) | CaO | 5.76 |
| Mg (magnesium) | MgO | 3.72 |
| Na (sodium) | $Na_2O$ | 0.34 |
| K (potassium) | $K_2O$ | 5.66 |
| S (sulfur) | $SO_3$ | 0.29 |
| Ba (barium) | BaO | 0.04 |
| Cl (chloride) | Cl | 0.44 |
| Mn (manganese) | MnO | 0.05 |
| Sr (strontium) | SrO | 0.02 |
| Unknowns | | 4.51 |
| Total | | 100.00 |

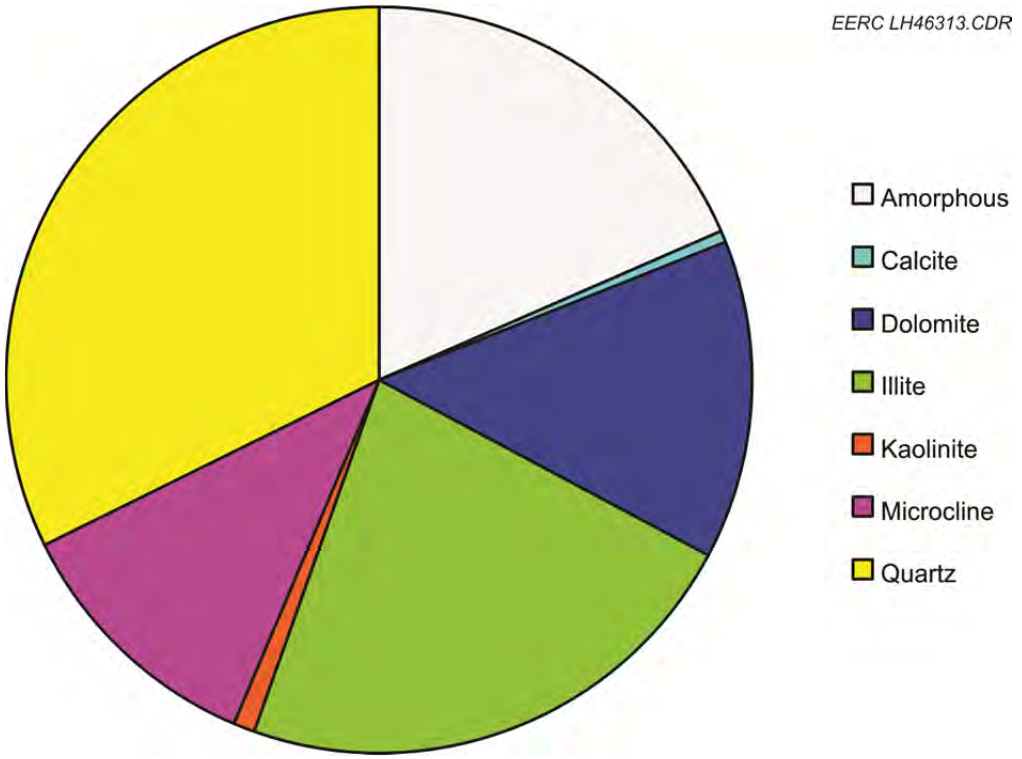
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**XRD MINERAL ANALYSIS**



| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**XRD Mineral-Phase Distribution**



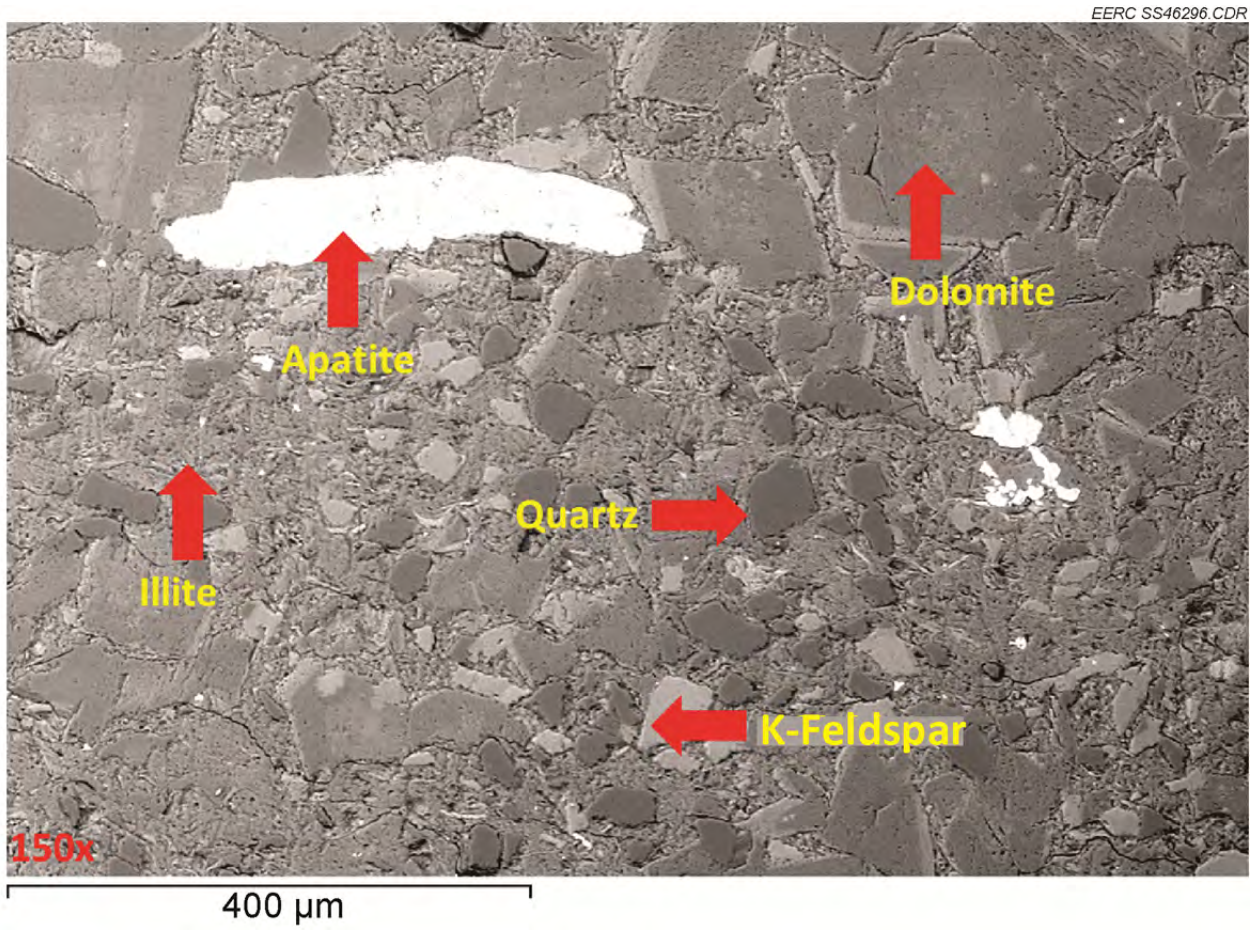

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 18.5 | NA |
| Quartz | $SiO_2$ | 32.3 | 2.65 |
| Calcite | $CaCO_3$ | 0.5 | 2.74 |
| Dolomite | $CaMg(CO_3)_2$ | 13.8 | 2.82 |
| Kaolinite | $Al_2Si_2O_6(OH)_4$ | 0.9 | 2.56 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 22.7 | 2.79 |
| Microcline | $KAlSi_3O_8$ | 11.3 | 2.56 |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**SEM**

| Observed Mineral Phases in All SEM Analyses |
|---|
| Quartz |
| Dolomite |
| K-Feldspar |
| Apatite |
| Illite |

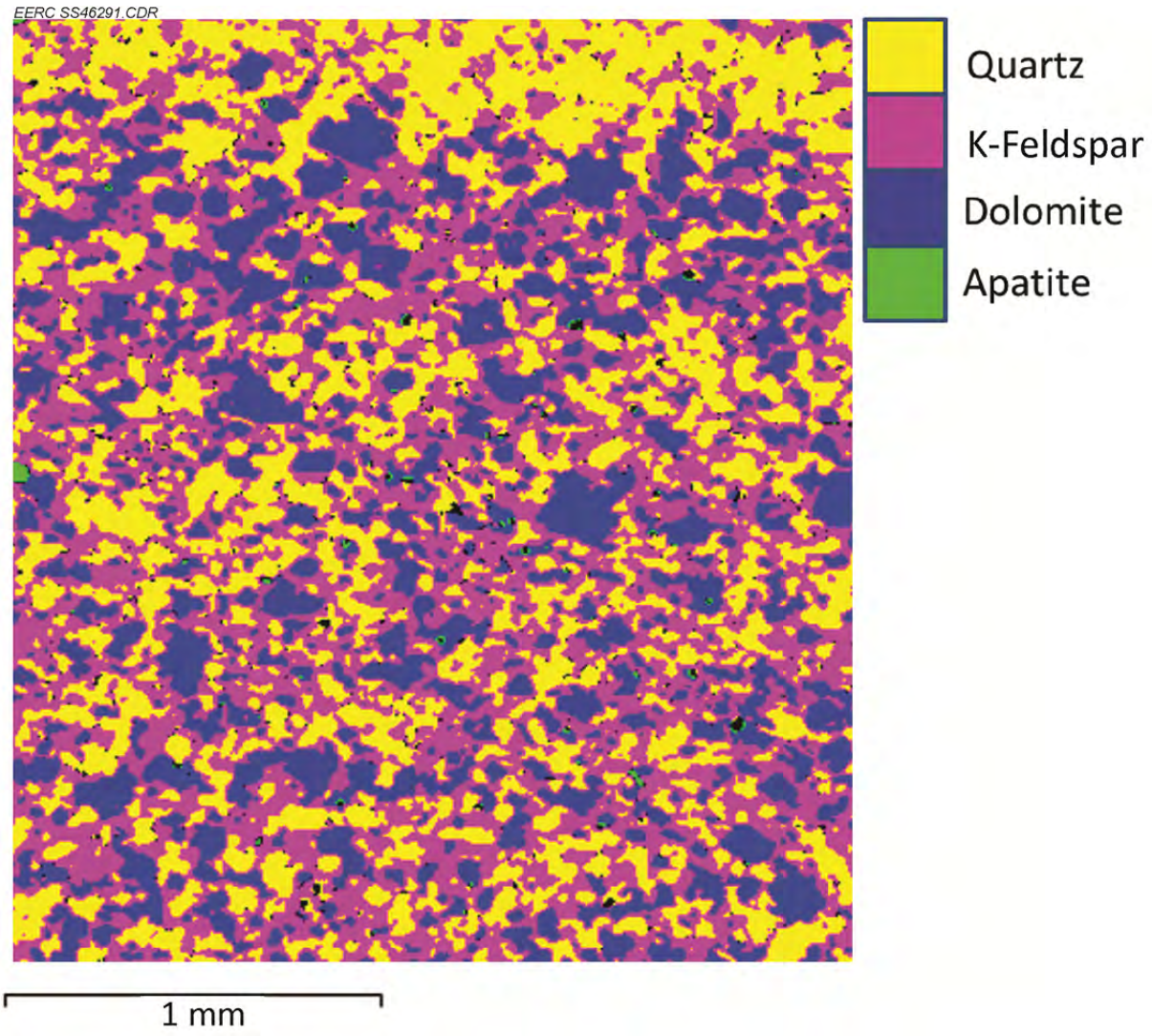
**Annotated High-Magnification BSE Image**




The BSE image shows the major mineral phases, including dolomite, quartz, K-feldspar, and illite, with apatite as the minor accessory mineral.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 9257 | | ID: S-00932 |
| Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**Composite Mineral Map**




This mineral map is a composite of 44 frames showing the major phases: quartz, dolomite, and K-feldspar, with apatite as a minor, accessory mineral phase.

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

## SAMPLE PHOTOGRAPH

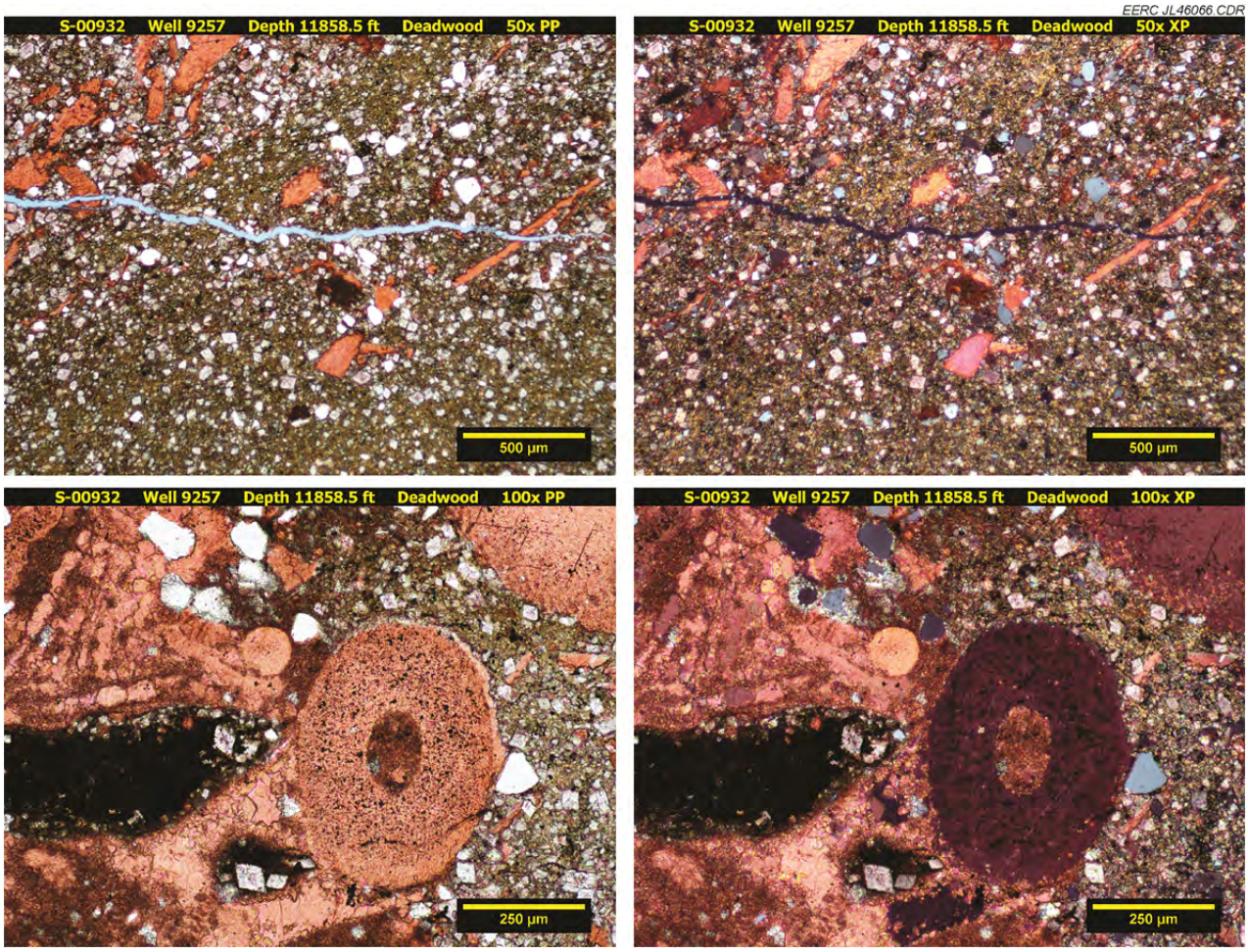



## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**PHOTOMICROGRAPHS**




This sample is a tight, fossil-rich carbonate grainstone expressing porosity in the form of fractures. This fine-grained sample shows recrystallized zones of dolomitization expressing many well-defined rhombs. Much of the sample is supported by a mix of micrite and clay. Calcite is preserved both as crystals and as lime mud. Trace amounts of quartz and pyrite were observed. The circular fossil is an example of a crinoid.

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

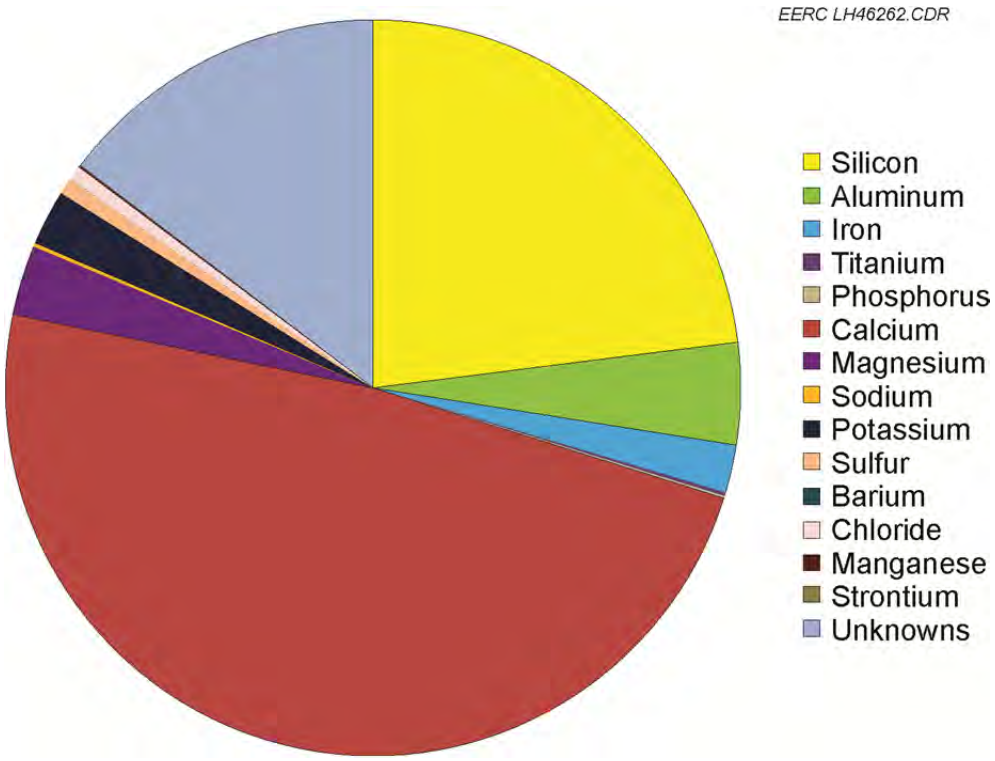
| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 2.4 | Randomly dispersed |
| Sparite | 8.0 | Fossils |
| Dolomite | 22.2 | Subhedral–rhombohedral |
| Clay | 5.2 | Matrix |
| Micrite | 61.6 | Matrix |
| Porosity | 0.6 | Fractures |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Shallow shelf |
| Energy Environment | Low–medium |
| Dott Classification | N/A |
| Dunham Classification | Dolomitic grainstone |

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 9257 | | ID: S-00932 |
| Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

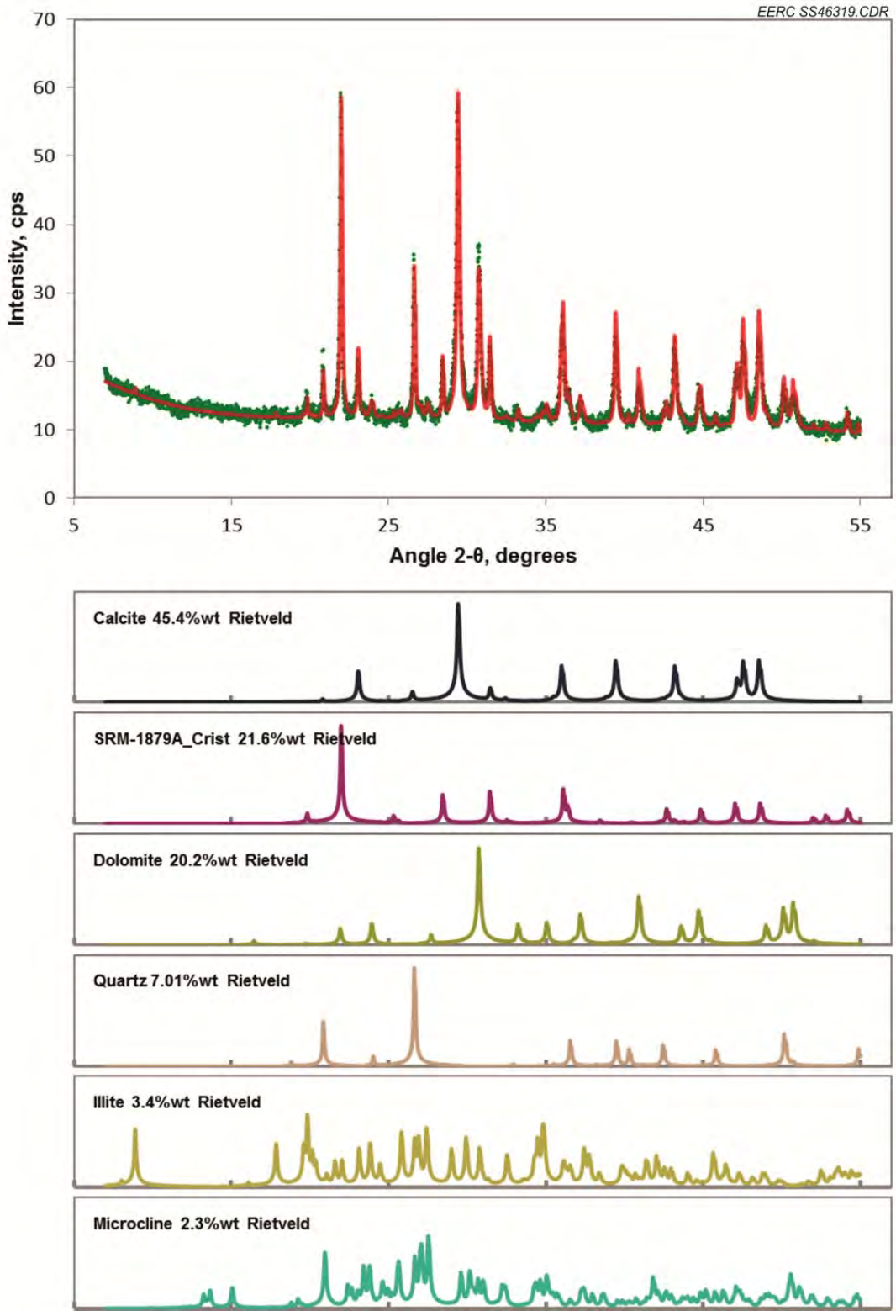
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 23.01 |
| Al (aluminum) | $Al_2O_3$ | 4.47 |
| Fe (iron) | $Fe_2O_3$ | 2.12 |
| Ti (titanium) | $TiO_2$ | 0.16 |
| P (phosphorus) | $P_2O_5$ | 0.09 |
| Ca (calcium) | CaO | 48.36 |
| Mg (magnesium) | MgO | 3.08 |
| Na (sodium) | $Na_2O$ | 0.16 |
| K (potassium) | $K_2O$ | 2.44 |
| S (sulfur) | $SO_3$ | 0.72 |
| Ba (barium) | BaO | 0.01 |
| Cl (chloride) | Cl | 0.63 |
| Mn (manganese) | MnO | 0.08 |
| Sr (strontium) | SrO | 0.02 |
| Unknowns | | 14.66 |
| Total | | 99.99 |

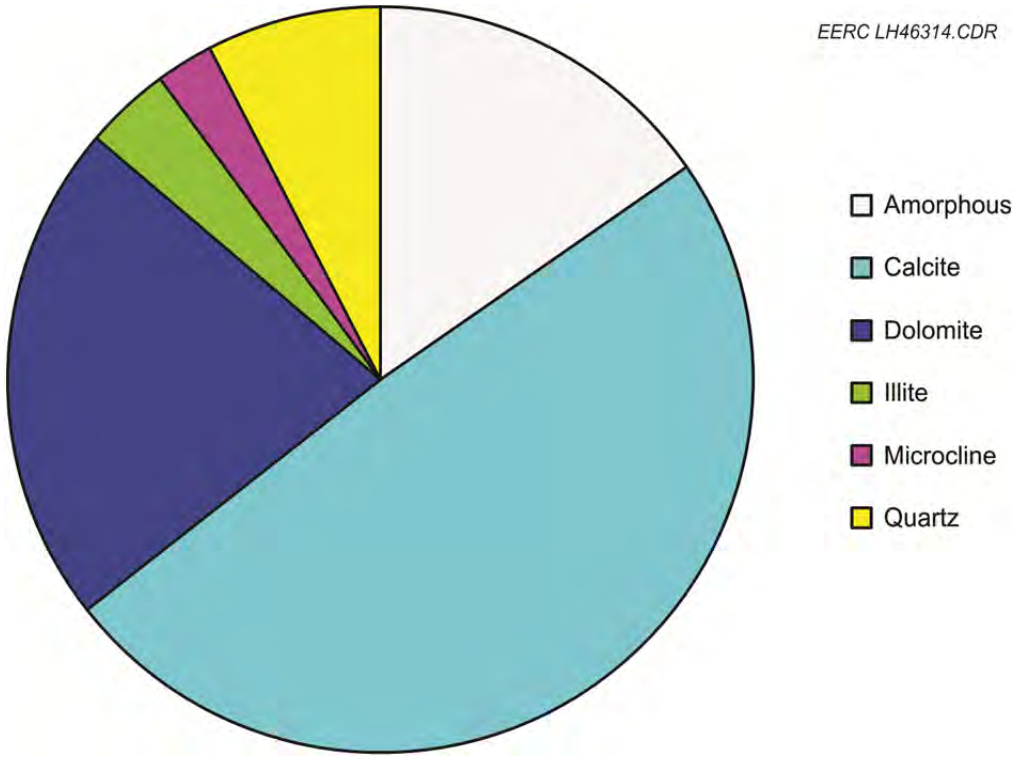
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**XRD MINERAL ANALYSIS**



| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**XRD Mineral-Phase Distribution**



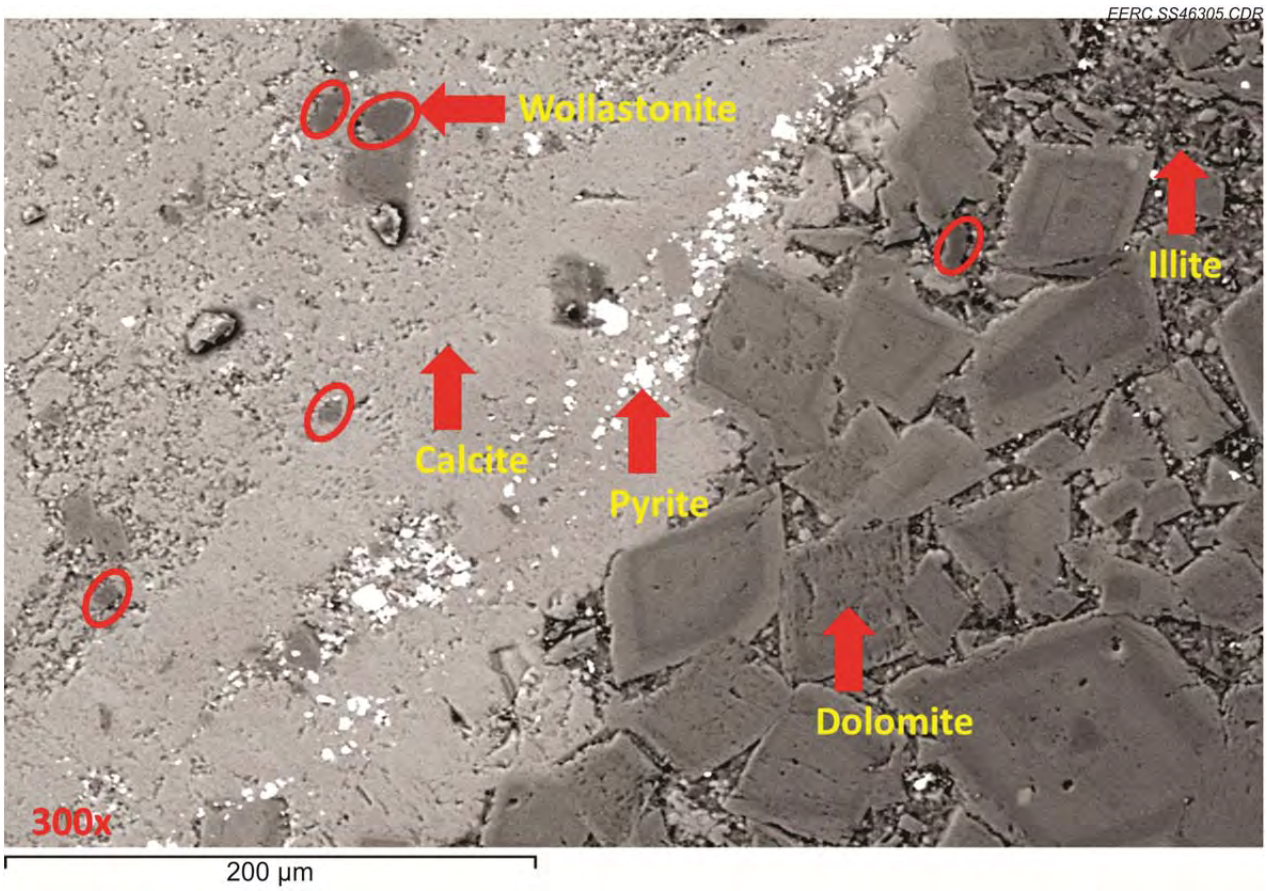

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 15.3 | NA |
| Quartz | $SiO_2$ | 7.6 | 2.65 |
| Calcite | $CaCO_3$ | 49.1 | 2.72 |
| Dolomite | $CaMg(CO_3)_2$ | 21.8 | 2.81 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 3.7 | 2.79 |
| Microcline | $KAlSi_3O_8$ | 2.5 | 2.57 |

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 9257 | | ID: S-00932 |
| Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**SEM**

| Observed Mineral Phases in All SEM Analyses |
|---|
| Calcite |
| Dolomite |
| Pyrite |
| Illite |
| Wollastonite |

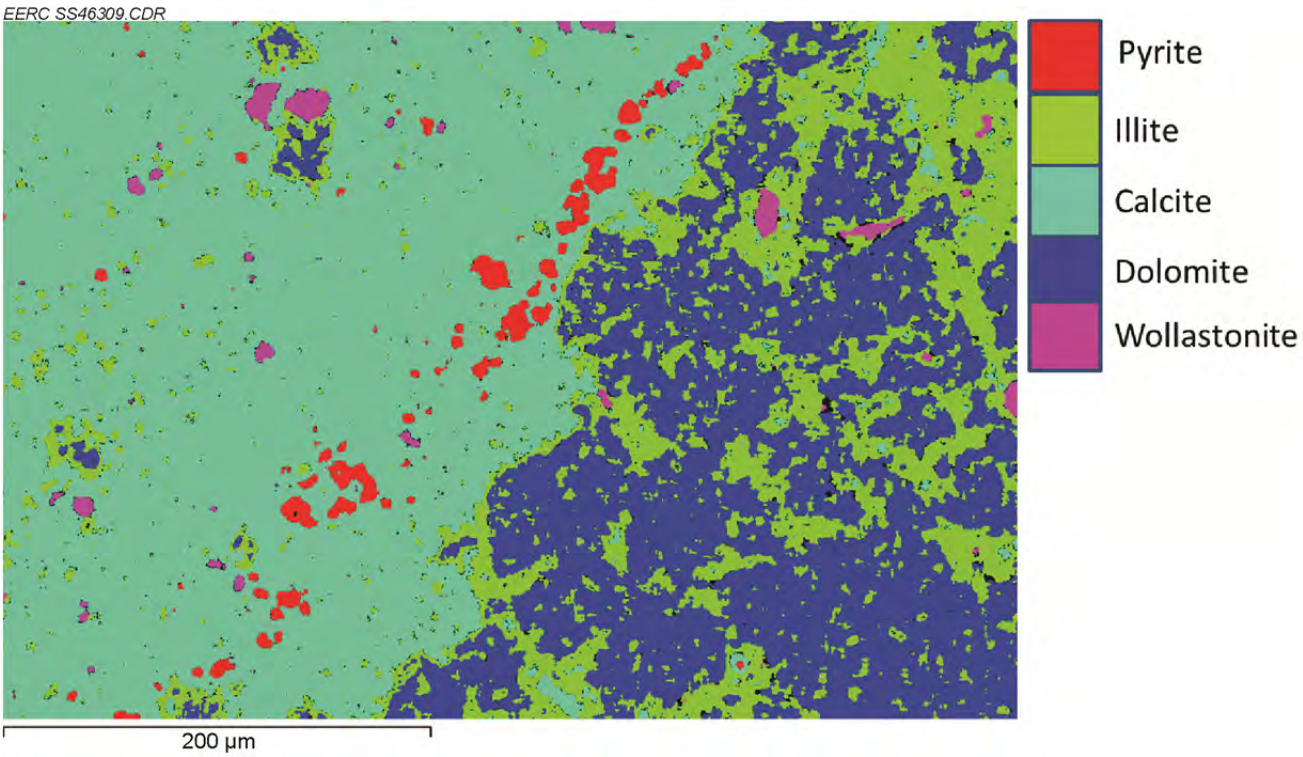
**Annotated High-Magnification BSE Image**




The BSE image shows wollastonite inclusions in a predominantly calcite–dolomite rock sample. Illite is also present in the pore space between dolomite grains, while the calcite phase appears to be tight. A line of pyrite inclusions is also shown along the interface between calcite and dolomite beds.

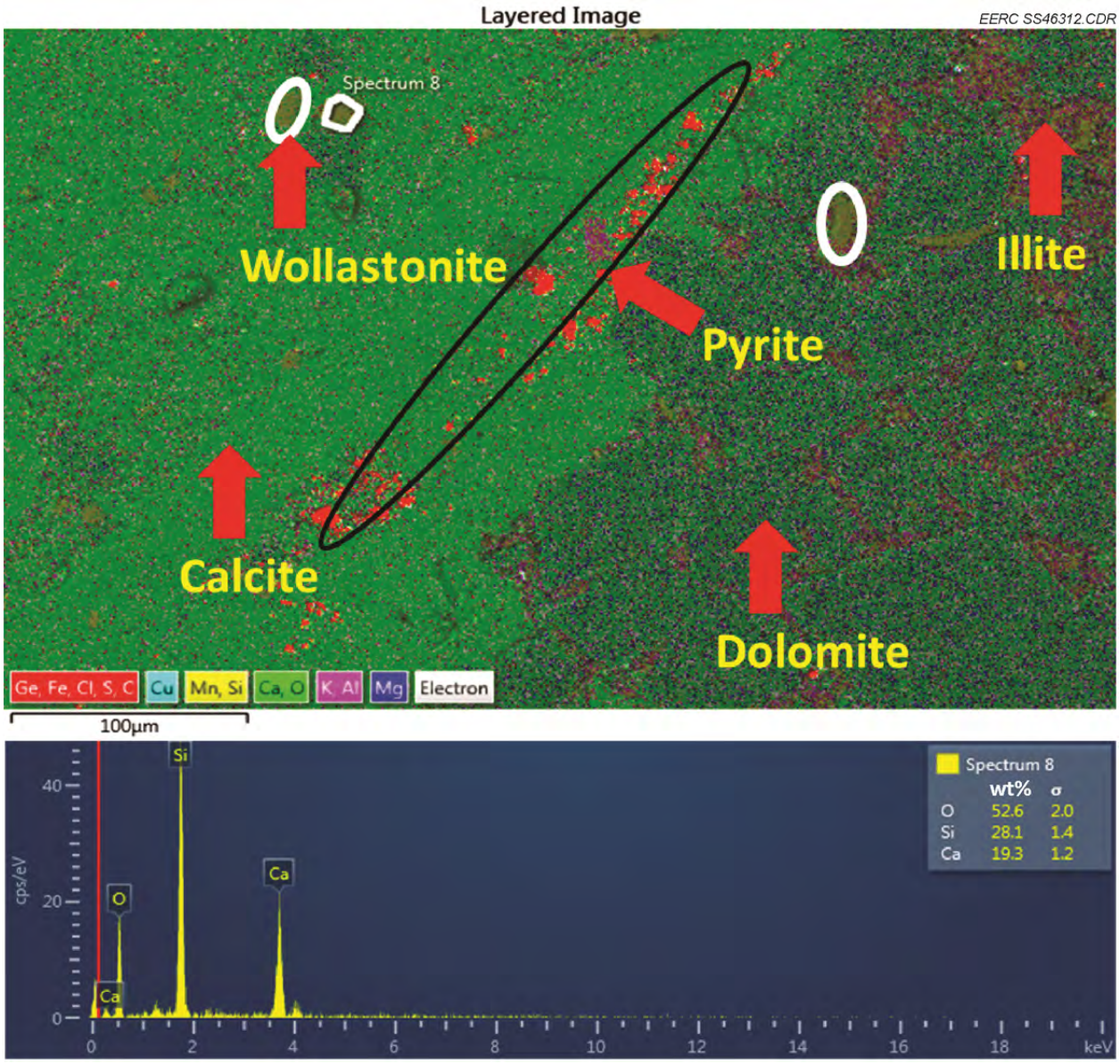
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9257 | | ID: S-00932 |
| | Deadwood Formation | Lithology: Grainstone | Depth: 11,858.5' |

**Mineral Map**




The mineral map was obtained for the same frame as that in the BSE image previous, showing the same mineralogy makeup as well as their associations.

**Mineral Map Overlain on BSE Image with Spectrum Indicating Wollastonite Identification**

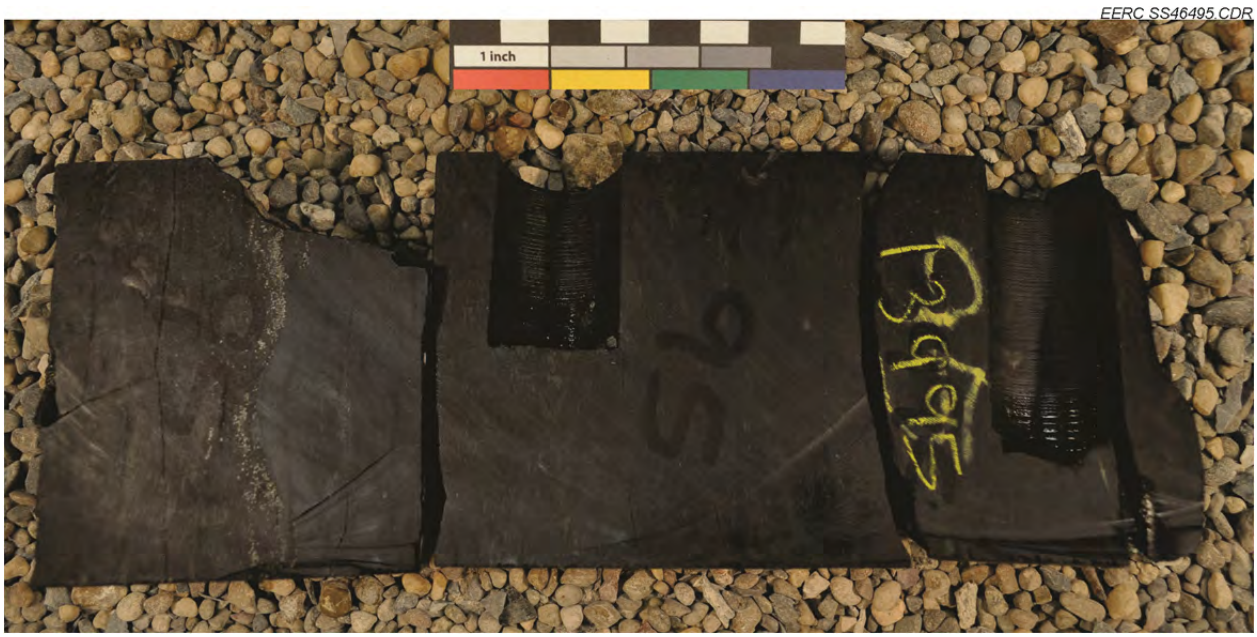



The layered image shows further analysis steps used to confirm the presence of wollastonite, which was not found in other samples in the batch. The spectrum below identifies the inclusions as wollastonite grains included in both calcite- and dolomite-dominant areas.

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| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00774 |
| | Icebox Formation | Lithology: Shale | Depth: 13,995.0' |

## SAMPLE PHOTOGRAPH




## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00774 |
| | Icebox Formation | Lithology: Shale | Depth: 13,995.0' |

**PHOTOMICROGRAPHS**

Thin Section Not Created

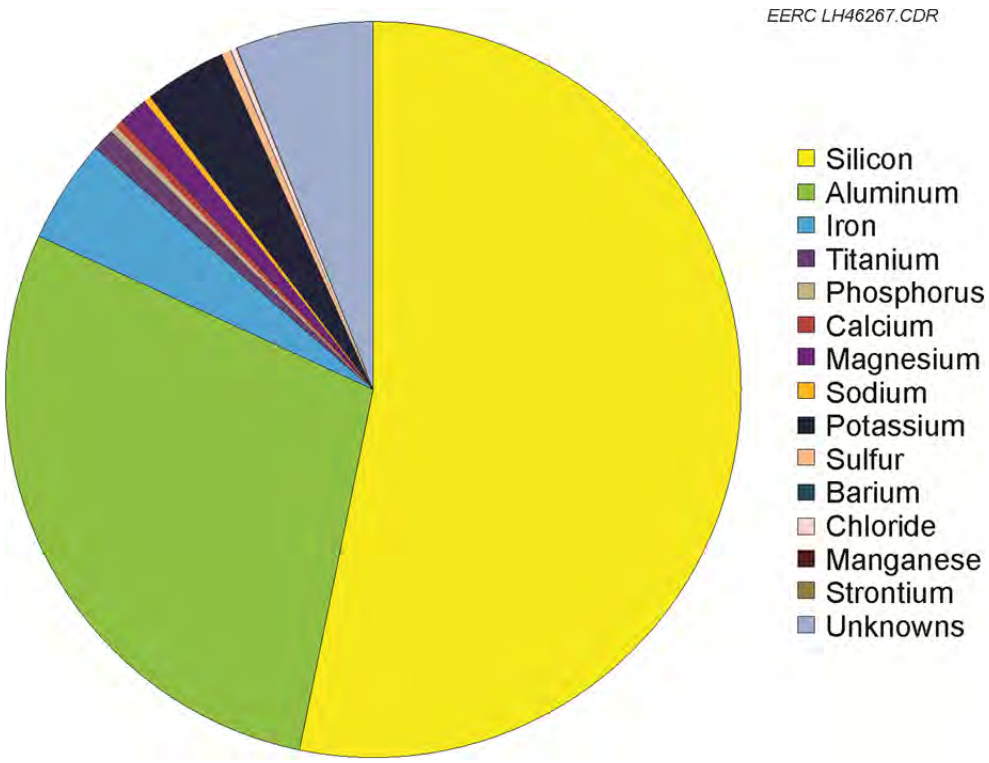
**PETROGRAPHIC DESCRIPTIONS**

**Classification**

| Category | Classification |
|---|---|
| Depositional Environment | Marine |
| Energy Environment | Low |
| Dott Classification | N/A |
| Dunham Classification | Mudstone |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00774 |
| | Icebox Formation | Lithology: Shale | Depth: 13,995.0' |

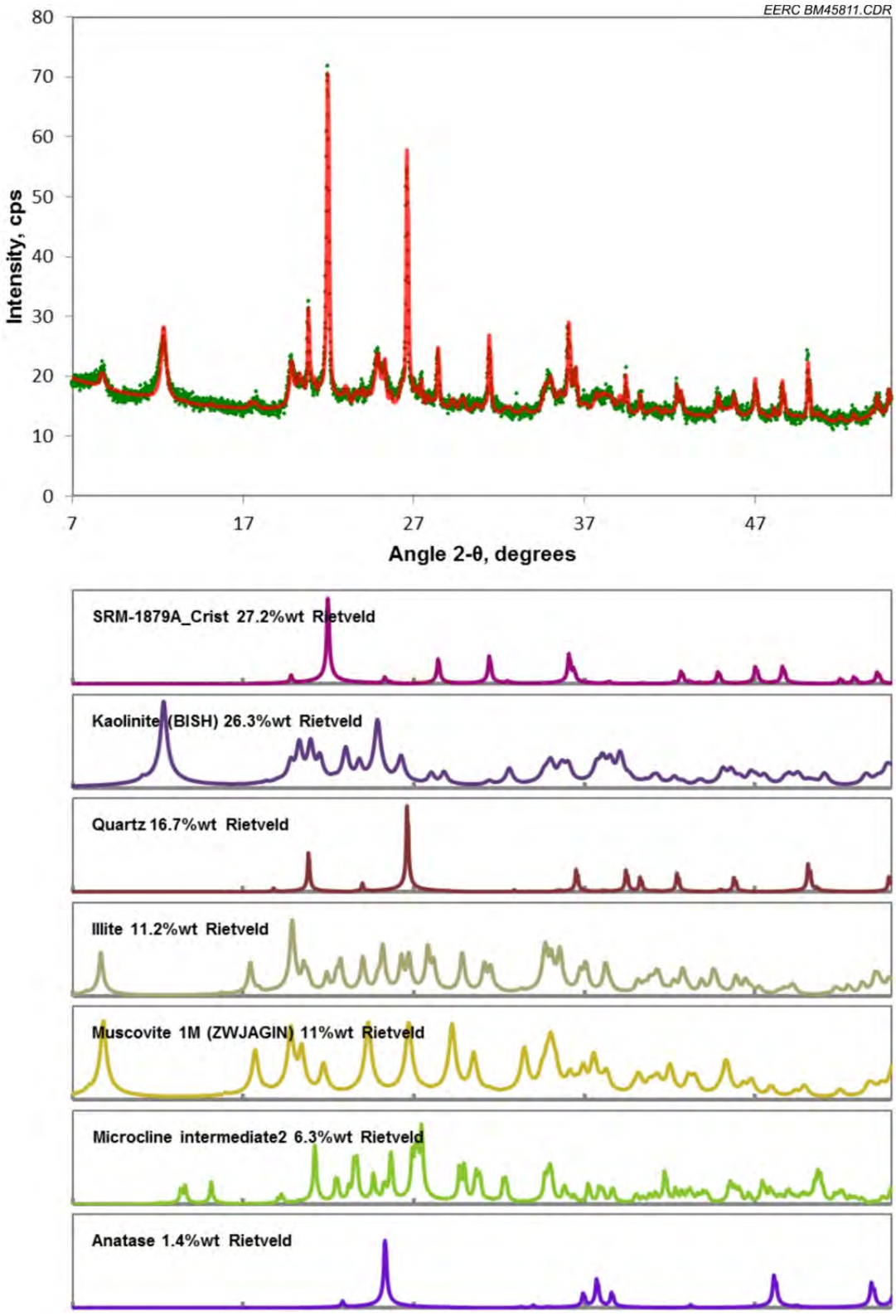
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 53.21 |
| Al (aluminum) | $Al_2O_3$ | 28.63 |
| Fe (iron) | $Fe_2O_3$ | 4.55 |
| Ti (titanium) | $TiO_2$ | 1.00 |
| P (phosphorus) | $P_2O_5$ | 0.27 |
| Ca (calcium) | CaO | 0.37 |
| Mg (magnesium) | MgO | 1.31 |
| Na (sodium) | $Na_2O$ | 0.29 |
| K (potassium) | $K_2O$ | 3.63 |
| S (sulfur) | $SO_3$ | 0.38 |
| Ba (barium) | BaO | 0.05 |
| Cl (chloride) | Cl | 0.22 |
| Mn (manganese) | MnO | 0.01 |
| Sr (strontium) | SrO | 0.03 |
| Unknowns | | 6.05 |
| Total | | 99.99 |

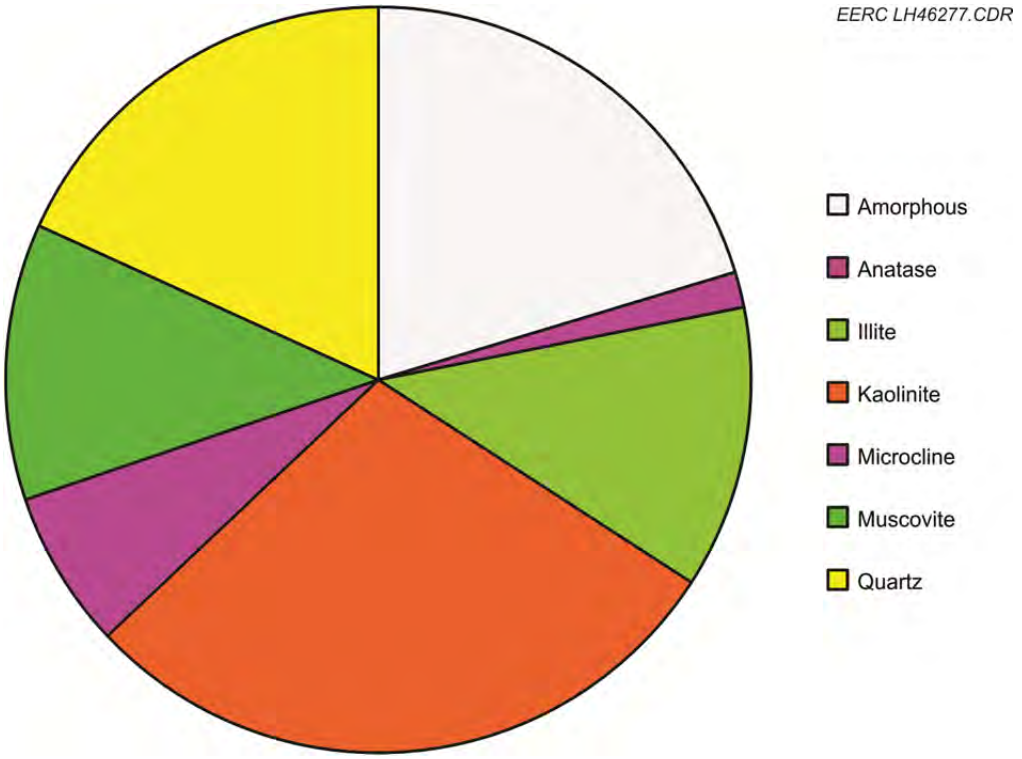
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00774 |
| | Icebox Formation | Lithology: Shale | Depth: 13,995.0' |

**XRD MINERAL ANALYSIS**



| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00774 |
| | Icebox Formation | Lithology: Shale | Depth: 13,995.0' |

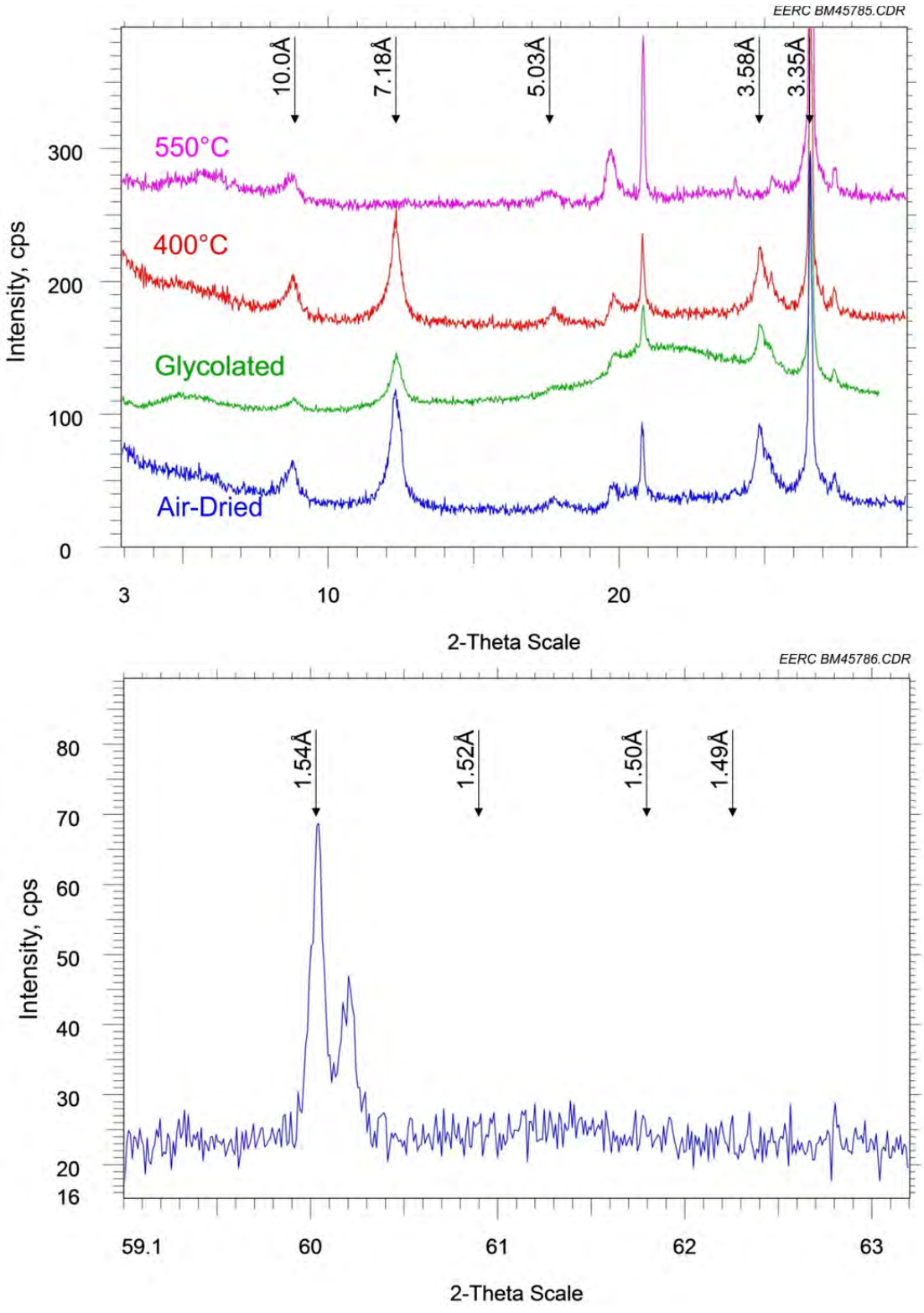
**XRD Mineral-Phase Distribution**



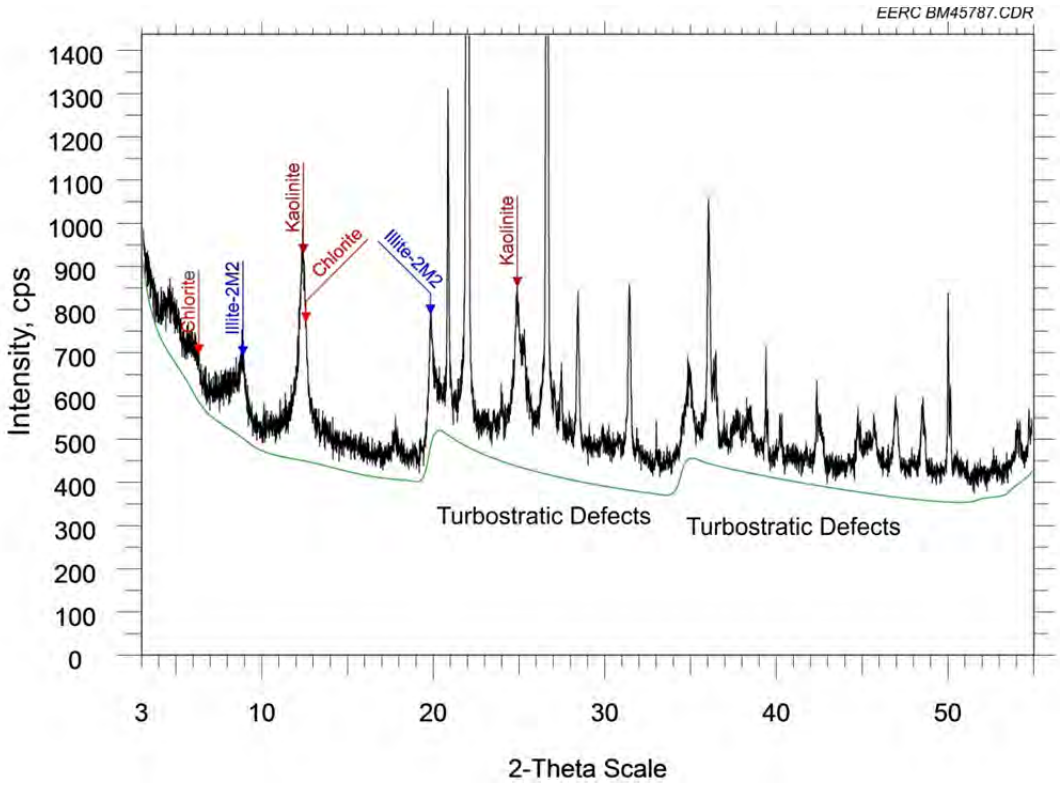

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 20.3 | NA |
| Quartz | $SiO_2$ | 18.2 | 2.65 |
| Kaolinite | $Al_2Si_2O_6(OH)_4$ | 28.8 | 2.53 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 12.3 | 2.81 |
| Microcline | $KAlSi_3O_8$ | 6.8 | 2.59 |
| Anatase | $TiO_2$ | 1.5 | 3.90 |
| Muscovite | $KAl_2(AlSi_3O_{10})(OH)_2$ | 12.0 | 2.75 |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00774 |
| | Icebox Formation | Lithology: Shale | Depth: 13,995.0' |

**XRD Clay Typing**



| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00774 |
| | Icebox Formation | Lithology: Shale | Depth: 13,995.0' |




The detailed clay analysis indicated that the clay contained biotite, kaolinite, and some mixed smectite layers determined by the use of glycolation, heating, and the analysis of turbostratic defects.

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| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00775 |
| | Icebox Formation | Lithology: Shale | Depth: 14,012.0' |

## SAMPLE PHOTOGRAPH

EERC SS46494.CDR




## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00775 |
| | Icebox Formation | Lithology: Shale | Depth: 14,012.0' |

**PHOTOMICROGRAPHS**

Thin Section Not Created

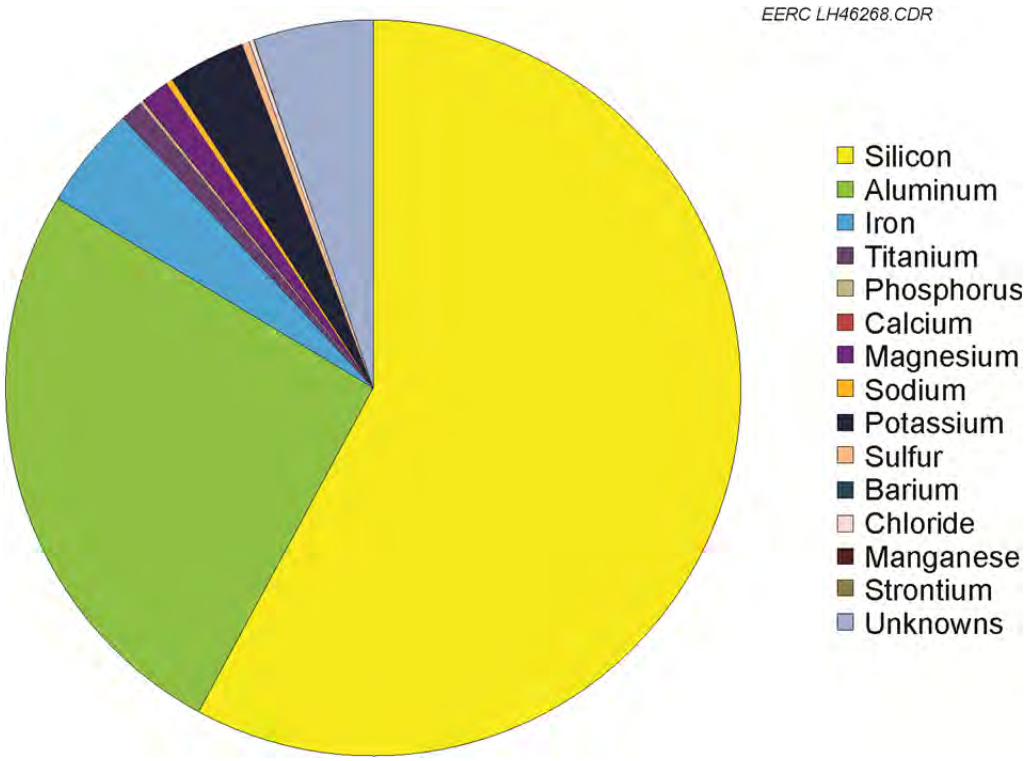
**PETROGRAPHIC DESCRIPTIONS**

**Classification**

| Category | Classification |
|---|---|
| Depositional Environment | Marine |
| Energy Environment | Low |
| Dott Classification | NA |
| Dunham Classification | Mudstone |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00775 |
| | Icebox Formation | Lithology: Shale | Depth: 14,012.0' |

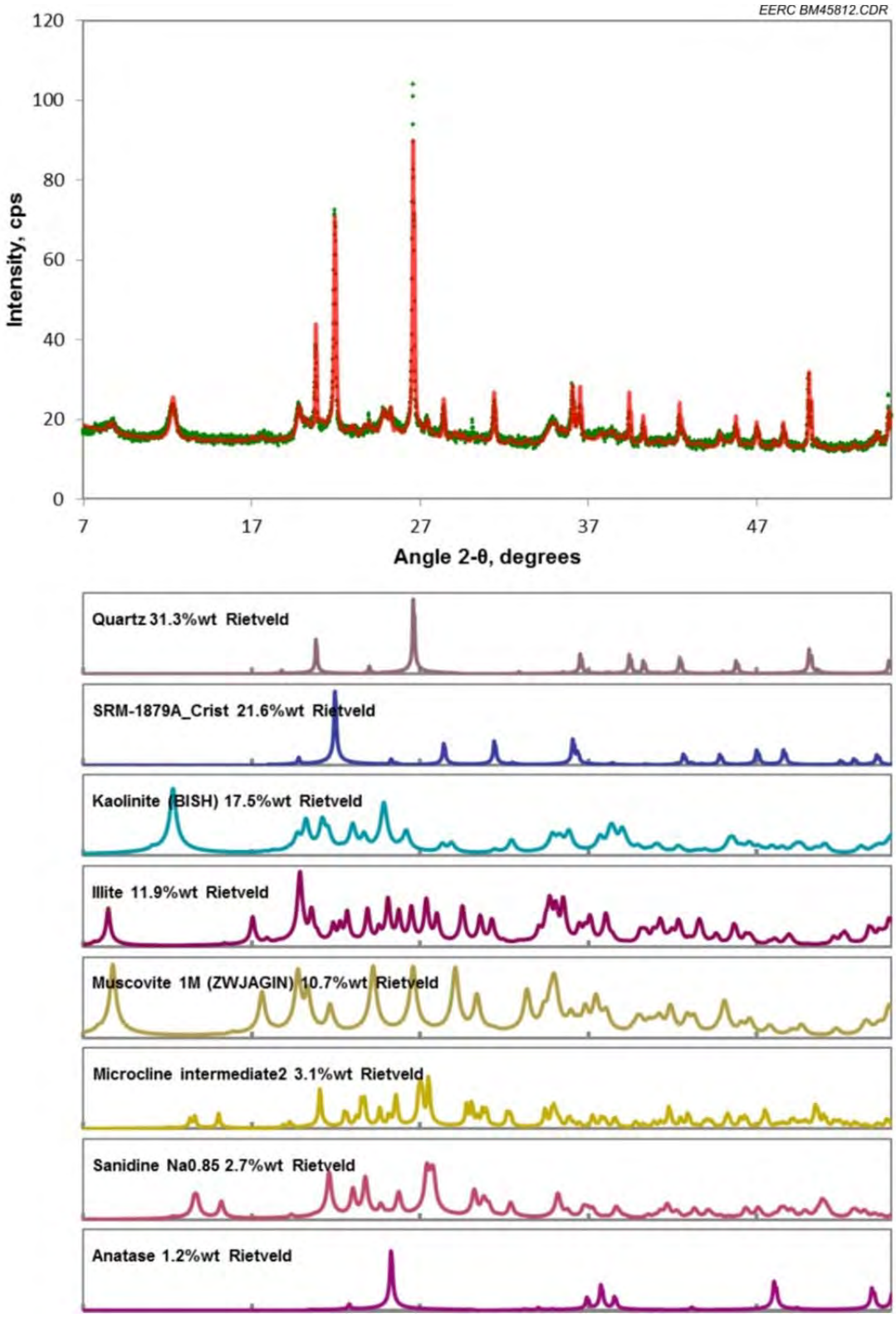
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 57.88 |
| Al (aluminum) | $Al_2O_3$ | 25.74 |
| Fe (iron) | $Fe_2O_3$ | 4.48 |
| Ti (titanium) | $TiO_2$ | 1.02 |
| P (phosphorus) | $P_2O_5$ | 0.12 |
| Ca (calcium) | CaO | 0.03 |
| Mg (magnesium) | MgO | 1.27 |
| Na (sodium) | $Na_2O$ | 0.27 |
| K (potassium) | $K_2O$ | 3.42 |
| S (sulfur) | $SO_3$ | 0.30 |
| Ba (barium) | BaO | 0.04 |
| Cl (chloride) | Cl | 0.16 |
| Mn (manganese) | MnO | 0.00 |
| Sr (strontium) | SrO | 0.02 |
| Unknowns | | 5.26 |
| Total | | 100.01 |

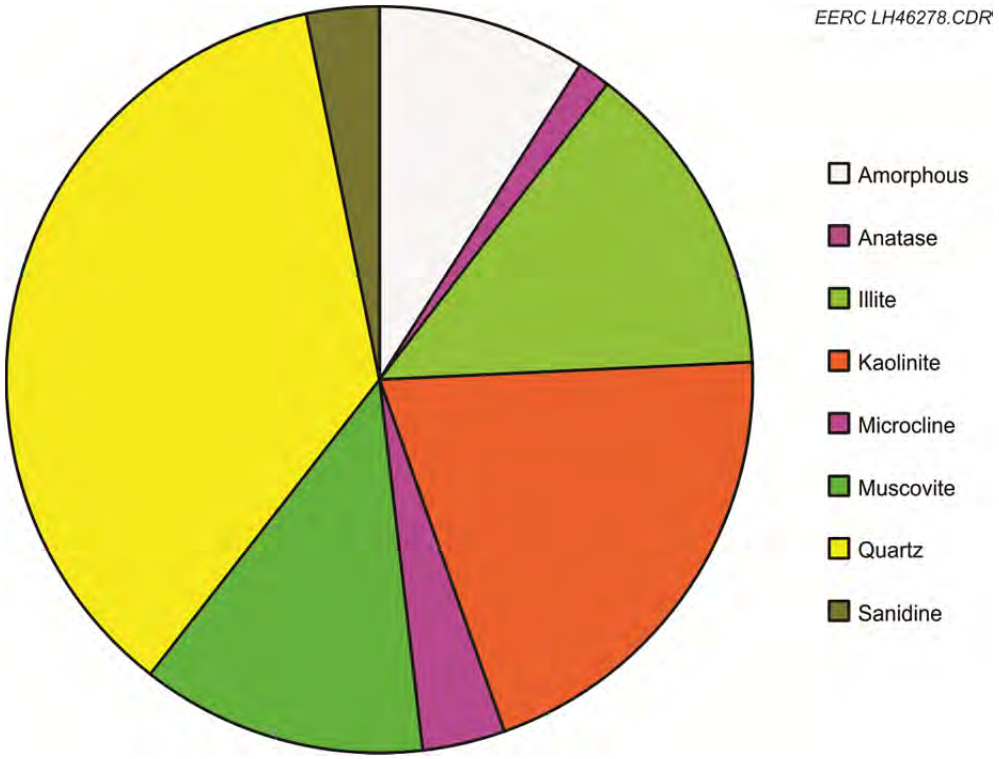
| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 9800 | | ID: S-00775 |
| Icebox Formation | Lithology: Shale | Depth: 14,012.0' |

## XRD MINERAL ANALYSIS



| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00775 |
| | Icebox Formation | Lithology: Shale | Depth: 14,012.0' |

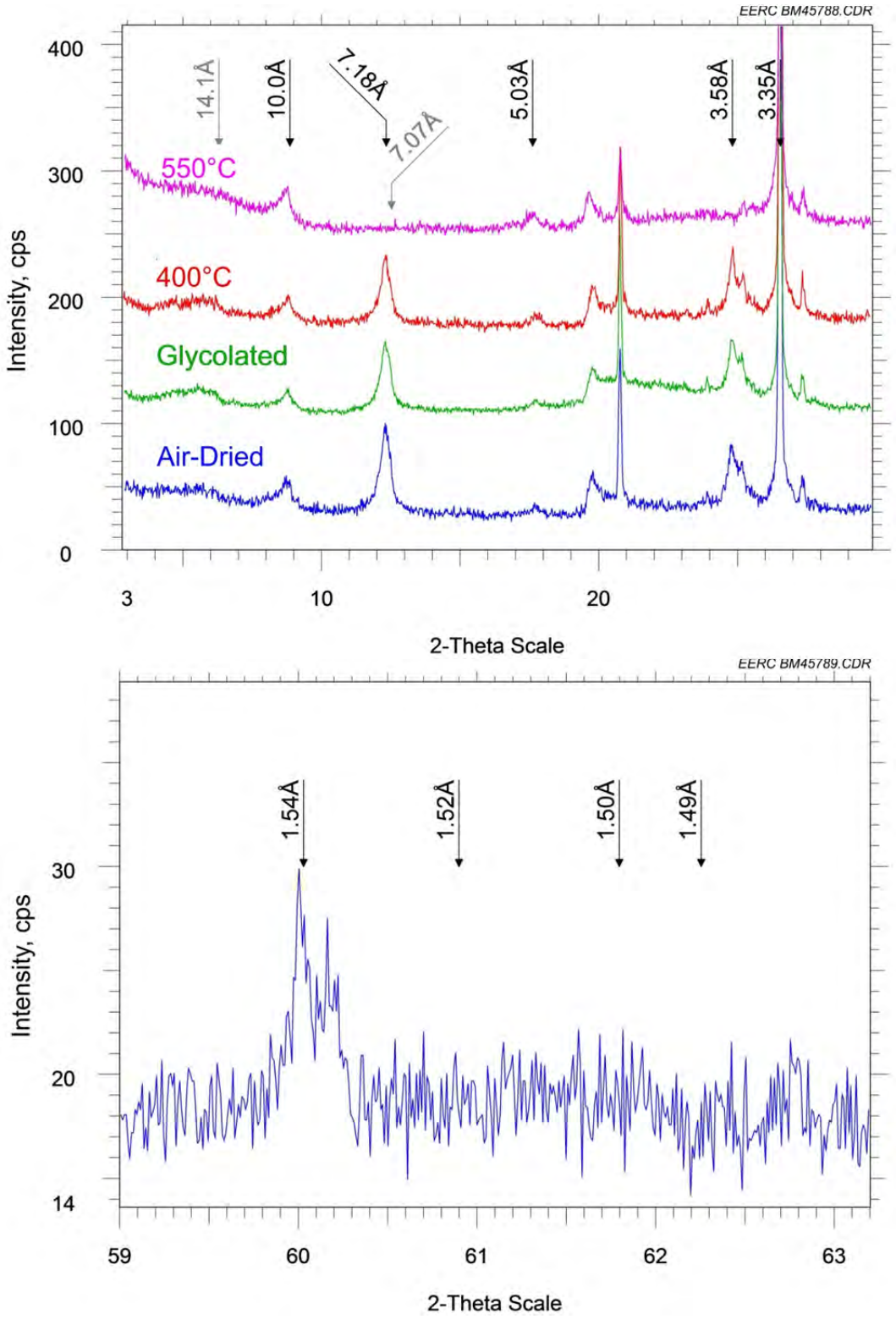
**XRD Mineral-Phase Distribution**



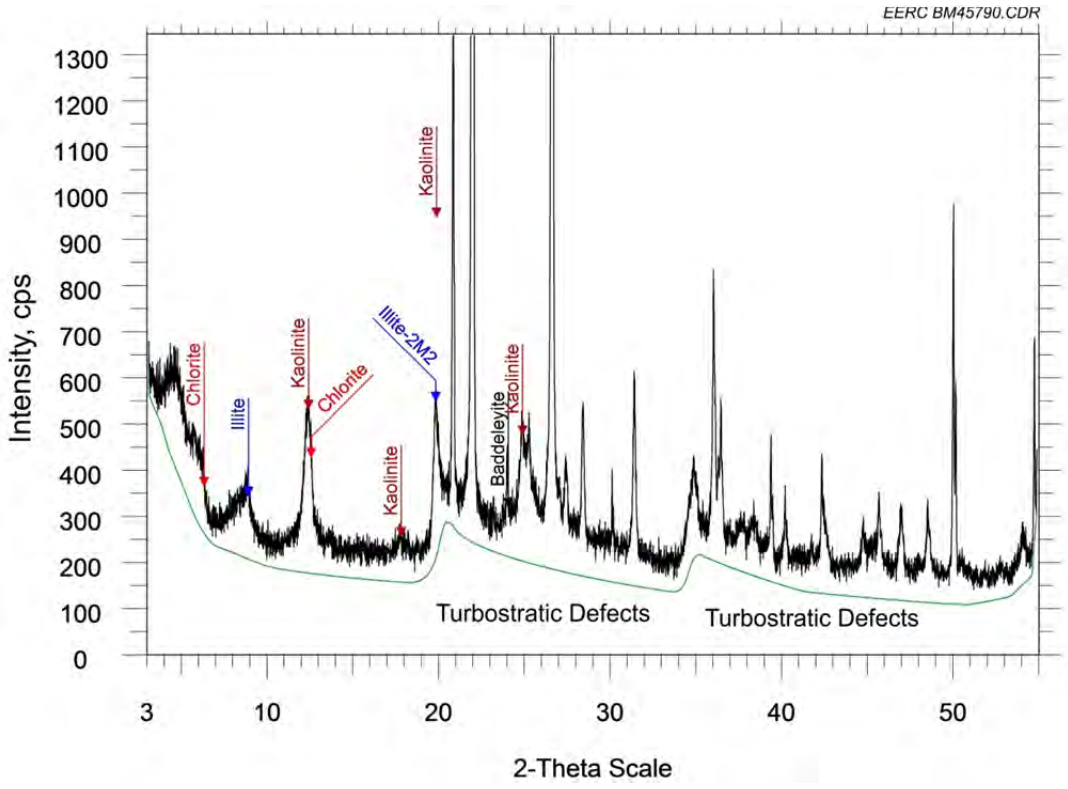

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 9.0 | NA |
| Quartz | $SiO_2$ | 36.3 | 2.65 |
| Kaolinite | $Al_2Si_2O_6(OH)_4$ | 20.3 | 2.54 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 13.8 | 2.75 |
| Microcline | $KAlSi_3O_8$ | 3.6 | 2.59 |
| Sanidine | $NaKAlSi_3O_8$ | 3.2 | 2.55 |
| Anatase | $TiO_2$ | 1.4 | 3.90 |
| Muscovite | $KAl_2(AlSi_3O_{10})(OH)_2$ | 12.4 | 2.72 |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 9800 | | ID: S-00775 |
| | Icebox Formation | Lithology: Shale | Depth: 14,012.0' |

**XRD Clay Typing**



| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 9800 | | ID: S-00775 |
| Icebox Formation | Lithology: Shale | Depth: 14,012.0' |




The detailed clay analysis indicated that the clay contained biotite, kaolinite, and some mixed smectite layers determined by the use of glycolation, heating, and the analysis of turbostratic defects.

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| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 12596 | | ID: S-00933 |
| | Black Island Formation | Lithology: Sandstone | Depth: 14,802.0' |

## SAMPLE PHOTOGRAPH

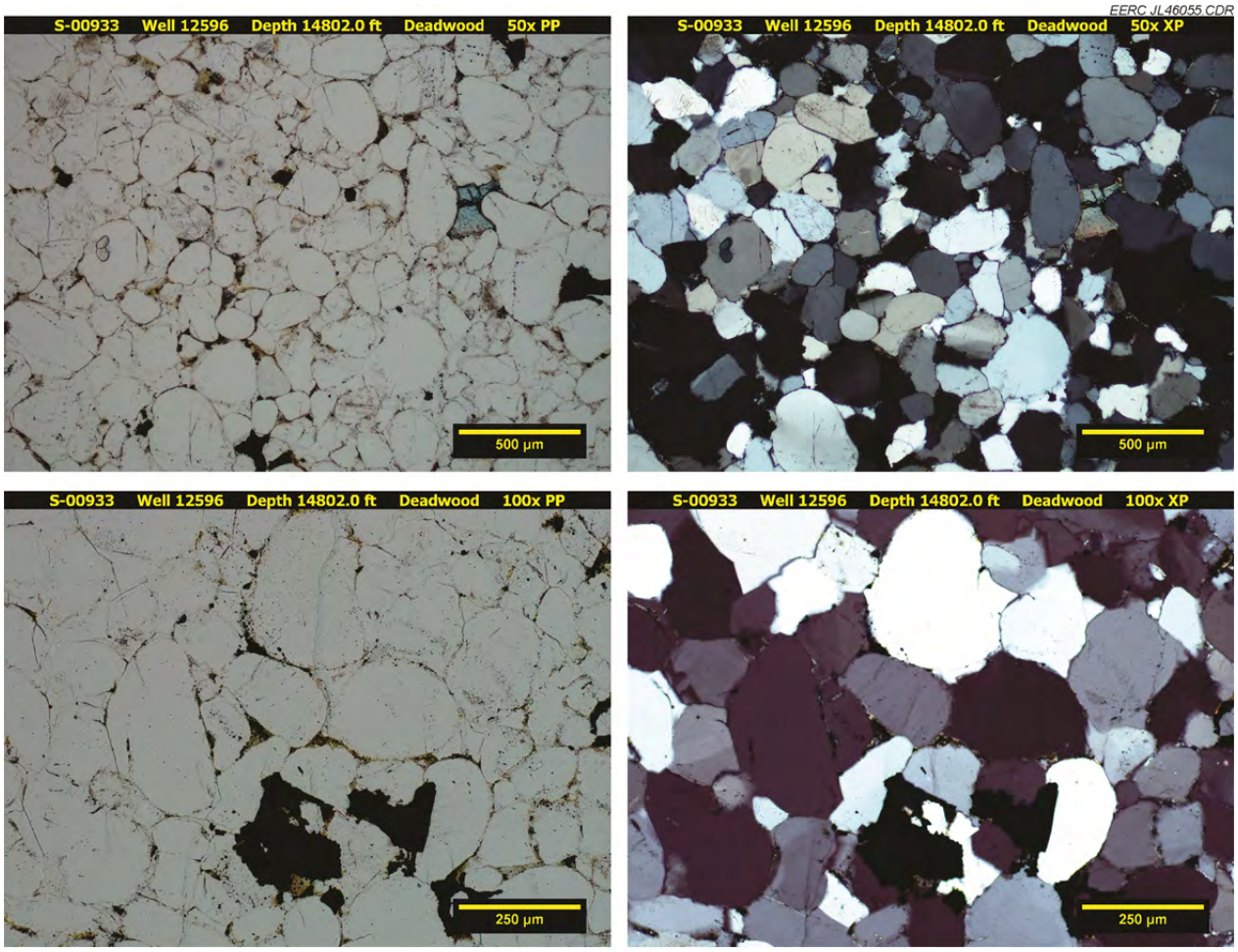



## PHYSICAL PROPERTIES

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 12596 | | ID: S-00933 |
| | Black Island Formation | Lithology: Sandstone | Depth: 14,802.0' |

**PHOTOMICROGRAPHS**




This sample is a fine-grained, friable, quartz grain-dominated sandstone. This noncemented (grain-supported) and well-packed sample shows a high degree of quartz overgrowths. Trace levels of pore-filling pyrite, clays, and iron-rich anhedral dolomite are found, and no presence of fossils is discovered.

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 12596 | | ID: S-00933 |
| | Black Island Formation | Lithology: Sandstone | Depth: 14,802.0' |

## PETROGRAPHIC DESCRIPTIONS

### Mineral Assemblages

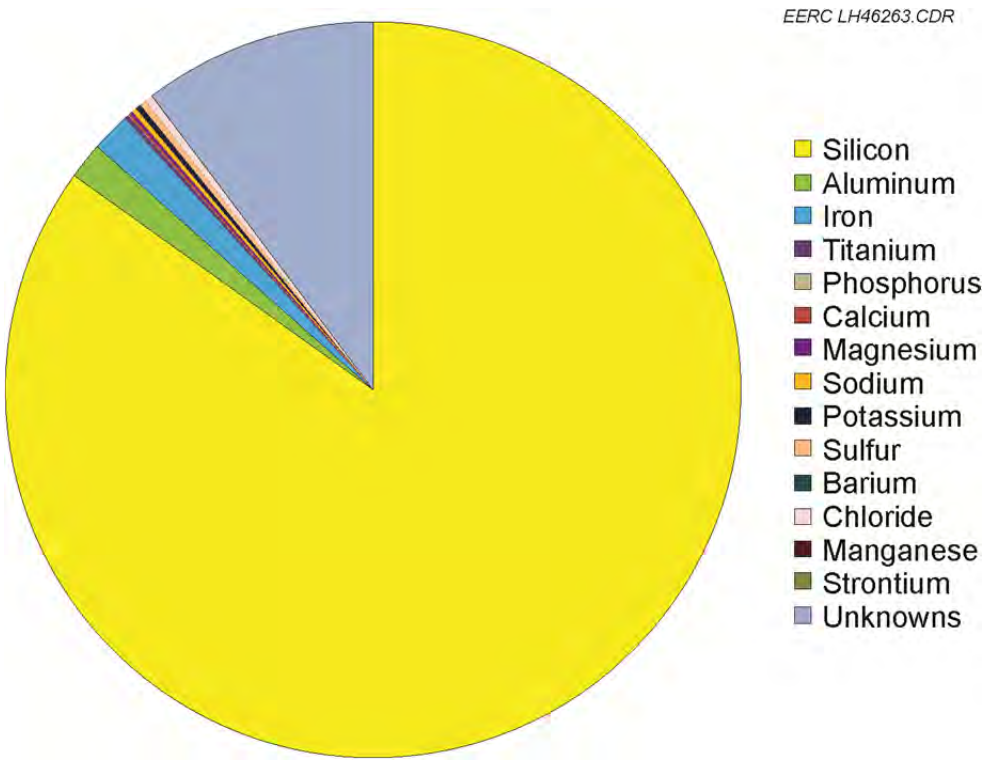
| Assemblage | Percentage | Comments |
|---|---|---|
| Quartz | 93.2 | Abundant overgrowth |
| Dolomite | 0.4 | Subhedral |
| Pyrite | 0.4 | |
| Clay | 6.0 | Cement |
| Porosity | 0.0 | None visible |

### Classification

| Category | Classification |
|---|---|
| Depositional Environment | Beach |
| Energy Environment | Medium–high |
| Dott Classification | Quartz arenitic sandstone |
| Dunham Classification | N/A |

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 12596 | | ID: S-00933 |
| | Black Island Formation | Lithology: Sandstone | Depth: 14,802.0' |

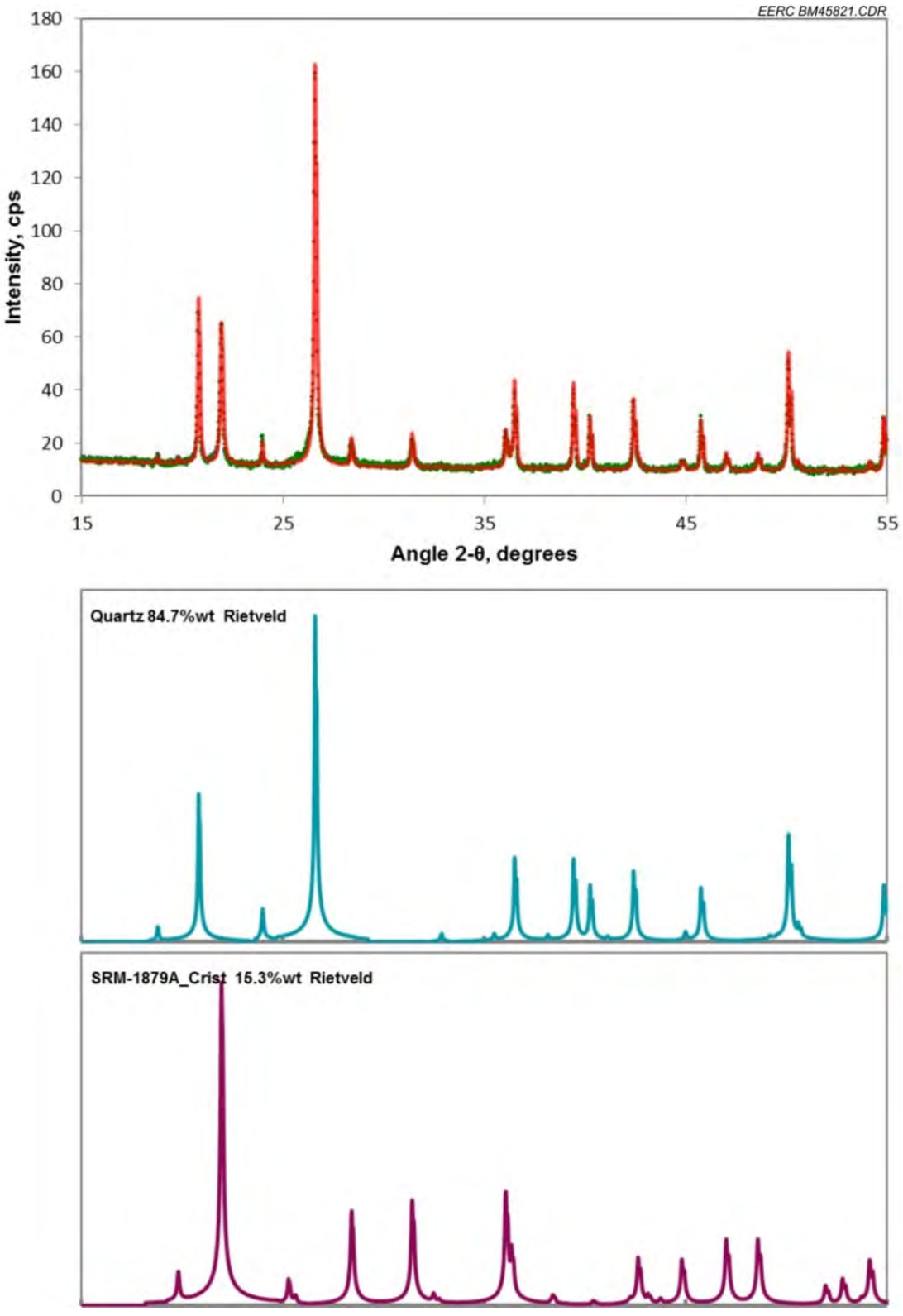
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 84.89 |
| Al (aluminum) | $Al_2O_3$ | 1.59 |
| Fe (iron) | $Fe_2O_3$ | 1.72 |
| Ti (titanium) | $TiO_2$ | 0.20 |
| P (phosphorus) | $P_2O_5$ | 0.02 |
| Ca (calcium) | CaO | 0.08 |
| Mg (magnesium) | MgO | 0.14 |
| Na (sodium) | $Na_2O$ | 0.21 |
| K (potassium) | $K_2O$ | 0.25 |
| S (sulfur) | $SO_3$ | 0.28 |
| Ba (barium) | BaO | 0.01 |
| Cl (chloride) | Cl | 0.33 |
| Mn (manganese) | MnO | 0.00 |
| Sr (strontium) | SrO | 0.01 |
| Unknowns | | 10.27 |
| Total | | 100.00 |

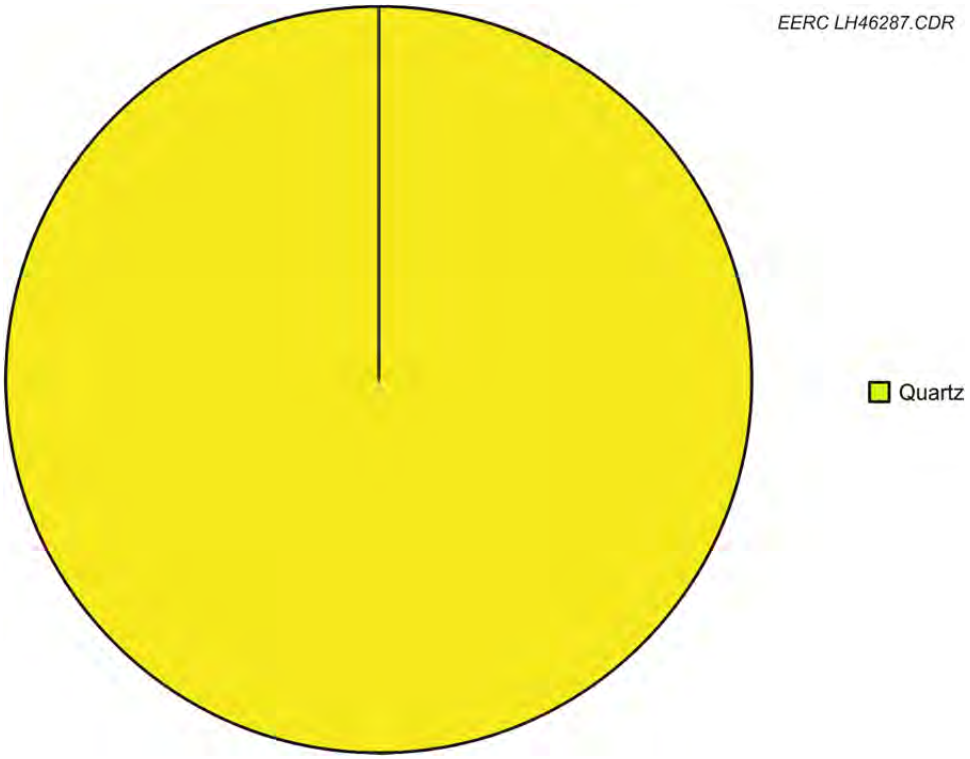
| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 12596 | | ID: S-00933 |
| | Black Island Formation | Lithology: Sandstone | Depth: 14,802.0' |

**XRD MINERAL ANALYSIS**



| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 12596 | | ID: S-00933 |
| Black Island Formation | Lithology: Sandstone | Depth: 14,802.0' |

**XRD Mineral-Phase Distribution**



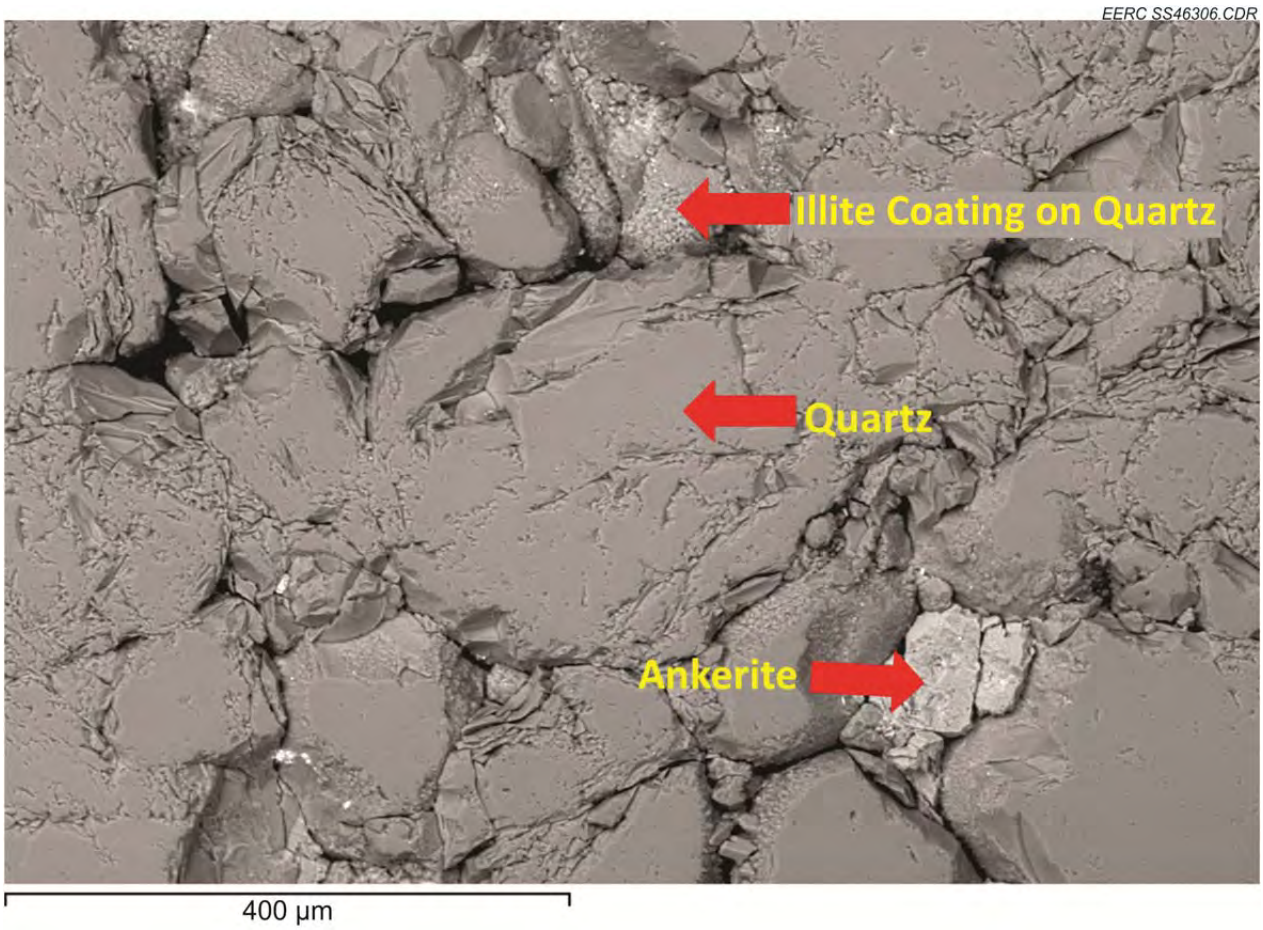

| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Quartz | $SiO_2$ | 100 | 2.65 |

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 12596 | | ID: S-00933 |
| Black Island Formation | Lithology: Sandstone | Depth: 14,802.0' |

**SEM**

| Observed Mineral Phases in All SEM Analyses |
|---|
| Quartz |
| Pyrite |
| Illite |
| Rutile |
| Ankerite |

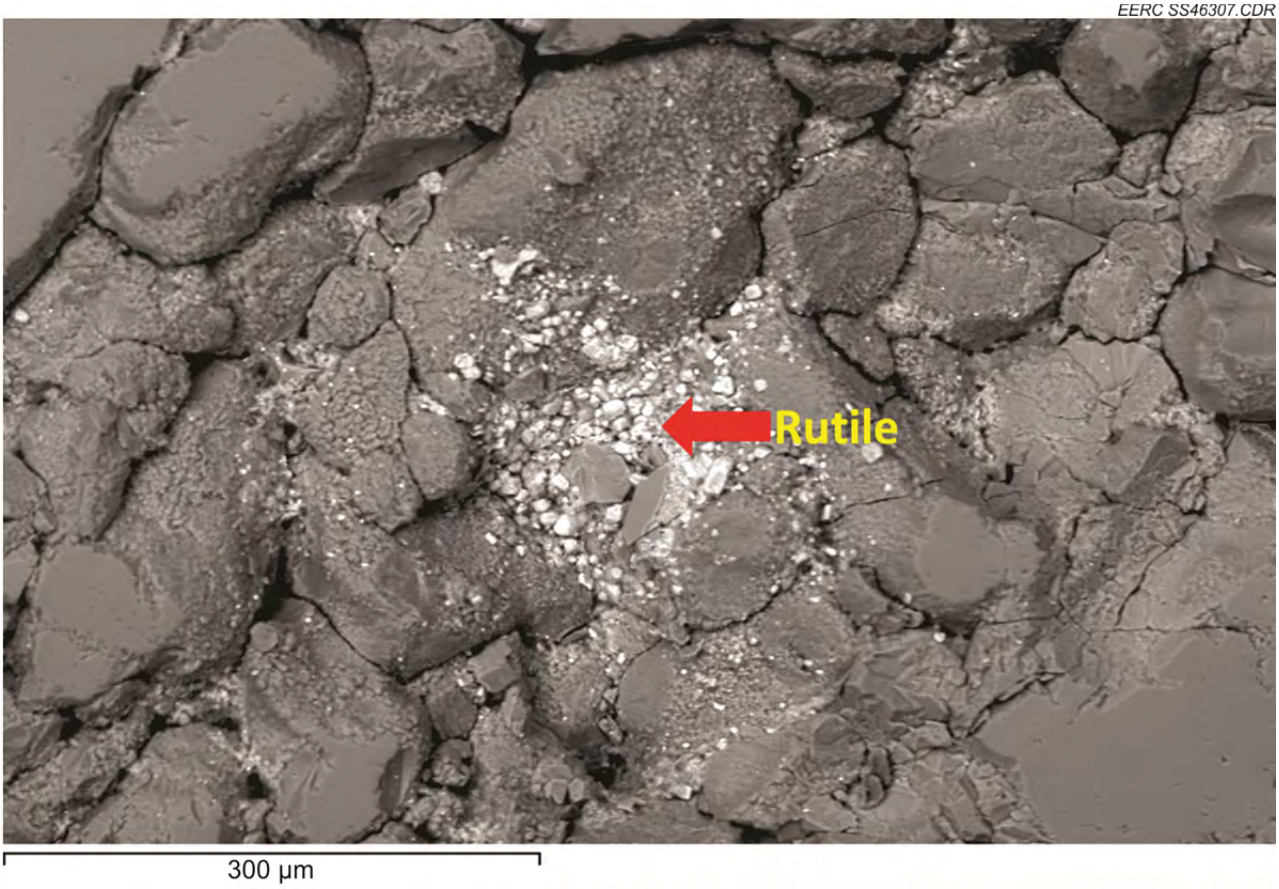
**Annotated High-Magnification BSE Images**




The BSE image shows an area that is predominantly sandstone with ankerite inclusion and minor-to-trace amounts of illite, mainly as a coating on the quartz grains in the pores.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 12596 | | ID: S-00933 |
| Black Island Formation | Lithology: Sandstone | Depth: 14,802.0' |

EERC SS46307.CDR




This BSE image shows small, rounded rutile grains in the pore spaces in the sandstone. Although rutile is a common trace mineral in sandstones, the texture and shape of these small rutile grains suggest they may have been weathered or transported from a remote location and deposited in this quartz “crater.”

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 12596 | | ID: S-00934 |
| Black Island Formation | Lithology: Shale | Depth: 14,831.0' |

**SAMPLE PHOTOGRAPH**




**PHYSICAL PROPERTIES**

| Pycnometer Effective Porosity Average, vol% | Bulk Density, g/cm$^3$ | Permeability to Water, mD |
|---|---|---|
| NT | NT | NT |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 12596 | | ID: S-00934 |
| | Black Island Formation | Lithology: Shale | Depth: 14,831.0' |

**PHOTOMICROGRAPHS**

Thin Section Not Created

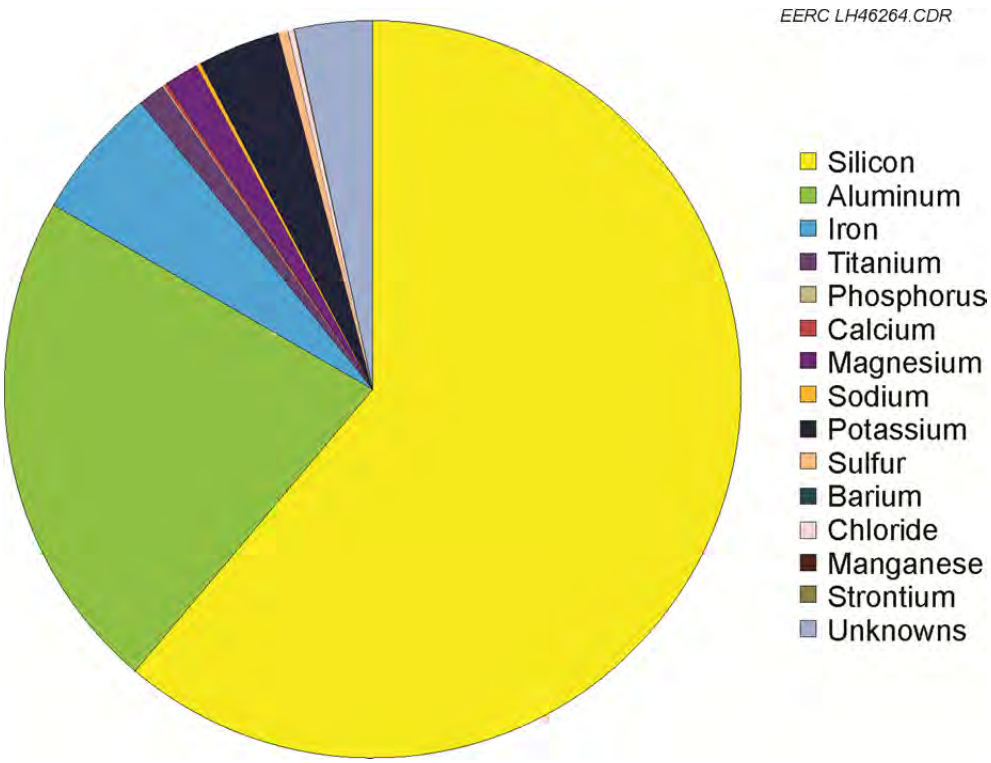
**PETROGRAPHIC DESCRIPTIONS**

**Classification**

| Category | Classification |
|---|---|
| Depositional Environment | Marine |
| Energy Environment | Low |
| Dott Classification | N/A |
| Dunham Classification | Mudstone |

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 12596 | | ID: S-00934 |
| | Black Island Formation | Lithology: Shale | Depth: 14,831.0' |

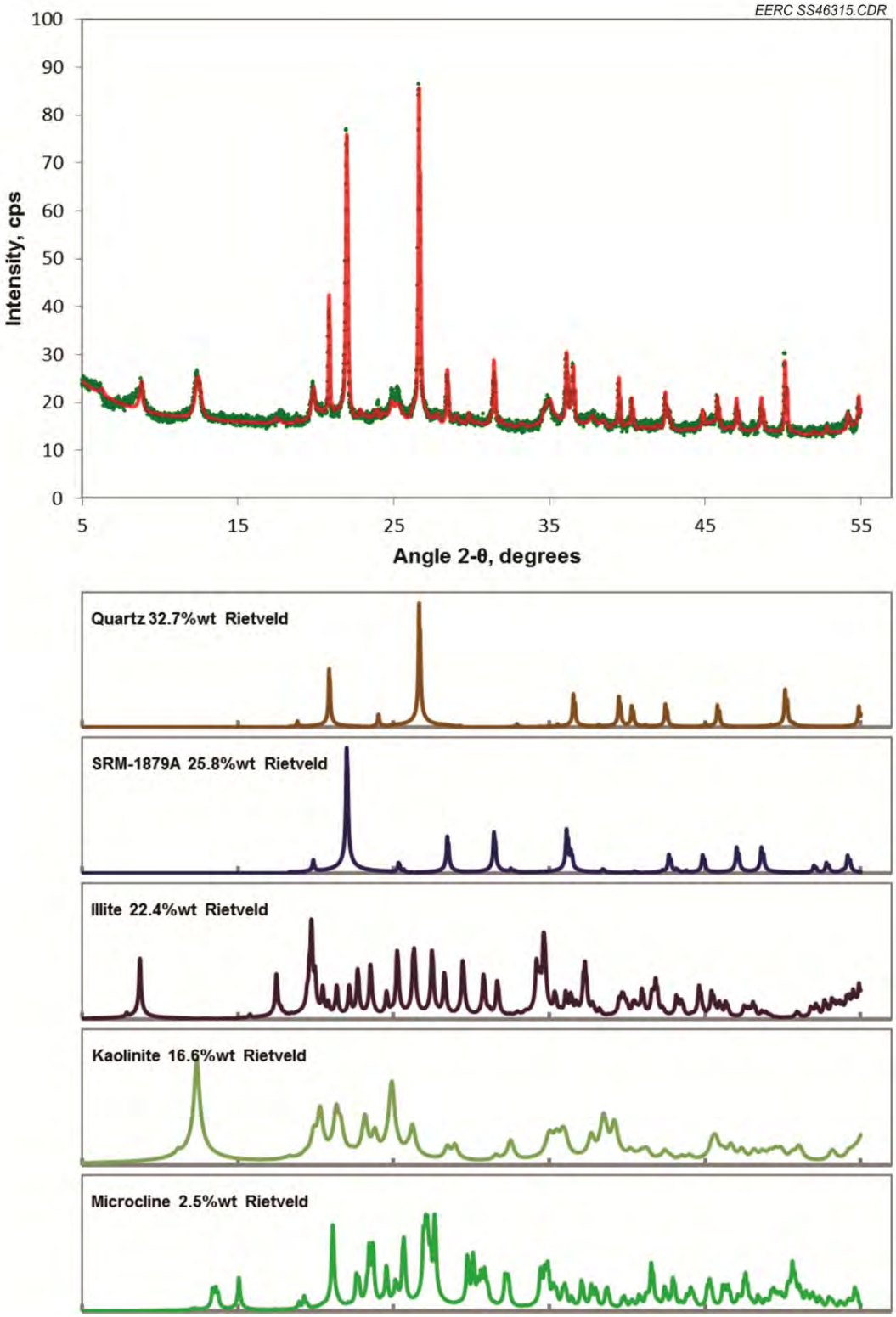
**XRF BULK CHEMICAL COMPOSITION**




| Element | Reporting Convention (oxide) | Weight % |
|---|---|---|
| Si (silicon) | $SiO_2$ | 61.15 |
| Al (aluminum) | $Al_2O_3$ | 22.17 |
| Fe (iron) | $Fe_2O_3$ | 5.83 |
| Ti (titanium) | $TiO_2$ | 1.20 |
| P (phosphorus) | $P_2O_5$ | 0.06 |
| Ca (calcium) | CaO | 0.15 |
| Mg (magnesium) | MgO | 1.52 |
| Na (sodium) | $Na_2O$ | 0.18 |
| K (potassium) | $K_2O$ | 3.63 |
| S (sulfur) | $SO_3$ | 0.41 |
| Ba (barium) | BaO | 0.03 |
| Cl (chloride) | Cl | 0.23 |
| Mn (manganese) | MnO | 0.01 |
| Sr (strontium) | SrO | 0.03 |
| Unknowns | | 3.41 |
| Total | | 99.99 |

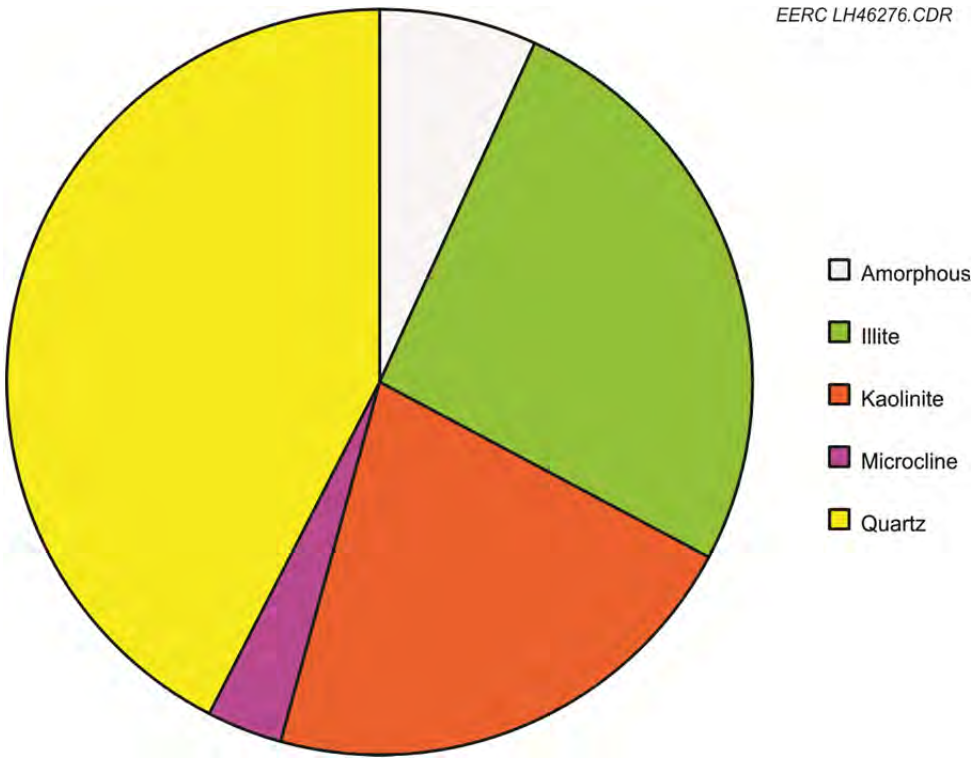
| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 12596 | | ID: S-00934 |
| Black Island Formation | Lithology: Shale | Depth: 14,831.0' |

## XRD MINERAL ANALYSIS



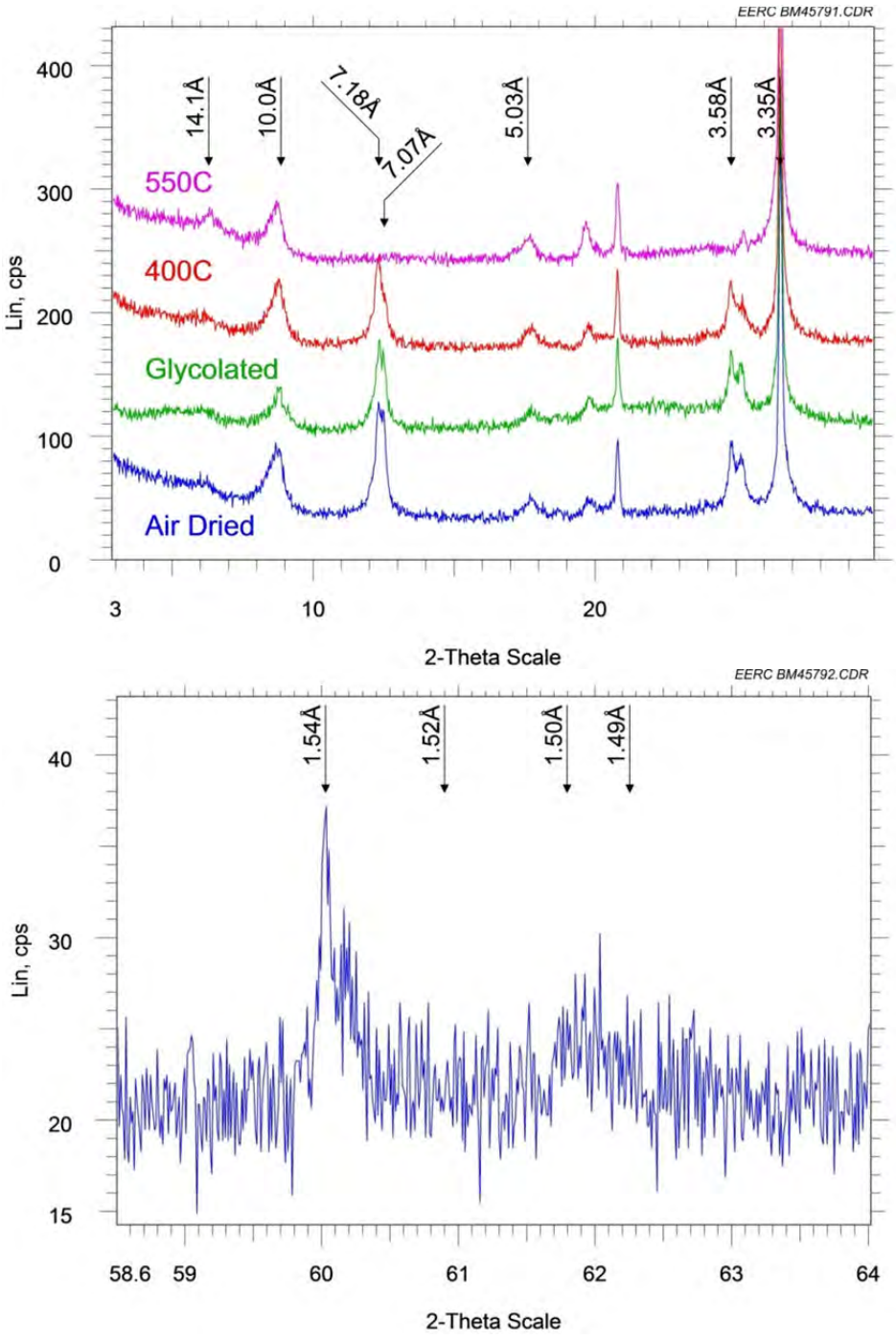
| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 12596 | | ID: S-00934 |
| Black Island Formation | Lithology: Shale | Depth: 14,831.0' |

**XRD Mineral-Phase Distribution**




| Mineral Phase | Formula | Weight % | Crystal Density, g/cm$^3$ |
|---|---|---|---|
| Amorphous | | 6.8 | NA |
| Quartz | $SiO_2$ | 42.4 | 2.65 |
| Kaolinite | $Al_2Si_2O_6(OH)_4$ | 21.5 | 2.56 |
| Illite | $(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$ | 26.0 | 2.71 |
| Microcline | $KAlSi_3O_8$ | 3.3 | 2.58 |

**XRD Clay Typing**



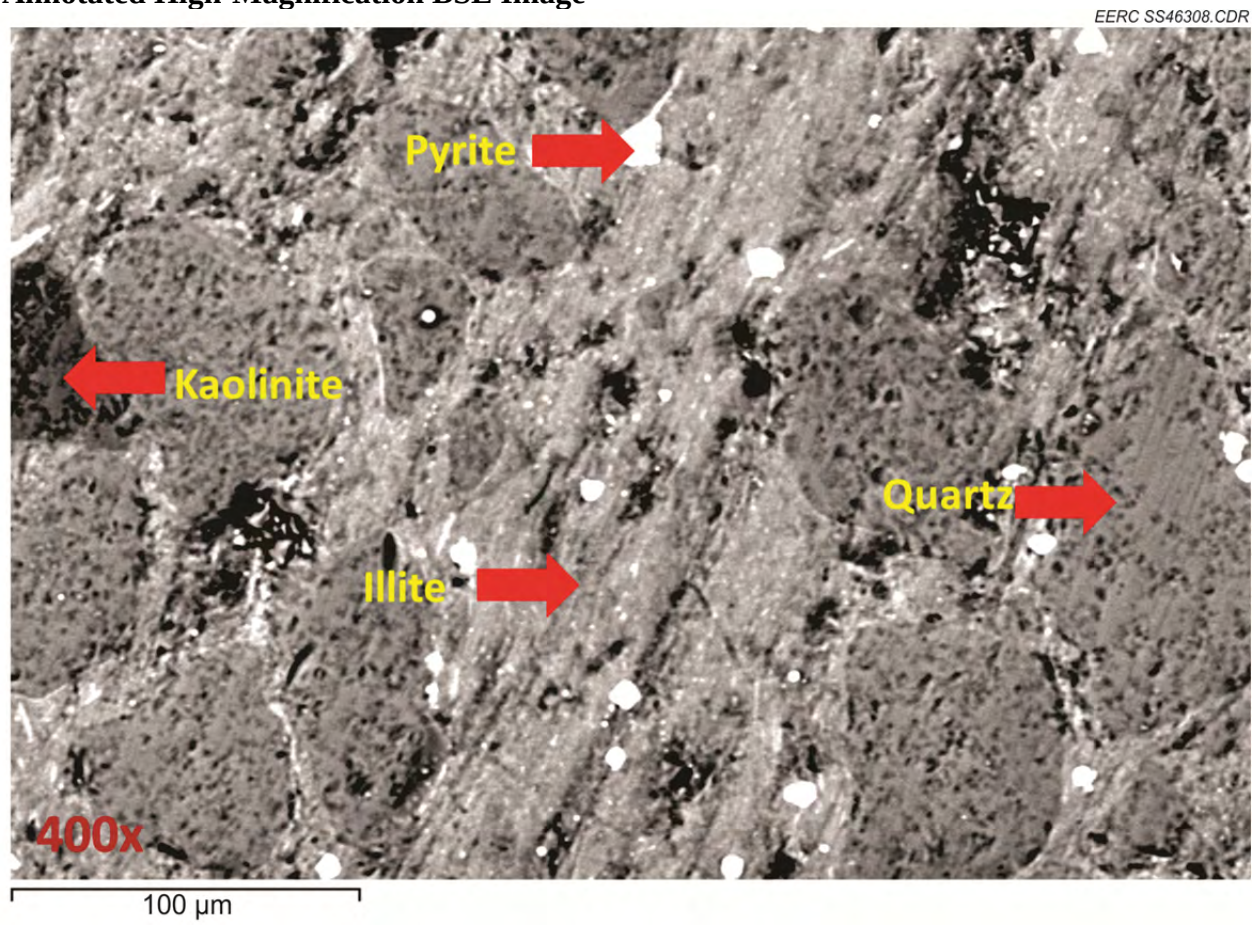

The detailed clay analysis indicated that the clay contained biotite, kaolinite, chlorite and, possibly, illitelike phases and mixed, layered illite–chlorite phases determined by the use of glycolation and heating.

| Applied Geology Laboratory | | |
|---|---|---|
| Well Name: NDIC Well 12596 | | ID: S-00934 |
| Black Island Formation | Lithology: Shale | Depth: 14,831.0' |

**SEM**

| Observed Mineral Phases in All SEM Analyses |
|---|
| Pyrite |
| Quartz |
| Kaolinite |
| Zircon |
| Rutile |
| Illite |

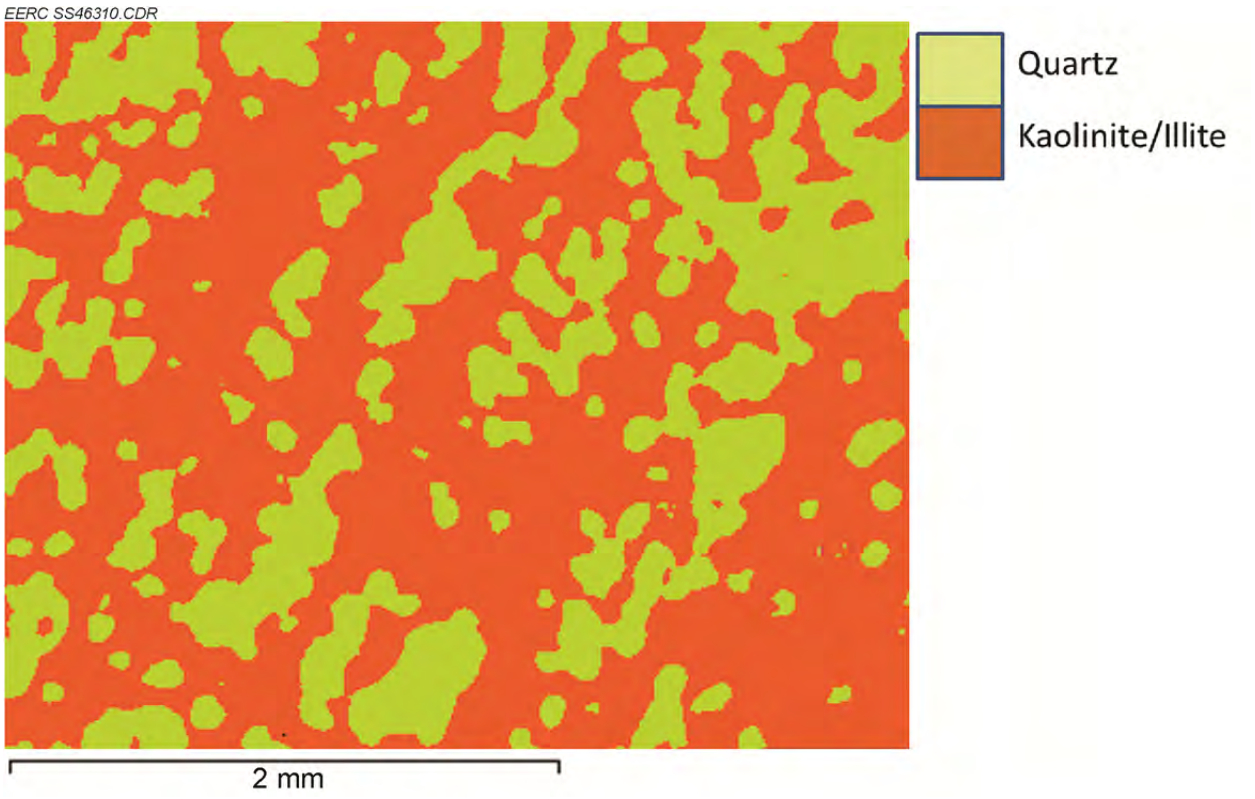
**Annotated High-Magnification BSE Image**




The BSE image shows the major mineral phases observed in this shale sample, including quartz, illite, kaolinite, and pyrite. This image is an example that illustrates the importance of using high-magnification SEM images for analysis. At much lower magnification, such as 100×, the sample appears dark, and it is not possible to distinguish between the different types of grains present. At 400×, it is possible to see clear quartz grain boundaries, as well as illite, kaolinite, and pyrite.

| | | | |
|---|---|---|---|
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| | Well Name: NDIC Well 12596 | | ID: S-00934 |
| | Black Island Formation | Lithology: Shale | Depth: 14,831.0' |

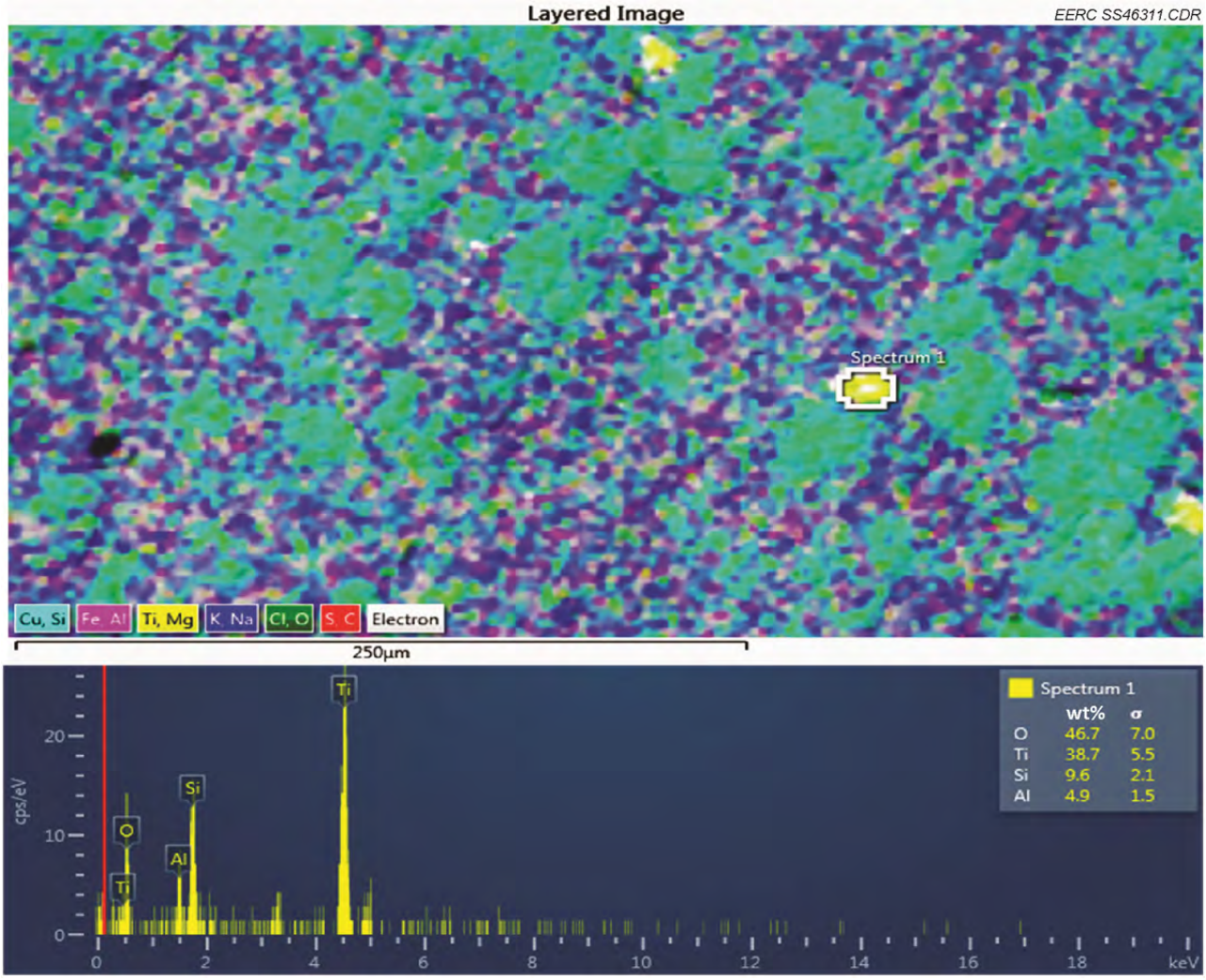
**Composite Mineral Map**




This mineral map of the sample at 90× shows the quartz phase distinctly, but illite and kaolinite are indistinguishable.

| | | | |
|---|---|---|---|
| EERC Energy & Environmental Research Center® Putting Research into Practice UND THE UNIVERSITY OF NORTH DAKOTA | **Applied Geology Laboratory** | | |
| | Well Name: NDIC Well 12596 | | ID: S-00934 |
| | Black Island Formation | Lithology: Shale | Depth: 14,831.0' |

**Mineral Map Overlain on BSE Image with Spectrum Indicating Rutile Identification**




The layered image was used to verify the presence of rutile inclusion in the sample. Although the spectrum shows aluminum and silicon present, those peaks are actually from surrounding clay grains because of electron beam excitation volume.

# APPENDIX B

# PHREEQC DATA AND CALCULATIONS

## Table B-1. Well Analysis

| Well Name | Formation | Sample Top, m | Sample Bottom, m | Sample Top, ft | Sample Bottom, ft | TDS[a] NaCl, mg/L | TDS from Resistivity, mg/L | TDS at Evaporation, mg/L | TDS at Ignition, Mg/L | TDS Calc., mg/L | Density, kg/m$^3$ | Density Temp., °C | pH | Resistivity | Resistivity Temp., °C | Sodium, mg/L | Potassium, mg/L | Calcium, mg/L | Magnesium, mg/L | Iron, mg/L | Chloride, mg/L | Bicarbonate, mg/L | Sulfate, mg/L | Initial Shut-In Pressure, kPa | Initial Shut-In Pressure, psi | Temp., °C | Temp., °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brown Foothills | Flathead | 1783 | | 5850 | | | | 2966 | 2758 | 2782 | 1.006 | 15.6 | 6.9 | 4.700 | 20 | 1 | | 630 | 143 | | 252 | 98 | 1658 | | | 62.0 | 79.6 |
| Government Warren | Cambrian | 3029 | 3059 | 9938 | 10,037 | | | | | 89,915 | 1.057 | 15.6 | 6.2 | | | 31,404 | | 2538 | 684 | | 54,000 | 171 | 1118 | 29,475.1 | 4275.0 | 129.4 | 201 |
| MT API[b] 05083 | Winnipeg | 2761 | 2777 | 9060 | 9110 | | | | | 26,974 | 1.020 | 15.6 | 7 | | | 8767 | | 1202 | 208 | | 14,627 | 617 | 1553 | | | 91.0 | 131.8 |
| Waller | Winnipeg | 2841 | 2851 | 9320 | 9354 | 218,493 | 220,776 | | | 222,209 | 1.132 | 15.6 | 5.6 | 0.052 | 20 | 85,476 | | 1216 | 194 | | 132,500 | 145 | 2678 | 30,716.1 | 4455.0 | 98.9 | 146.002 |
| MT API 21061 | Winnipeg | 2484 | 2585 | 8150 | 8480 | 1970 | 3930 | | | 5123 | 1.004 | 15.6 | 7.6 | 1.300 | 20 | 1230 | | 380 | 53 | | 1200 | 390 | 1870 | 25,028.0 | 3630.0 | 82.8 | 117 |
| MT API 21112 | Flathead | 2071 | 2128 | 6795 | 6980 | 36400 | | | | 44,227 | 1.033 | 15.6 | 6.6 | 0.180 | 20 | 15,000 | 253 | 535 | 272 | | 22,100 | 477 | 5590 | 21,132.4 | 3065.0 | 77.8 | 108 |
| MT API 05008 | Winnipeg | 3585 | 3591 | 11,762 | 11,782 | 280,901 | 275,072 | | | 276,144 | 1.177 | 15.6 | 6.1 | 0.049 | 20 | 81,425 | | 21,582 | 2352 | | 170,346 | 195 | 244 | | | 127.0 | 196.6 |
| MT API 05059 | Winnipeg | 3180 | 3199 | 10,434 | 10,496 | | | | | 329,574 | 1.200 | 15.6 | 6.3 | | | 120,921 | | 6408 | 972 | | 199,384 | 559 | 1330 | 33,349.9 | 4837.0 | 109.0 | 164.2 |
| Ruegsegger | Winnipeg | 3039 | 3057 | 9970 | 10,030 | | | | | 268,579 | 1.164 | 15.6 | 6 | | | 97,321 | | 6453 | 739 | | 162,724 | 168 | 1174 | 24,876.3 | 3608.0 | 104.0 | 155.2 |
| MT API 05112 | Winnipeg | 3021 | 3027 | 9910 | 9930 | | | | | 254,996 | 1.156 | 15.6 | 6.4 | | | 88,593 | | 9214 | 984 | | 155,000 | 370 | 835 | | | 126.0 | 194.8 |
| MT API 21500 | Winnipeg | 3329 | 3343 | 10,921 | 10,967 | 268,000 | | | | 273,376 | 1.175 | 15.6 | 5.2 | 0.050 | 20 | 93,600 | 5280 | 10,200 | 774 | | 163,000 | 174 | 348 | 35,804.5 | 5193.0 | 99.4 | 147 |
| Sed Connole | Winnipeg | 3393 | 3405 | 11,133 | 11,171 | 303,970 | | | | 307,165 | 1.195 | 25.0 | 5.3 | 0.044 | 25 | 104,700 | 4230 | 11,107 | 999 | 496 | 184,338 | 262 | 1033 | 35,804.5 | 5193.0 | 115.0 | 175 |
| Loberg | Flathead | 2304 | 2311 | 7558 | 7582 | 13,306 | 16,017 | | | 17,554 | 1.013 | 15.6 | 6.6 | 0.430 | 20 | 5794 | | 614 | 72 | | 8069 | 330 | 2675 | 24,131.7 | 3500.0 | 74.0 | 101.2 |
| Unit 1 | Winnipeg | 2206 | 2223 | 7238 | 7293 | 200 | 2009 | | | 2939 | 1.005 | 15.6 | 6.7 | 3.450 | 20 | 188 | | 510 | 128 | | 121 | 160 | 1832 | 23,442.2 | 3400.0 | 70.0 | 94 |
| Federal Unit 1 | Winnipeg | 2023 | 2059 | 6638 | 6756 | | | 4384 | 3516 | 3438 | 1.009 | 15.6 | 6.8 | 2.580 | 20 | 541 | | 443 | 88 | | 604 | 180 | 1582 | 22,408.0 | 3250.0 | 74.0 | 101.2 |
| Lillestrand | Winnipeg | 2003 | 2013 | 6570 | 6604 | 224,100 | | | | 224,549 | 1.151 | 15.6 | 5.8 | 0.045 | 20 | 81,880 | | 4772 | 680 | | 135,820 | 27 | 1370 | 21,870.2 | 3172.0 | 67.0 | 88.6 |
| ND 6436 | Deadwood | 2905 | 2925 | 9532 | 9596 | 304,572 | | | | 302,575 | 1.184 | 15.6 | 5.3 | 0.059 | 20 | 88,703 | 6713 | 18,796 | 3090 | | 185,000 | 73 | 200 | 29,819.8 | 4325.0 | 86.7 | 124 |
| ND 0151 | Deadwood | 2356 | 2366 | 7729 | 7763 | | | 144,830 | 141,490 | 143,506 | 1.089 | 15.6 | 6.9 | 0.070 | 20 | 52,358 | | 2801 | 485 | | 85,000 | 105 | 2757 | 25,511.0 | 3700.1 | 68.0 | 90.4 |
| Beaver Lodge Dev. | Deadwood | 4267 | 4279 | 14,000 | 14,040 | | | | | 283,097 | 1.154 | 15.6 | 6.6 | 0.049 | 20 | 106,013 | | 4569 | 204 | | 171,378 | 635 | 298 | | | 150.0 | 238 |
| ND 1636 | Deadwood | 4130 | 4138 | 13,550 | 13,577 | | | | | 328,194 | 1.186 | 15.6 | 6.7 | 0.056 | 20 | 107,871 | | 15,939 | 2467 | | 201,501 | 160 | 256 | | | 134.0 | 209.2 |
| Wendell Haley | Winnipeg | 979 | | 3211 | | | | | | 24,568 | 1.019 | 15.6 | 6.6 | 1.330 | 20 | 7201 | | 1063 | 538 | | 9674 | 304 | 6383 | | | 37.0 | 34.6 |
| Harold Billey | Winnipeg | 561 | | 1840 | | | | | | 3701 | 1.005 | 15.6 | 7.1 | 2.250 | 20 | 1171 | | 46 | 22 | | 651 | 221 | 1590 | | | | −32 |
| John Stadum | Winnipeg | 1541 | 1544 | 5057 | 5065 | | | | | 53,480 | 1.036 | 15.6 | 7 | | | 18,309 | | 1638 | 277 | | 28,368 | 165 | 4723 | 16,547.4 | 2400.0 | 53.0 | 63.4 |
| Craig | Winnipeg | 1320 | 1323 | 4330 | 4342 | | | | | 3458 | 1.006 | 15.6 | 7.9 | | | 1160 | | 48 | 10 | | 1200 | 240 | 800 | 14,596.2 | 2117.0 | 65.6 | 86 |
| Zwinger | Winnipeg | 1309 | 1323 | 4293 | 4340 | | | | | 13,092 | 1.012 | 15.6 | 7.7 | | | 3714 | | 702 | 77 | | 3920 | 364 | 4315 | | | 54.0 | 65.2 |
| Ferguson | Winnipeg | 1909 | 1910 | 6262 | 6266 | | | | | 2826 | 1.006 | 15.6 | 7 | | | 439 | | 413 | 36 | | 420 | 170 | 1348 | 18,084.9 | 2623.0 | 62.0 | 79.6 |
| Elk Basin | Flathead | 2182 | 2216 | 7160 | 7271 | 4601 | 6484 | | | 7571 | 1.006 | 15.6 | 7.3 | 1.000 | 20 | 2244 | | 442 | 12 | | 2790 | 305 | 1778 | | | 54.0 | 65.2 |

[a] Total dissolved solids.
[b] Montana American Petroleum Institute.

**Table B-2. Average Shale Composition**

| Sample: | S-00774 | S-00775 | Average |
|---|---|---|---|
| Formation: | Icebox | Icebox | |
| Depth, ft: | 9800 | 9800 | |
| Mineral | wt Fraction | wt Fraction | wt Fraction |
| Illite | 0.155 | 0.152 | 0.153 |
| Kaolinite | 0.362 | 0.223 | 0.292 |
| Muscovite | 0.151 | 0.136 | 0.144 |
| Quartz | 0.229 | 0.399 | 0.314 |
| Microcline | 0.085 | 0.040 | 0.062 |
| Sanidine | 0.000 | 0.035 | 0.018 |
| Anatase | 0.019 | 0.015 | 0.017 |

**Table B-3. ND 6436 Average Mineral Composition for Aquifer and Cap Rock Zones**

Well Name: ND 6436
API Number: 33-075-00744-0000
State Identification: ND 6436

| Formation Zone: | Aquifer Total Without $CO_2$ | With $CO_2$ | Difference |
|---|---|---|---|
| pH | 5.847 | 4.342 | −1.505 |
| pE | −2.382 | −0.440 | 1.942 |
| Activity | 0.847 | 0.833 | −0.014 |
| Ionic Strength | 4.334 | 4.262 | −0.072 |
| Total $CO_2$, moles | 2.321E-04 | 0.859 | 0.859 |
| moles/kg $H_2O$ | | | |
| Al | 0.000 | 0.000 | 0.000 |
| C | 0.000 | 0.879 | 0.879 |
| Ca | 0.532 | 0.003 | −0.529 |
| Cl | 5.920 | 5.920 | 0.000 |
| Fe | 0.000 | 0.002 | 0.002 |
| K | 0.001 | 0.046 | 0.045 |
| Mg | 0.241 | 0.786 | 0.545 |
| Na | 4.374 | 4.374 | 0.000 |
| S | 0.001 | 0.005 | 0.004 |
| Si | 0.001 | 0.001 | 0.000 |
| Initial, moles/kg $H_2O$ | | | |
| Annite | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 |
| Illite | 3.912 | 3.912 | 0.000 |
| K-Feldspar | 1.084 | 1.084 | 0.000 |
| Kaolinite | 27.060 | 27.060 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 |
| Muscovite | 21.910 | 21.910 | 0.000 |
| Phlogopite | 0.064 | 0.064 | 0.000 |
| Pyrite | 21.770 | 21.770 | 0.000 |
| Quartz | 204.400 | 204.400 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-3. ND 6436 Average Mineral Composition for Aquifer and Cap Rock Zones (continued)**

| Formation Zone: | Aquifer Total Without $CO_2$ | With $CO_2$ | Difference |
|---|---|---|---|
| Final, moles/kg $H_2O$ | | | |
| Annite | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 298.100 | 298.100 |
| Dolomite | 0.000 | 0.529 | 0.529 |
| Goethite | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 |
| Kaolinite | 26.960 | 26.670 | −0.290 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 |
| Muscovite | 25.240 | 25.550 | 0.310 |
| Phlogopite | 0.358 | 0.000 | −0.358 |
| Pyrite | 21.770 | 21.760 | −0.010 |
| Quartz | 210.700 | 211.400 | 0.700 |
| Rutile | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 |
| Change, moles/kg $H_2O$ | | | |
| Annite | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | −1.937 | 1.937 |
| Dolomite | 0.000 | 0.529 | 0.529 |
| Goethite | 0.000 | 0.000 | 0.000 |
| Illite | −3.912 | −3.912 | 0.000 |
| K-Feldspar | −1.084 | −1.084 | 0.000 |
| Kaolinite | −0.102 | −0.392 | −0.290 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 |
| Muscovite | 3.331 | 3.644 | 0.313 |
| Phlogopite | 0.294 | −0.064 | −0.358 |
| Pyrite | 0.000 | −0.002 | −0.002 |
| Quartz | 6.274 | 6.990 | 0.716 |
| Rutile | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 |

**Table B-3. ND 6436 Average Mineral Composition for Aquifer and Cap Rock Zones (continued)**

| Formation Zone: | Aquifer Total Without $CO_2$ | With $CO_2$ | Difference |
|---|---|---|---|
| Formation Water Solution | | | |
| $CaCO_3$ | 1.15E-06 | 8.24E-08 | −1.06E-06 |
| $CaHCO_3^+$ | 5.83E-05 | 1.35E-04 | 7.68E-05 |
| $CO_2$ | 5.95E-05 | 7.87E-01 | 7.87E-01 |
| $CO_3^{2-}$ | 1.89E-08 | 2.37E-07 | 2.18E-07 |
| $FeCO_3$ | 1.72E-11 | 2.56E-08 | 2.56E-08 |
| $FeCO_3^+$ | 2.42E-22 | 3.17E-17 | 3.17E-17 |
| $FeHCO_3^+$ | 6.71E-09 | 3.22E-04 | 3.22E-04 |
| $HCO_3^-$ | 4.58E-05 | 1.85E-02 | 1.85E-02 |
| $MgCO_3$ | 1.66E-07 | 6.31E-06 | 6.15E-06 |
| $MgHCO_3^+$ | 3.12E-05 | 3.83E-02 | 3.83E-02 |
| $NaCO_3^-$ | 2.54E-09 | 3.15E-08 | 2.89E-08 |
| $NaHCO_3$ | 3.60E-05 | 1.42E-02 | 1.42E-02 |
| $CO_2$ moles/kg $H_2O$ | | | |
| $CO_2$ Calcite | 0.000 | 0.000 | 0.000 |
| $CO_2$ Dolomite | 0.000 | 1.058 | 1.058 |
| $CO_2$ Siderite | 0.000 | 0.000 | 0.000 |
| Total Mineral $CO_2$ | 0.000 | 1.058 | 1.058 |
| Solution $CO_2$ | 2.32E-04 | 0.859 | 0.859 |
| Total Moles $CO_2$ | 2.32E-04 | 1.92E+00 | 1.916 |
| Water, $g/cm^3$ | 0.081 | 0.081 | 0.081 |
| Water, $kg/m^3$ | 81.206 | 81.206 | 81.206 |
| $CO_2$, $moles/m^3$ | 0.019 | 155.625 | 155.604 |

## Table B-4. Mineral Used in the Calculations

| Well Mineral Analysis | | | | | LLNL* Database | |
|---|---|---|---|---|---|---|
| Mineral | Formula | Substitution | Mineral | Formula | Mineral | Formula |
| Biotite | $KMg_{2.5}Fe^{2+}_{0.5}AlSi_3O_{10}(OH)_{1.75}F_{0.25}$ | Yes | Phlogopite | $KMg_3(Si_3Al)O_{10}(F,OH)_2$ | Phlogopite | $KAlMg_3Si_3O_{10}(OH)_2$ |
| Calcite | $CaCO_3$ | | Calcite | $CaCO_3$ | Calcite | $CaCO_3$ |
| Chlorite | (group) | Yes | Clinochlore | $Mg_{3.75}Fe^{2+}_{1.25}Si_3Al_2O_{10}(OH)_8$ | Clinochlore-7A | $Mg_5Al_2Si_3O_{10}(OH)_8$ |
| Dolomite | $CaMg(CO_3)_2$ | | Dolomite | $CaMg(CO_3)_2$ | Dolomite | $CaMg(CO_3)_2$ |
| Glauconite | $K_{0.6}Na_{0.05}Fe^{3+}_{1.3}Mg_{0.4}Fe^{2+}_{0.2}Al_{0.3}Si_{3.8}O_{10}(OH)_2$ | Yes | Celadonite | $KMgAlSi_4O_{10}(OH)_2$ | Celadonite | $KMgAlSi_4O_{10}(OH)_2$ |
| Illite | $K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$ | | Illite | $K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$ | Illite | $K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$ |
| K-Feldspar | $KAlSi_3O_8$ | | K-Feldspar | $KAlSi_3O_8$ | K-Feldspar | $KAlSi_3O_8$ |
| Kaolinite | $Al_2Si_2O_5(OH)_4$ | | Kaolinite | $Al_2Si_2O_5(OH)_4$ | Kaolinite | $Al_2Si_2O_5(OH)_4$ |
| Muscovite | $KAl_3Si_3O_{10}(OH)_2$ | | Muscovite | $KAl_3Si_3O_{10}(OH)_2$ | Muscovite | $KAl_3Si_3O_{10}(OH)_2$ |
| Pyrite | $FeS_2$ | | Pyrite | $FeS_2$ | Pyrite | $FeS_2$ |
| Quartz | $SiO_2$ | | Quartz | $SiO_2$ | Quartz | $SiO_2$ |
| Anatase | $TiO_2$ | Yes | Rutile | $TiO_2$ | Rutile | $TiO_2$ |
| Microcline | $KAlSi_3O_8$ | | Microcline | $KAlSi_3O_8$ | Maximum microcline | $KAlSi_3O_8$ |
| Sanidine | $K_{0.75}Na_{0.25}AlSi_3O_8$ | | Sanidine | $KAlSi_3O_8$ | Sanidine high | $KAlSi_3O_8$ |
| Mica | (group) | Yes | Muscovite | $KAl_3Si_3O_{10}(OH)_2$ | Muscovite | $KAl_3Si_3O_{10}(OH)_2$ |
| Smectite | $Na_{0.6}Ca_{0.3}K_{0.1}Al_6Si_6O_{20}(OH)_4 \cdot 2(H_2O)$ | Yes | Illite | $K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$ | Illite | $K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$ |
| Ankerite | $CaFé^{2+}_{0.6}Mg_{0.3}Mn^{2+}_{0.1}(CO_3)_2$ | Yes | Dolomite | $CaMg(CO_3)_2$ | Dolomite | $CaMg(CO_3)_2$ |

* Lawrence Livermore national Laboratory

Continued…

**Table B-4. Mineral Used in the Calculations (continued)**

| Well Mineral Analysis | | | LLNL Database | | | |
|---|---|---|---|---|---|---|
| Mineral | Formula | Substitution | Mineral | Formula | Mineral | Formula |
| Shale Composition, wt fraction | | | | | | |
| Illite = 0.142 | $K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$ | | Illite | $K_{0.6}Mg_{0.25}Al_{1.8}$ $Al_{0.5}Si_{3.5}O_{10}(OH)_2$ | Illite | $K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$ |
| K-Feldspar = 0.074 | $KAlSi_3O_8$ | | K-Feldspar | $KAlSi_3O_8$ | K-Feldspar | $KAlSi_3O_8$ |
| Kaolinite = 0.271 | $Al_2Si_2O_5(OH)_4$ | | Kaolinite | $Al_2Si_2O_5(OH)_4$ | Kaolinite | $Al_2Si_2O_5(OH)_4$ |
| Muscovite = 0.133 | $KAl_3Si_3O_{10}(OH)_2$ | | Muscovite | $KAl_3Si_3O_{10}(OH)_2$ | Muscovite | $KAl_3Si_3O_{10}(OH)_2$ |
| Quartz = 0.291 | $SiO_2$ | | Quartz | $SiO_2$ | Quartz | $SiO_2$ |
| Microcline = 0.058 | $KAlSi_3O_8$ | | Microcline | $KAlSi_3O_8$ | Maximum microcline | $KAlSi_3O_8$ |
| Sanidine = 0.016 | $KAlSi_3O_8$ | | Sanidine | $KAlSi_3O_8$ | Sanidine high | $KAlSi_3O_8$ |
| Anatase = 0.016 | $TiO_2$ | Yes | Rutile | $TiO_2$ | Rutile | $TiO_2$ |

## Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MT API 21152 API Identification: 25-033-21152-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 0.06 | 0.04 | 0.12 | 0.02 | 0.18 | 0.02 | 0.02 | NA[1] | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 1.10 | 1.15 | 0.99 | 1.02 | 0.98 | 1.22 | 1.00 | NA | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.93 | 0.53 | 1.80 | 1.70 | 1.86 | 0.20 | 1.88 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 2.10 | 1.72 | 2.91 | 2.74 | 3.03 | 1.43 | 2.90 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 152.55 | 124.96 | 210.83 | 198.75 | 219.60 | 104.10 | 210.07 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 4.32 | 3.54 | 5.97 | 5.63 | 6.22 | 2.95 | 5.95 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 6.71 | 5.50 | 9.28 | 8.75 | 9.66 | 4.58 | 9.25 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.42 | 0.34 | 0.58 | 0.55 | 0.60 | 0.29 | 0.58 | NA | NA | NA | NA | NA | NA | NA |
| ND 7577 API Identification 33-075-00798-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 1.07 | 1.07 | 1.07 | Did not converge | Did not converge | Did not converge | 1.06 | NA | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.80 | 0.76 | 0.76 | Did not converge | Did not converge | Did not converge | 1.23 | NA | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.19 | 0.18 | 0.18 | Did not converge | Did not converge | Did not converge | 0.27 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 2.06 | 2.00 | 2.01 | Did not converge | Did not converge | Did not converge | 2.57 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 103.80 | 118.05 | 60.47 | Did not converge | Did not converge | Did not converge | 9.70 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 2.94 | 3.34 | 1.71 | Did not converge | Did not converge | Did not converge | 0.27 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 4.57 | 5.20 | 2.66 | Did not converge | Did not converge | Did not converge | 0.43 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.29 | 0.32 | 0.17 | Did not converge | Did not converge | Did not converge | 0.03 | NA | NA | NA | NA | NA | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ND 6436 API Identification 33-075-00744-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 0.55 | 1.08 | 1.12 | 0.14 | 0.09 | 0.06 | 0.43 | 0.05 | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.77 | 0.77 | 0.73 | 0.81 | 0.78 | 0.78 | 0.78 | 0.78 | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.39 | 0.55 | 1.27 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 1.71 | 2.41 | 3.13 | 0.98 | 0.89 | 0.87 | 1.24 | 0.85 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 167.89 | 174.55 | 455.48 | 66.65 | 34.09 | 33.07 | 101.90 | 50.51 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 4.75 | 4.94 | 12.90 | 1.89 | 0.97 | 0.94 | 2.89 | 1.43 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 7.39 | 7.68 | 20.05 | 2.93 | 1.50 | 1.46 | 4.48 | 2.22 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.46 | 0.48 | 1.25 | 0.18 | 0.09 | 0.09 | 0.28 | 0.14 | NA | NA | NA | NA | NA | NA |
| ND 6264 API Identification 33-015-00032-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 0.25 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.22 | 0.66 | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.75 | 0.80 | 0.76 | 0.80 | 0.80 | 0.89 | 0.63 | 0.81 | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 2.66 | 1.47 | 3.42 | 1.60 | 1.52 | 0.19 | 3.81 | 3.29 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 3.66 | 2.42 | 4.33 | 2.54 | 2.47 | 1.23 | 4.67 | 4.76 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 228.25 | 432.63 | 72.54 | 309.39 | 394.84 | 250.79 | 238.80 | 59.79 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 6.46 | 12.25 | 2.05 | 8.76 | 11.18 | 7.10 | 6.76 | 1.69 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 10.05 | 19.04 | 3.19 | 13.62 | 17.38 | 11.04 | 10.51 | 2.63 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.63 | 1.19 | 0.20 | 0.85 | 1.08 | 0.69 | 0.66 | 0.16 | NA | NA | NA | NA | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ND 9622<br>API Identification<br>33-023-00221-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 15.96 | 0.23 | 100.42 | 0.04 | -0.01 | 0.36 | 1.07 | 1.08 | 1.09 | Did not converge | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.90 | 0.81 | 1.09 | 0.81 | 0.82 | 0.82 | 0.82 | 1.03 | 1.00 | Did not converge | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.11 | 0.01 | 0.05 | 0.02 | 0.02 | 0.02 | 0.30 | 0.21 | 0.30 | Did not converge | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 16.94 | 1.05 | 101.57 | 0.87 | 0.82 | 0.38 | 2.19 | 2.33 | 2.39 | Did not converge | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 417.62 | 56.96 | 2426.79 | 75.03 | 57.99 | 35.57 | 68.51 | 12.38 | 5.65 | Did not converge | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 11.83 | 1.61 | 68.72 | 2.12 | 1.64 | 1.01 | 1.94 | 0.35 | 0.16 | Did not converge | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 18.38 | 2.51 | 106.80 | 3.30 | 2.55 | 1.57 | 3.01 | 0.54 | 0.25 | Did not converge | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 1.15 | 0.16 | 6.67 | 0.21 | 0.16 | 0.10 | 0.19 | 0.03 | 0.02 | Did not converge | NA | NA | NA | NA |
| MT API 21127<br>API Identification<br>25-019-21127-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 0.40 | 0.19 | −0.01 | 0.72 | 0.03 | 0.04 | 0.18 | 0.38 | 1.61 | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.64 | 0.66 | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.05 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.50 | 0.03 | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 1.10 | 0.86 | 0.66 | 1.40 | 0.70 | 0.72 | 0.86 | 1.52 | 2.30 | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 62.42 | 61.62 | 26.46 | 69.46 | 16.11 | 13.40 | 69.03 | 21.53 | 76.88 | NA | NA | NA | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total $CO_2$, moles/ft$^3$ | 1.77 | 1.74 | 0.75 | 1.97 | 0.46 | 0.38 | 1.95 | 0.61 | 2.18 | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/m$^3$ | 2.75 | 2.71 | 1.16 | 3.06 | 0.71 | 0.59 | 3.04 | 0.95 | 3.38 | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/ft$^3$ | 0.17 | 0.17 | 0.07 | 0.19 | 0.04 | 0.04 | 0.19 | 0.06 | 0.21 | NA | NA | NA | NA | NA |
| MT API 21500 API Identification: 25-091-21500-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 1.47 | −0.01 | 0.13 | 0.29 | 0.56 | 1.04 | 8.13 | 0.31 | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.98 | 1.00 | 1.00 | 1.00 | 0.87 | 1.00 | 0.99 | 1.01 | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.17 | 0.04 | 0.04 | 0.04 | 0.88 | 0.04 | 0.04 | 0.04 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 2.62 | 1.03 | 1.17 | 1.33 | 2.31 | 2.08 | 9.15 | 1.35 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/m$^3$ | 153.54 | 113.23 | 95.07 | 131.19 | 78.95 | 126.59 | 361.39 | 145.51 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/ft$^3$ | 4.35 | 3.21 | 2.69 | 3.71 | 2.24 | 3.58 | 10.23 | 4.12 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/m$^3$ | 6.76 | 4.98 | 4.18 | 5.77 | 3.47 | 5.57 | 15.90 | 6.40 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/ft$^3$ | 0.42 | 0.31 | 0.26 | 0.36 | 0.22 | 0.35 | 0.99 | 0.40 | NA | NA | NA | NA | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ND 12596 API Identification: 33-053-02268-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 23.94 | 14.75 | 0.47 | 16.47 | 0.94 | 37.88 | NA | NA | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 1.20 | 1.22 | 1.44 | 1.34 | 1.20 | 1.10 | NA | NA | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.13 | 0.42 | 0.21 | 0.20 | 0.02 | 0.02 | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 25.28 | 16.39 | 2.13 | 18.01 | 2.16 | 39.00 | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 421.45 | 1236.30 | 57.02 | 527.27 | 83.49 | 217.66 | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 11.93 | 35.01 | 1.61 | 14.93 | 2.36 | 6.16 | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 18.55 | 54.41 | 2.51 | 23.21 | 3.67 | 9.58 | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 1.16 | 3.40 | 0.16 | 1.45 | 0.23 | 0.60 | NA | NA | NA | NA | NA | NA | NA | NA |
| MT API 21606 FLB API Identification: 25-091-21606-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 0.53 | 0.66 | 0.48 | 0.58 | 0.23 | 0.58 | 0.40 | 0.59 | 0.56 | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.77 | 0.82 | 0.85 | 0.76 | 0.86 | 0.77 | 0.86 | 0.84 | 0.40 | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.41 | 0.59 | 0.03 | 0.58 | 0.02 | 0.59 | 0.02 | 0.59 | 0.50 | NA | NA | NA | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total $CO_2$, moles/kg $H_2O$ | 1.70 | 2.07 | 1.37 | 1.93 | 1.11 | 1.94 | 1.29 | 2.02 | 1.47 | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 121.96 | 130.84 | 185.11 | 76.05 | 49.41 | 62.01 | 166.16 | 183.26 | 18.52 | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 3.45 | 3.70 | 5.24 | 2.15 | 1.40 | 1.76 | 4.71 | 5.19 | 0.52 | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 5.37 | 5.76 | 8.15 | 3.35 | 2.17 | 2.73 | 7.31 | 8.07 | 0.82 | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.34 | 0.36 | 0.51 | 0.21 | 0.14 | 0.17 | 0.46 | 0.50 | 0.05 | NA | NA | NA | NA | NA |
| ND 12831 API Identification: 33-1-5-01389-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 24.73 | 15.33 | 17.42 | 0.87 | 1.53 | 19.38 | 0.31 | 76.46 | 0.93 | 34.04 | 46.10 | 35.97 | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 1.18 | 1.15 | 1.16 | 1.07 | 1.08 | 1.18 | 1.07 | 1.34 | 1.06 | 1.21 | 1.28 | 1.23 | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.06 | 0.03 | 0.03 | 0.02 | 0.02 | 0.14 | 0.01 | 0.05 | 0.22 | 0.04 | 0.05 | 0.04 | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 25.97 | 16.51 | 18.61 | 1.96 | 2.63 | 20.70 | 1.39 | 77.86 | 2.21 | 35.29 | 47.43 | 37.24 | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 1082.17 | 314.45 | 1347.93 | 114.76 | 210.49 | 859.46 | 207.13 | 1636.18 | 124.69 | 885.59 | 2206.58 | 1470.11 | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 30.64 | 8.90 | 38.17 | 3.25 | 5.96 | 24.34 | 5.87 | 46.33 | 3.53 | 25.08 | 62.48 | 41.63 | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 47.63 | 13.84 | 59.32 | 5.05 | 9.26 | 37.82 | 9.12 | 72.01 | 5.49 | 38.97 | 97.11 | 64.70 | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 2.97 | 0.86 | 3.70 | 0.32 | 0.58 | 2.36 | 0.57 | 4.50 | 0.34 | 2.43 | 6.06 | 4.04 | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MT API 21748 API Identification: 25-091-21748-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 4.47 | 0.35 | 2.04 | 9.74 | 8.55 | 1.72 | 0.96 | NA | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.86 | 0.88 | 0.85 | 0.86 | 0.82 | 0.86 | 0.93 | NA | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.53 | 0.02 | 0.63 | 0.03 | 0.64 | 0.65 | 0.66 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 5.86 | 1.25 | 3.53 | 10.64 | 10.01 | 3.22 | 2.55 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 341.12 | 182.41 | 341.60 | 522.00 | 492.39 | 264.59 | 151.46 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 9.66 | 5.17 | 9.67 | 14.78 | 13.94 | 7.49 | 4.29 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 15.01 | 8.03 | 15.03 | 22.97 | 21.67 | 11.64 | 6.67 | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.94 | 0.50 | 0.94 | 1.43 | 1.35 | 0.73 | 0.42 | NA | NA | NA | NA | NA | NA | NA |
| MT API 21112 API Indentification 25-069-21112-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 3.41 | 0.08 | 1.00 | 12.16 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.55 | 0.85 | 0.54 | 0.46 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.44 | 1.17 | 0.04 | 1.34 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total $CO_2$, moles/kg $H_2O$ | 4.40 | 2.10 | 1.58 | 13.96 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 289.82 | 212.23 | 194.10 | 614.83 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 8.21 | 6.01 | 5.50 | 17.41 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 12.76 | 9.34 | 8.54 | 27.06 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.80 | 0.58 | 0.53 | 1.69 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| ND 9800 API Identification: 33-105-01044-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 19.48 | 20.34 | 23.63 | 22.01 | 18.73 | 19.97 | 20.90 | 15.68 | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 1.11 | 1.10 | 1.09 | 1.10 | 1.11 | 1.11 | 1.11 | 1.12 | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 20.61 | 21.46 | 24.74 | 23.13 | 19.86 | 21.09 | 22.02 | 16.82 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 353.24 | 463.74 | 364.44 | 321.47 | 288.12 | 456.41 | 528.97 | 379.44 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 10.00 | 13.13 | 10.32 | 9.10 | 8.16 | 12.92 | 14.98 | 10.74 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 15.55 | 20.41 | 16.04 | 14.15 | 12.68 | 20.09 | 23.28 | 16.70 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.97 | 1.27 | 1.00 | 0.88 | 0.79 | 1.25 | 1.45 | 1.04 | NA | NA | NA | NA | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MT API 21279 API Identification: 25-011-21279-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 8.75 | 0.08 | 10.91 | 7.34 | 12.75 | 0.07 | 16.34 | 0.05 | 11.95 | 0.33 | 13.44 | 32.27 | 2.92 | 3.07 |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 1.31 | 1.22 | 1.32 | 1.33 | 1.33 | 1.21 | 1.33 | 1.18 | 1.34 | 1.35 | 1.35 | 1.35 | 1.25 | 1.36 |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.17 | 0.66 | 0.04 | 0.04 | 0.04 | 0.67 | 0.04 | 0.68 | 0.04 | 0.04 | 0.04 | 0.04 | 0.67 | 0.04 |
| | Total $CO_2$, moles/kg $H_2O$ | 10.23 | 1.96 | 12.28 | 8.71 | 14.12 | 1.95 | 17.71 | 1.91 | 13.33 | 1.73 | 14.83 | 33.67 | 4.85 | 4.47 |
| | Total $CO_2$, moles/$m^3$ | 321.41 | 50.76 | 207.01 | 179.15 | 308.77 | 34.02 | 569.50 | 30.73 | 474.28 | 143.91 | 706.09 | 1077.06 | 286.28 | 223.85 |
| | Total $CO_2$, moles/$ft^3$ | 9.10 | 1.44 | 5.86 | 5.07 | 8.74 | 0.96 | 16.13 | 0.87 | 13.43 | 4.08 | 19.99 | 30.50 | 8.11 | 6.34 |
| | Total $CO_2$, kg/$m^3$ | 14.15 | 2.23 | 9.11 | 7.88 | 13.59 | 1.50 | 25.06 | 1.35 | 20.87 | 6.33 | 31.08 | 47.40 | 12.60 | 9.85 |
| | Total $CO_2$, lb/$ft^3$ | 0.88 | 0.14 | 0.57 | 0.49 | 0.85 | 0.09 | 1.56 | 0.08 | 1.30 | 0.40 | 1.94 | 2.96 | 0.79 | 0.62 |
| ND 7087 API Identification: 33-023-00171-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 1.14 | 1.07 | 1.06 | 1.08 | 1.09 | 1.07 | Did not converge | 1.07 | Did not converge | Did not converge | 3.34 | 1.08 | 1.07 | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.82 | 1.05 | 0.69 | 0.79 | 0.91 | 0.83 | Did not converge | 0.76 | Did not converge | Did not converge | 0.86 | 0.83 | 0.84 | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.33 | 0.39 | 0.38 | 0.39 | 0.39 | 0.20 | Did not converge | 0.39 | Did not converge | Did not converge | 0.03 | 0.40 | 0.28 | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total $CO_2$, moles/kg $H_2O$ | 2.29 | 2.51 | 2.13 | 2.25 | 2.38 | 2.09 | Did not converge | 2.22 | Did not converge | Did not converge | 4.23 | 2.30 | 2.20 | NA |
| | Total $CO_2$, moles/$m^3$ | 109.80 | 14.20 | 39.05 | 80.61 | 29.35 | 155.22 | Did not converge | 93.10 | Did not converge | Did not converge | 455.81 | 101.94 | 198.90 | NA |
| | Total $CO_2$, moles/$ft^3$ | 3.11 | 0.40 | 1.11 | 2.28 | 0.83 | 4.40 | Did not converge | 2.64 | Did not converge | Did not converge | 12.91 | 2.89 | 5.63 | NA |
| | Total $CO_2$, kg/$m^3$ | 4.83 | 0.62 | 1.72 | 3.55 | 1.29 | 6.83 | Did not converge | 4.10 | Did not converge | Did not converge | 20.06 | 4.49 | 8.75 | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.30 | 0.04 | 0.11 | 0.22 | 0.08 | 0.43 | Did not converge | 0.26 | Did not converge | Did not converge | 1.25 | 0.28 | 0.55 | NA |
| MT API 21320 API Identification: 25-083-21320-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 13.27 | 0.20 | 2.74 | 27.92 | 300.10 | 1.22 | 1.35 | 1.20 | 1.29 | 0.74 | 42.35 | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 1.15 | 1.13 | 1.13 | 1.32 | 0.00 | 1.17 | 1.59 | 0.60 | 1.59 | 1.17 | 1.41 | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.53 | 0.04 | 0.04 | 0.07 | 0.00 | 0.61 | 0.82 | 0.73 | 0.65 | 0.04 | 0.08 | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 14.95 | 1.37 | 3.90 | 29.31 | 300.10 | 3.00 | 3.76 | 2.53 | 3.53 | 1.94 | 43.84 | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 115.35 | 127.22 | 201.87 | 907.42 | 514.14 | 56.64 | 8.02 | 13.29 | 17.97 | 91.54 | 768.52 | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 3.27 | 3.60 | 5.72 | 25.70 | 14.56 | 1.60 | 0.23 | 0.38 | 0.51 | 2.59 | 21.76 | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 5.08 | 5.60 | 8.88 | 39.94 | 22.63 | 2.49 | 0.35 | 0.58 | 0.79 | 4.03 | 33.82 | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.32 | 0.35 | 0.55 | 2.49 | 1.41 | 0.16 | 0.02 | 0.04 | 0.05 | 0.25 | 2.11 | NA | NA | NA |

[1] Not applicable.

Continued…

**Table B-5. Summary of $CO_2$ Interaction with Minerals in the Aquifer and Cap Rock (continued)**

| Well Name | | Weighted Average | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MT API 21328 API Identification: 25-085-21328-0000 | Mineral $CO_2$, moles/kg $H_2O$ | 10.28 | 0.01 | 0.58 | 0.07 | 11.21 | 0.34 | 2.91 | 90.06 | NA | NA | NA | NA | NA | NA |
| | Dissolved $CO_2$, moles/kg $H_2O$ | 0.59 | 0.74 | 0.74 | 0.74 | 0.81 | 0.74 | 0.01 | 0.96 | NA | NA | NA | NA | NA | NA |
| | Solution $CO_2$, moles/kg $H_2O$ | 0.25 | 0.03 | 0.03 | 0.03 | 0.33 | 0.03 | 0.75 | 0.11 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/kg $H_2O$ | 11.12 | 0.77 | 1.34 | 0.84 | 12.36 | 1.10 | 3.67 | 91.13 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$m^3$ | 244.67 | 48.03 | 83.90 | 42.01 | 321.36 | 73.04 | 213.92 | 1318.35 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, moles/$ft^3$ | 6.93 | 1.36 | 2.38 | 1.19 | 9.10 | 2.07 | 6.06 | 37.33 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, kg/$m^3$ | 10.77 | 2.11 | 3.69 | 1.85 | 14.14 | 3.21 | 9.41 | 58.02 | NA | NA | NA | NA | NA | NA |
| | Total $CO_2$, lb/$ft^3$ | 0.67 | 0.13 | 0.23 | 0.12 | 0.88 | 0.20 | 0.59 | 3.62 | NA | NA | NA | NA | NA | NA |

**Table B-6. Wells with Mineral Data for the Basal Cambrian Aquifer**

| Report Well Name | Well Name | API Number | State ID | State | County | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| MT API 21152 | Carnosaurus 1-17 | 25-033-21152-0000 | | MT | Garfield | 46.8830 | −107.6794 |
| ND 7577 | Dewing 12-15 | 33-075-00798-0000 | ND 7577 | ND | Renville | 48.6857 | −101.7741 |
| ND 6436 | E-M Duerre 5-9 | 33-075-00744-0000 | ND 6436 | ND | Renville | 48.9707 | −101.9816 |
| Federal 4-33 | Federal 4-33 | 25-075-22266-0000 | | MT | Powder River | 45.0112 | −105.6045 |
| Federal 9-1 | Federal 9-1 | 25-071-21806-0000 | | MT | Phillips | 48.8104 | −108.2046 |
| ND 6264 | Funston 1 | 33-015-00032-0000 | ND 6264 | ND | Burleigh | 46.8786 | −100.2692 |
| Hackberry Creek | Hackberry Creek 13-1 | 25-011-21323-0000 | | MT | Carter | 45.4236 | −104.2699 |
| ND 9622 | Arnold Hagen State 1 | 33-023-00221-0000 | ND 9622 | ND | Divide | 48.9650 | −103.3962 |
| Halkoa | Halkoa 16-22 | 25-013-21047-0000 | | MT | Cascade | 47.3788 | −111.1991 |
| ND 9257 | Hamann 1-19-4B | 33-089-00262-0000 | ND 9257 | ND | Stark | 46.8380 | −102.3404 |
| MT API 21127 | Hersel 14-5 | 25-019-21127-0000 | | MT | Daniels | 48.8117 | −105.8607 |
| MT API 21500 | Hoven 1-12 | 25-091-21500-0000 | | MT | Sheridan | 48.7096 | −104.4686 |
| ND 12596 | Isabel Bryant 1-3 | 33-053-02268-0000 | ND 12596 | ND | McKenzie | 47.8445 | −103.0719 |
| Jackson | Jackson 1-12-4A | 25-109-21047-0000 | | MT | Wibaux | 47.2424 | −104.2748 |
| MT API 21606 | Joyes FLB 1 | 25-091-21606-0000 | | MT | Sheridan | 48.9736 | −104.2827 |
| Kendrick | Kendrick No. 2 21-7 | 25-003-21177-0000 | | MT | Big Horn | 45.8537 | −107.2931 |
| Larson | Bakken Larson 24-2 | 25-083-21244-0000 | | MT | Richland | 47.6036 | −104.2425 |
| Lawrence | Lawrence “E” 16-29 | 25-109-21039-0000 | | MT | Wibaux | 46.9338 | −104.1396 |
| ND 12831 | Nelson 22-44 | 33-1-5-01389-0000 | ND 12831 | ND | Williams | 48.3163 | −103.0049 |
| Orestad | Orestad-Oddy 6-11 | 25-075-22030-0000 | | MT | Wibaux | 45.7858 | −105.1127 |
| MT API 21748 | Rovig 1-8 | 25-091-21748-0000 | | MT | Sheridan | 48.9803 | −104.8883 |
| MT API 21112 | Sharptail 1 | 25-069-21112-0000 | | MT | Petroleum | 47.2370 | −108.6813 |
| ND 9800 | Simpson 1-H | 33-105-01044-0000 | ND 9800 | ND | Williams | 48.4795 | −103.1977 |
| MT API 21279 | State 1 | 25-011-21279-0000 | | MT | Carter | 45.9308 | −104.1530 |
| State 36-37-20 | State 36-37-20 | 25-005-23310-0000 | | MT | Blaine | 48.9182 | −109.0378 |
| ND 7087 | Svangstu 24-18 | 33-023-00171-0000 | ND 7087 | ND | Divide | 48.9396 | −103.0616 |
| MT API 21320 | Too # 1 State 44-16 | 25-083-21320-0000 | | MT | Richland | 47.7485 | −104.6604 |
| MT API 21328 | Voorhees 1-25 | 25-085-21328-0000 | | MT | Roosevelt | 48.4948 | −105.1664 |
| Whitworth | Whitworth 1 | 33-025-00079-0000 | ND 6148 | ND | Dunn | 47.0550 | −102.8172 |

**Table B-7. Correspondence of Wells with Mineral Water Data**

| Mineral Data | Water Data | Distance, miles | Distance, km | Aquifer Top, feet | Lowest Aquifer Data Bottom, feet | Highest Cap Rock Data Top, feet | Cap Rock Bottom, feet | Aquifer Top, m | Lowest Aquifer Data Bottom, m | Highest Cap Rock Data Top, m | Cap Rock Bottom, m | Formation Pressure, kPa | Temp., °C | Formation Pressure, psi | Temp., °F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ND 9622 | ND 6436 | 64.2 | 103.3 | 11,117.0 | 11329.0 | NA | NA | 3388.5 | 3453.1 | NA | NA | 33,764 | 122 | 4897 | 252 |
| MT API 21152 | MT API 21061 | 41.2 | 66.4 | 7253.0 | 7420.0 | NA | NA | 2210.7 | 2261.6 | NA | NA | 22,003 | 72 | 3191 | 161 |
| ND 7577 | ND 6436 | 21.9 | 35.2 | 9874.5 | 10,316.0 | NA | NA | 3009.8 | 3144.3 | NA | NA | 32,364 | 116 | 4694 | 241 |
| ND 6436e | ND 6436 | 0.0 | 0.0 | 9380.5 | 9557.0 | 9254 | 9380 | 2859.2 | 2913.0 | 2820.6 | 2859.0 | 29,820 | 87 | 4325 | 188 |
| ND 6264 | ND 0151 | 26.8 | 43.1 | 6072.0 | 6285.0 | NA | NA | 1850.7 | 1915.7 | NA | NA | 19,041 | 59 | 2762 | 138 |
| MT API 21127 | MT API 05059 | 41.3 | 66.5 | 9063.0 | 9369.5 | NA | NA | 2762.4 | 2855.8 | NA | NA | 27,641 | 106 | 4009 | 222 |
| MT API 21500 | MT API 21500 | 0.0 | 0.0 | 10,931.0 | 11,031.0 | NA | NA | 3331.8 | 3362.3 | NA | NA | 35,804 | 99 | 5193 | 211 |
| ND 12596 | ND 12596 | 0.0 | 0.0 | 14,801.0 | 15,260.0 | 14,652 | 14,800 | 4511.4 | 4651.3 | 4465.9 | 4511.0 | 39,859 | 131 | 5781 | 268 |
| MT API 21606 | MT API 21500 | 20.1 | 32.4 | 10,372.0 | 10,518.0 | NA | NA | 3161.4 | 3205.9 | NA | NA | 32,405 | 105 | 4700 | 221 |
| ND 12831 | ND 1636 | 2.7 | 4.3 | 13,700.0 | 14,038.0 | NA | NA | 4175.8 | 4278.8 | NA | NA | 40,024 | 137 | 5805 | 278 |
| MT API 21748 | MT API 05112 | 9.8 | 15.8 | 9847.0 | 10,708.0 | NA | NA | 3001.4 | 3263.8 | NA | NA | 33,095 | 104 | 4800 | 219 |
| MT API 21112 | MT API 21112 | 0.0 | 0.0 | 6782.0 | 6927.5 | 6744 | 6781.5 | 2067.2 | 2111.5 | 2055.6 | 2067.0 | 21,132 | 78 | 3065 | 172 |
| ND 9800 | ND 1636 | 16.9 | 27.2 | 14,214.0 | 14,359.0 | NA | NA | 4332.4 | 4376.6 | NA | NA | 41,962 | 159 | 6086 | 318 |
| MT API 21279 | MT API 05083 | 10.9 | 17.5 | 9516.5 | 10,262.0 | NA | NA | 2900.6 | 3127.9 | NA | NA | 31,026 | 101 | 4500 | 214 |
| ND 7087 | ND 6436 | 49.1 | 79.0 | 11,040.0 | 11,778.0 | NA | NA | 3365.0 | 3589.9 | NA | NA | 33,440 | 116 | 4850 | 240 |
| MT API 21320 | MT API 05008 | 7.6 | 12.2 | 12,265.0 | 12,950.0 | NA | NA | 3738.4 | 3947.2 | NA | NA | 39,990 | 105 | 5800 | 221 |
| MT API 21328 | MT API 05059 | 18.1 | 29.2 | 10,303.0 | 10,451.0 | NA | NA | 3140.4 | 3185.5 | NA | NA | 31,256 | 118 | 4533 | 244 |

**Table B-8. Names and Locations of Wells with Formation Water Analyses**

| Report Name | Full Name | API Number | State ID | State | County | Latitude | Longitude | Formation | Well Top, m | Well Bottom, m | Well Top, ft | Well Bottom, ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beaver Lodge Dev. | Beaver Lodge-Devonian | 33-105-00534-0000 | ND 1231 | ND | Williams | 48.3311 | −102.9307 | Deadwood | 4267 | 4279 | 14,000 | 14,040 |
| ND 1636 | Beaver Lodge-Ordovician | 33-105-00495-0000 | ND 1636 | ND | Williams | 48.2802 | −102.9836 | Deadwood | 4130 | 4138 | 13,550 | 13,577 |
| MT API 21061 | BN 1-5 | 25-033-21061-0000 | | MT | Garfield | 46.9150 | −106.8077 | Winnipeg | 2484 | 2585 | 8150 | 8480 |
| Brown Foothills | Brown Foothills 1 | 25-009-05274-0000 | | MT | Carbon | 45.3469 | −109.5255 | Flathead | 1783 | NA | 5850 | NA |
| Craig | Craig No. 1 | 33-047-00004-0000 | ND 1347 | ND | Logan | 46.5718 | −99.5561 | Winnipeg | 1320 | 1323 | 4330 | 4342 |
| ND 6436 | E.M. Duerre 5-9 | 33-075-00744-0000 | ND 6436 | ND | Renville | 48.9707 | −101.9816 | Deadwood | 2905 | 2925 | 9532 | 9596 |
| Elk Basin | Elk Basin Unit 189 | 49-029-06705-0000 | | WY | Park | 44.9950 | −108.8636 | Flathead | 2182 | 2216 | 7160 | 7271 |
| ND 0151 | Emma Kleven 1 | 33-015-00003-0000 | ND 0151 | ND | Burleigh | 46.9415 | −100.8286 | Deadwood | 2356 | 2366 | 7729 | 7763 |
| Federal Unit 1 | Federal Unit No. 1 | 25-105-05003-0000 | | MT | Valley | 47.9700 | −107.3537 | Winnipeg | 2023 | 2059 | 6638 | 6756 |
| Ferguson | Ferguson “A” No. 1 | 40-093-05032-0000 | SD Permit 251 | SD | Meade | 44.5230 | −102.5241 | Winnipeg | 1909 | 1910 | 6262 | 6266 |
| Government Warren | Government Warren 15-23 | 25-025-05326-0000 | | MT | Fallon | 46.4312 | −104.3187 | Cambrian | 3029 | 3059 | 9938 | 10,037 |
| MT API 05059 | A.M. Hagan 7-1 | 25-091-05059-0000 | | MT | Sheridan | 48.7205 | −104.9644 | Winnipeg | 3180 | 3199 | 10,434 | 10,496 |
| Harold Billey | Harold Billey 2 | 33-021-00001-0000 | ND 0515 | ND | Dickey | 46.0046 | −98.5395 | Winnipeg | 561 | NA | 1840 | NA |
| MT API 21500 | Hoven 1-12 | 25-091-21500-0000 | | MT | Sheridan | 48.7095 | −104.4683 | Winnipeg | 3329 | 3343 | 10,921 | 10,967 |
| ND 12596 | Isabel Bryant No. 1-3 | 33-053-02268-0000 | ND 12596 | ND | McKenzie | 47.8445 | −103.0719 | Red River "B" | 4283 | 4289 | 14,052 | 14,073 |
| John Stadum | John Stadum 1 | 33-005-00004-0000 | ND 0632 | ND | Benson | 48.1134 | −99.7046 | Winnipeg | 1541 | 1544 | 5057 | 5065 |

Continued…

**Table B-8. Names and Locations of Wells with Formation Water Analyses (continued)**

| Report Name | Full Name | API Number | State ID | State | County | Latitude | Longitude | Formation | Well Top, m | Well Bottom, m | Well Top, ft | Well Bottom, ft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lillestrand | H. D Lillestrand 1 | 33-009-01010-0000 | ND 4655 | ND | Bottineau | 48.8082 | −100.8321 | Winnipeg | 2003 | 2013 | 6570 | 6604 |
| Loberg | Loberg 1 | 25-105-05018-0000 | | MT | Valley | 48.3306 | −107.0000 | Flathead | 2304 | 2311 | 7558 | 7582 |
| MT API 05008 | NPRR 12-33 | 25-083-05008-0000 | | MT | Richland | 47.7993 | −104.8048 | Winnipeg | 3585 | 3591 | 11,762 | 11,782 |
| Ruegsegger | Ruegsegger 1 | 25-091-05120-0000 | | MT | Sheridan | 48.8652 | −104.8443 | Winnipeg | 3039 | 3057 | 9970 | 10,030 |
| Sed Connole | Sed Connole Trust 1A | 25-091-21617-0000 | | MT | Sheridan | 48.6019 | −104.4561 | Winnipeg | 3393 | 3405 | 11,133 | 11,171 |
| MT API 21112 | Sharptail 1 | 25-069-21112-0000 | | MT | Fergus | 47.2370 | −108.6806 | Flathead | 2071 | 2128 | 6795 | 6980 |
| MT API 05112 | Tange 1 | 25-091-05112-0000 | | MT | Sheridan | 48.8580 | −104.8013 | Winnipeg | 3021 | 3027 | 9910 | 9930 |
| MT API 05083 | Texas Pacific Government No. 2 | 25-011-05083-0000 | | MT | Carter | 45.7913 | −104.0491 | Winnipeg | 2761 | 2777 | 9060 | 9110 |
| Unit 1 | Unit 1 | 25-105-05091-0000 | | MT | Valley | 48.5329 | −106.8321 | Winnipeg | 2206 | 2223 | 7238 | 7293 |
| Waller | Waller 14-21-45 | 25-055-21095-0000 | | MT | McCone | 47.5744 | −105.9011 | Winnipeg | 2841 | 2851 | 9320 | 9354 |
| Wendell Haley | Wendell Haley 2 | 33-071-00006-0000 | ND 0408 | ND | Ramsey | 48.0954 | −98.6998 | Winnipeg | 979 | NA | 3211 | NA |
| Zwinger | F. Zwinger No. 1 | 33-103-00010-0000 | ND 1211 | ND | Wells | 47.4848 | −99.3539 | Winnipeg | 1309 | 1323 | 4293 | 4340 |

## Table B-9. Formation Water Analyses

| Well Name | Sample Top, m | Sample Bottom, m | Sample Top, ft | Sample Bottom, ft | ISIP,[a] kpa | ISIP, psi | Temp., °C | Temp., °F | TDS NaCl, mg/L | TDS from Resistivity, mg/L | TDS at Evaporation, mg/L | TDS at Ignition, mg/L | Calculated TDS, mg/L | Density, g/cm$^3$ | Density Temp., °C | pH | Resistivity, Ω/m | Resistivity Temp., °C | Sodium, mg/L | Potassium, mg/L | Calcium, mg/L | Magnesium, mg/L | Iron, mg/L | Chloride, mg/L | Bicarbonate, mg/L | Sulfate, mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beaver Lodge Dev. | 4267 | 4279 | 14,000 | 14,040 | NA | NA | 150.0[b] | 302.0[b] | NA[4] | NA | NA | NA | 283,097 | 1.154 | 15.6 | 6.6 | 0.049 | 20 | 106,013 | NA | 4569 | 204 | NA | 171,378 | 635 | 298 |
| ND 1636 | 4130 | 4138 | 13,550 | 13,577 | NA | NA | 134.0[b] | 273.2[b] | NA | NA | NA | NA | 328,194 | 1.186 | 15.6 | 6.7 | 0.056 | 20 | 107,871 | NA | 15,939 | 2467 | NA | 201,501 | 160 | 256 |
| MT API 21061 | 2484 | 2585 | 8150 | 8480 | 25028 | 3630 | 82.8 | 181.0 | 1970 | 3930 | NA | NA | 5123 | 1.004 | 15.6 | 7.6 | 1.300 | 20 | 1230 | NA | 380 | 53 | NA | 1200 | 390 | 1870 |
| Brown Foothills | 1783 | NA | 5850 | NA | NA | NA | 62.0[b] | 143.6[b] | NA | NA | 2966 | 2758 | 2782 | 1.006[b] | 15.6[b] | 6.9 | 4.700 | 20 | 1 | NA | 630 | 143 | NA | 252 | 98 | 1658 |
| Craig | 1320 | 1323 | 4330 | 4342 | 14,596 | 2117 | 65.6 | 150.0 | NA | NA | NA | NA | 3458 | 1.006[b] | 15.6[b] | 7.9 | NA | NA | 1160 | NA | 48 | 10 | NA | 1200 | 240 | 800 |
| ND 6436 | 2905 | 2925 | 9532 | 9596 | 29,820 | 4325 | 86.7 | 188.0 | 304,572 | NA | NA | NA | 302,575 | 1.184[b] | 15.6[b] | 5.3 | 0.059 | 20 | 88,703 | 6713 | 18,796 | 3090 | NA | 185,000 | 73 | 200 |
| Elk Basin | 2182 | 2216 | 7160 | 7271 | NA | NA | 54.0[b] | 129.2[b] | 4601 | 6484 | NA | NA | 7571 | 1.006[b] | 15.6[b] | 7.3 | 1.000 | 20 | 2244 | NA | 442 | 12 | NA | 2790 | 305 | 1778 |
| ND 0151 | 2356 | 2366 | 7729 | 7763 | 25,511 | 3700 | 68.0[b] | 154.4[b] | NA | NA | 144,830 | 141,490 | 143,506 | 1.089[b] | 15.6[b] | 6.9 | 0.070 | 20 | 52,358 | NA | 2801 | 485 | NA | 85,000 | 105 | 2757 |
| Federal Unit 1 | 2023 | 2059 | 6638 | 6756 | 22,408 | 3250 | 74.0[b] | 165.2[b] | NA | NA | 4384 | 3516 | 3438 | 1.009 | 15.6 | 6.8 | 2.580 | 20 | 541 | NA | 443 | 88 | NA | 604 | 180 | 1582 |
| Ferguson | 1909 | 1910 | 6262 | 6266 | 18,085 | 2623 | 62.0[b] | 143.6[b] | NA | NA | NA | NA | 2826 | 1.006[b] | 15.6[b] | 7 | NA | NA | 439 | NA | 413 | 36 | NA | 420 | 170 | 1348 |
| Government Warren | 3029 | 3059 | 9938 | 10,037 | 29,475 | 4275 | 129.4 | 265.0 | NA | NA | NA | NA | 89,915 | 1.057[b] | 15.6[b] | 6.2 | NA | NA | 31,404 | NA | 2538 | 684 | NA | 54,000 | 171 | 1118 |
| MT API 05059 | 3180 | 3199 | 10,434 | 10,496 | 33,350 | 4837 | 109.0[b] | 228.2[b] | NA | NA | NA | NA | 329,574 | 1.200[b] | 15.6[b] | 6.3 | NA | NA | 120,921 | NA | 6408 | 972 | NA | 199,384 | 559 | 1330 |
| Harold Billey | 561 | NA | 1840 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 3701 | 1.005 | 15.6 | 7.1 | 2.250 | 20 | 1171 | NA | 46 | 22 | NA | 651 | 221 | 1590 |
| MT API 21500 | 3329 | 3343 | 10,921 | 10,967 | 35,804 | 5193 | 99.4 | 211.0 | 268,000 | NA | NA | NA | 273,376 | 1.175 | 15.6 | 5.2 | 0.050 | 20 | 93,600 | 5280 | 10,200 | 774 | NA | 163,000 | 174 | 348 |
| ND 12596 | 4283 | 4289 | 14,052 | 14,071 | 39,859 | 5781 | NA | NA | 304,572 | NA | NA | NA | 300,303.5 | 1.22 | 25 | 7.18 | 0.052 | 25 | 106,200 | 1600 | 9020 | 1328.6 | 2.3 | 174,988 | 5235.5 | 1916.1 |
| John Stadum | 1541 | 1544 | 5057 | 5065 | 16,547 | 2400 | 53.0[b] | 127.4[3] | NA | NA | NA | NA | 53,480 | 1.036[b] | 15.6[b] | 7 | NA | NA | 18,309 | NA | 1638 | 277 | NA | 28,368 | 165 | 4723 |
| Lillestrand | 2003 | 2013 | 6570 | 6604 | 21,870 | 3172 | 67.0[b] | 152.6[b] | 224,100 | NA | NA | NA | 224,549 | 1.151 | 15.6 | 5.8 | 0.045 | 20 | 81,880 | NA | 4772 | 680 | NA | 135,820 | 27 | 1370 |
| Loberg | 2304 | 2311 | 7558 | 7582 | 24,132 | 3500 | 74.0[b] | 165.2[b] | 13,306 | 16,017 | NA | NA | 17,554 | 1.013 | 15.6 | 6.6 | 0.430 | 20 | 5794 | NA | 614 | 72 | NA | 8069 | 330 | 2675 |
| MT API 05008 | 3585 | 3591 | 11,762 | 11,782 | NA | NA | 127.0[b] | 260.6[b] | 280,901 | 275,072 | NA | NA | 276,144 | 1.177 | 15.6 | 6.1 | 0.049 | 20 | 81,425 | NA | 21,582 | 2352 | NA | 170,346 | 195 | 244 |
| Ruegsegger | 3039 | 3057 | 9970 | 10,030 | 24,876 | 3608 | 104.0[b] | 219.2[b] | NA | NA | NA | NA | 268,579 | 1.164[b] | 15.6[b] | 6 | NA | NA | 97,321 | NA | 6453 | 739 | NA | 162,724 | 168 | 1174 |
| Sed Connole | 3393 | 3405 | 11,133 | 11,171 | 35,804 | 5193 | 115.0 | 239.0 | 303,970 | NA | NA | NA | 307,165 | 1.195 | 25.0 | 5.3 | 0.044 | 25 | 104,700 | 4230 | 11,107 | 999 | 496 | 184,338 | 262 | 1033 |
| MT API 21112 | 2071 | 2128 | 6795 | 6980 | 21,132 | 3065 | 77.8 | 172.0 | 36,400 | NA | NA | NA | 44,227 | 1.033 | 15.6 | 6.6 | 0.180 | 20 | 15,000 | 253 | 535 | 272 | NA | 22,100 | 477 | 5590 |
| MT API 05112 | 3021 | 3027 | 9910 | 9930 | NA | NA | 126.0[b] | 258.8[b] | NA | NA | NA | NA | 254,996 | 1.156[b] | 15.6[b] | 6.4 | NA | NA | 88,593 | NA | 9214 | 984 | NA | 155,000 | 370 | 835 |
| MT API 05112 | 2761 | 2777 | 9060 | 9110 | NA | NA | 91.0[b] | 195.8[b] | NA | NA | NA | NA | 26,974 | 1.020[b] | 15.6[b] | 7 | NA | NA | 8767 | NA | 1202 | 208 | NA | 14,627 | 617 | 1553 |
| Unit 1 | 2206 | 2223 | 7238 | 7293 | 23,442 | 3400 | 70.0[b] | 158.0[b] | 200 | 2009 | NA | NA | 2939 | 1.005 | 15.6 | 6.7 | 3.450 | 20 | 188 | NA | 510 | 128 | NA | 121 | 160 | 1832 |
| Waller | 2841 | 2851 | 9320 | 9354 | 30,716 | 4455 | 98.9 | 210.0 | 218,493 | 220,776 | NA | NA | 222,209 | 1.132 | 15.6 | 5.6 | 0.052 | 20 | 85,476 | NA | 1216 | 194 | NA | 132,500 | 145 | 2678 |
| Wendell Haley | 979 | NA | 3211 | NA | NA | NA | 37.0[b] | 98.6[b] | NA | NA | NA | NA | 24,568 | 1.019 | 15.6 | 6.6 | 1.330 | 20 | 7201 | NA | 1063 | 538 | NA | 9674 | 304 | 6383 |
| Zwinger | 1309 | 1323 | 4293 | 4340 | NA | NA | 54.0[b] | 129.2[b] | NA | NA | NA | NA | 13,092 | 1.012[b] | 15.6[b] | 7.7 | NA | NA | 3714 | NA | 702 | 77 | NA | 3920 | 364 | 4315 |

[a] Initial shut-in pressure.
[b] Calculated value.

**Table B-10. Wells Used for Modeling with Zone Designations**

| MT API 21152<br>API Identification:<br>25-033-21152-0000 | Formation | Formation Top, ft | Thickness, ft | Start, ft | End, ft | Thickness, ft | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1, ft | Aquifer Zone 2, ft | Aquifer Zone 3, ft | Aquifer Zone 4, ft | Aquifer Zone 5, ft | Aquifer Zone 6, ft | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flathead Formation | 7252 | 210 | 7253 | 7420 | 167 | 0.795 | Unknown | 7253 | 7357 | 7384 | 7385.5 | 7406 | 7415 | | | | |
| | Total depth | 7462 | | | | | | | 7357 | 7384 | 7385.5 | 7406 | 7415 | 7420 | | | | |
| ND 7577<br>API Identification:<br>33-075-00798-0000 | Formation | Formation Top, ft | Thickness | Start, ft | End, ft | Thickness, ft | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Precambrian | Precambrian | Precambrian | |
| | Winnipeg SS | 9868 | 267 | 9874.5 | 10316 | 441.5 | 1.654 | 1.654 | 9874.5 | 9971.5 | 9979.5 | 10,008 | 10,088 | 10,125 | 10,136 | 10,186 | 10,191 | |
| | Cambrian | 9973 | | | | | | | 9971.5 | 9979.5 | 10,008 | 10,088 | 10,125 | 10,136 | 10,186 | 10,191 | 10,316 | |
| | Precambrian | 10,135 | | | | | | | | | | | | | | | | |
| | Total depth | 10,315 | | | | | | | | | | | | | | | | |
| ND 6436<br>API Identification:<br>33-075-00744-0000 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Precambrian 7 | | | |
| | Winnipeg SS | 9378 | 165 | 9380.5 | 9557 | 176.5 | 1.070 | 1.070 | 9380.5 | 9412 | 9450 | 9478 | 9499 | 9515 | 9546.5 | | | |
| | Log start | 9380.5 | | | | | | | 9412 | 9450 | 9478 | 9499 | 9515 | 9546.5 | 9557 | | | |
| | Deadwood | 9407 | | | | | | | | | | | | | | | | |
| | Upper Deadwood SS | 9515 | | | | | | | | | | | | | | | | |
| | Lower Deadwood SS | 9530 | | | | | | | | | | | | | | | | |
| | Precambrian | 9543 | | | | | | | | | | | | | | | | |
| | Total depth | 9901 | | | | | | | | | | | | | | | | |
| ND 6264<br>API Identification:<br>33-015-00032-0000 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | | | |
| | Winnipeg SS | 6070 | 232 | 6072 | 6285 | 213 | 0.918 | Unknown | 6072 | 6088 | 6123 | 6150.5 | 6179 | 6193 | 6251 | | | |
| | Deadwood | 6104 | | | | | | | 6088 | 6123 | 6150.5 | 6179 | 6193 | 6251 | 6285 | | | |
| | Total depth | 6302 | | | | | | | | | | | | | | | | |
| ND 9622<br>API Identification:<br>33-023-00221-0000 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Cap Rock 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | |
| | Winnipeg SH | 11,072 | 302 | 11,117 | 11,329 | 212 | 0.702 | Unknown | 11,117 | 11,141 | 11,170 | 11,218 | 11,240 | 11,246 | 11,260 | 11,268 | 11,304 | |
| | Winnipeg SS | 11,143 | | | | | | | 11,141 | 11,170 | 11,218 | 11,240 | 11,246 | 11,260 | 11,268 | 11,304 | 11,329 | |
| | Deadwood | 11,293 | | | | | | | | | | | | | | | | |
| | Total depth | 11,445 | | | | | | | | | | | | | | | | |
| MT API 21127<br>API Identification:<br>25-019-21127-00-00 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | | |
| | Cambrian | 8830 | 1178 | 9063 | 9369.5 | 306.5 | 0.260 | Unknown | 9063 | 9074 | 9077 | 9094 | 9112.5 | 9124 | 9314.5 | 9326 | | |
| | Log start | 9063 | | | | | | | 9074 | 9077 | 9094 | 9112.5 | 9124 | 9314.5 | 9326 | 9369.5 | | |
| | Total depth | 10,241 | | | | | | | | | | | | | | | | |

Continued…

**Table B-10. Wells Used for Modeling with Zone Designations (continued)**

| MT API 21500<br>API Identification:<br>25-091-21500-00-00 | Formation | Formation Top, ft | Thickness, ft | Start, ft | End, ft | Thickness, ft | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1, ft | Aquifer Zone 2, ft | Aquifer Zone 3, ft | Aquifer Zone 4, ft | Aquifer Zone 5, ft | Aquifer Zone 6, ft | Aquifer Zone 7, ft | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winnipeg Formation | 10,854 | 109 | 10,931 | 11,031 | 100 | 0.917 | Unknown | 10,931 | 10,947 | 10,954 | 10,958 | 10,974 | 10,986 | 11,000 | | | |
| | Log start | 10,931 | | | | | | | 10,947 | 10,954 | 10,958 | 10,974 | 10,986 | 11,000 | 11,031 | | | |
| | Total depth | 11,040 | | | | | | | | | | | | | | | | |
| ND 12596<br>API Identification:<br>33-053-02268-0000 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | | | | |
| | Winnipeg SS | 14,745 | 497 | 14,801 | 15,260 | 459 | 0.924 | Unknown | 14,801 | 14,868 | 14,888 | 15,000 | 15,046 | 15,260 | | | | |
| | Log start | 14,801 | | | | | | | | | | | | | | | | |
| | Deadwood | 14,890 | | | | | | | | | | | | | | | | |
| | Total depth | 15,298 | | | | | | | | | | | | | | | | |
| MT API 21606<br>API Identification:<br>25-091-21606-00-00 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | | |
| | Winnipeg Formation | 10,302 | 182 | 10,372 | 10,518 | 146 | 0.802 | Unknown | 10,372 | 10,383 | 10,392 | 10,406 | 10,414 | 10,431 | 10,458 | 10,498 | | |
| | Log start | 10,372 | | | | | | | 10,383 | 10,392 | 10,406 | 10,414 | 10,431 | 10,458 | 10,498 | 10,518 | | |
| | Deadwood Formation | 10,497 | | | | | | | | | | | | | | | | |
| | Total depth | 10,554 | | | | | | | | | | | | | | | | |
| ND 12831<br>API Identification:<br>33-1-5-01389-0000 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 |
| | Winnipeg SS | 13,692 | 346 | 13,700 | 14,038 | 338 | 0.977 | 0.977 | 13,700 | 13,712 | 13,802 | 13,814 | 13,848 | 13,906 | 13,920 | 13,949 | 13,956 | 13,972 |
| | Granate Wash | 14,038 | | | | | | | 13,712 | 13,802 | 13,814 | 13,848 | 13,906 | 13,920 | 13,949 | 13,956 | 13,972 | 13,999 |
| | Total depth | 14,150 | | | | | | | | | | | | | | | | |
| MT API 21748<br>API Identification:<br>25-091-21748-00-00 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | | | | |
| | Winnipeg Formation | 9780 | 908 | 9847 | 10,708 | 861 | 0.948 | Unknown | 9847 | 9921 | 9997 | 10,087 | 10,358 | 10,542 | | | | |
| | Log start | 9847 | | | | | | | 9921 | 9997 | 10,087 | 10,358 | 10,542 | 10,708 | | | | |
| | Deadwood Formation | 9988 | | | | | | | | | | | | | | | | |
| | Total depth | 10,755 | | | | | | | | | | | | | | | | |

Continued…

**Table B-10. Wells Used for Modeling with Zone Designations (continued)**

| MT API 21112<br>API Identification:<br>25-069-21112-00-00 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Red River | 5474 | 198 | 6782 | 6927.5 | 145.5 | 0.735 | Unknown | 6796 | 6895.5 | 6927.5 | | | | | | | |
| | Log start | 6782 | | | | | | | | | | | | | | | | |
| | Flathead Formation | 6796 | | | | | | | | | | | | | | | | |
| | Total depth | 6980 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| ND 9800<br>API Identification:<br>33-105-01044-0000 | Formation | Formation Top, ft | Thickness, ft | Start, ft | End, ft | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | | | |
| | Roughlock | 13,795 | 413 | 14,214 | 14,359 | 145 | 0.351 | 0.351 | 14,214 | 14,218 | 14,228 | 14,251 | 14,310 | 14,330 | 14,338 | | | |
| | Black Island | 13,900 | | | | | | | 14,218 | 14,228 | 14,251 | 14,310 | 14,330 | 14,338 | 14,359 | | | |
| | Deadwood Formation | 14,020 | | | | | | | | | | | | | | | | |
| | Precambrian basement | 14,700 | | | | | | | | | | | | | | | | |
| | Total depth | 14,433 | | | | | | | | | | | | | | | | |
| MT API 21279<br>API Identification:<br>25-011-21279-00-00 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 |
| | Deadwood Formation | 9515 | 747 | 9516.5 | 10,262 | 745.5 | 0.998 | 0.998 | 9516.5 | 9575 | 9660.5 | 9695 | 9795 | 9828 | 9894 | 9917 | 10,018 | 10,068 |
| | Precambrian undifferentiated | 10,262 | | | | | | | 9575 | 9660.5 | 9695 | 9795 | 9828 | 9894 | 9917 | 10,018 | 10,068 | 10,112 |
| | Total depth | 10,300 | | | | | | | | | | | | | | | | |
| ND 7087<br>API Identification:<br>33-023-00171-0000 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Cap Rock 1 | Cap Rock 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 |
| | Winnipeg SH | 11,054 | 650 | 11,040 | 11,778 | 738 | 1.135 | 1.135 | 11,040 | 11,076 | 11,135 | 11,152 | 11,188 | 11,286 | 11,474 | 11,572 | 11,627 | 11,672 |
| | Winnipeg SS | 11,134 | | | | | | | 11,076 | 11,135 | 11,152 | 11,188 | 11,286 | 11,474 | 11,572 | 11,627 | 11,672 | 11,686 |
| | Upper Deadwood | 11,288 | | | | | | | | | | | | | | | | |
| | Lower Deadwood | 11,474 | | | | | | | | | | | | | | | | |
| | Precambrian | 11,784 | | | | | | | | | | | | | | | | |
| | Total depth | 11,848 | | | | | | | | | | | | | | | | |
| MT API 21320<br>API Identification:<br>25-083-21320-00-00 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 |
| | Winnipeg Formation | 12,119 | 799 | 12,265 | 12,950 | 685 | 0.857 | unknown | 12,265 | 12,280 | 12,320 | 12,330 | 12,350 | 12,364 | 12,456 | 12,660 | 12,845 | 12,902 |
| | Deadwood Formation | 12,264 | | | | | | | 12,280 | 12,320 | 12,330 | 12,350 | 12,364 | 12,456 | 12,660 | 12,845 | 12,902 | 12,950 |
| | Total depth | 13,063 | | | | | | | | | | | | | | | | |

Continued…

**Table B-10. Wells Used for Modeling with Zone Designations (continued)**

| MT API 21328<br>API Identification:<br>25-085-21328-00-00 | Formation | Formation Top, ft | Thickness | Start | End | Thickness | Fraction of Known Depth | Fraction of Total Aquifer | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winnipeg Formation | 10,218 | 172 | 10,303 | 10,451 | 148 | 0.860 | Unknown | 10,303 | 10,320 | 10,346 | 10,368 | 10,388 | 10,402 | 10,438 | | | |
| | Log start | 10,303 | | | | | | | 10,320 | 10,346 | 10,368 | 10,388 | 10,402 | 10,438 | 10,451 | | | |
| | Deadwood Formation | 10,388 | | | | | | | | | | | | | | | | |
| | Total depth | 10,475 | | | | | | | | | | | | | | | | |

**MT API 21152**

The water composition used for MT API 21152 is from the BN 1-5 well 41 miles (66 km) east. Mineral data were available for 80% of the total Cambro-Ordovician saline system (COSS) represented in the well. The total thickness of the COSS is not known, as the MT API 21152 well did not penetrate to the Precambrian.

Quartz is the dominant mineral in the upper zones (1, 2, 4, 5, and 6) comprising 85% to 99% of the total. The very narrow Zone 3 contains 32% glauconite and 13% illite and has a very high porosity of 0.22. Zones 2, 3, and 4 have porosities much higher than the other zones.

The effect on mineral transformations of $CO_2$ is that less celadonite (glauconite) dissolves and there is an increase in the dissolution of kaolinite. There is a concurrent increase in solid muscovite as well as quartz with the exception of Zone 3. There is also a small increase in solid dolomite. Some phlogopite (biotite) is predicted to form, but less than when $CO_2$ is absent. Some of the pyrite dissolves, with the formation of siderite ($FeCO_3$).

Very little $CO_2$ is associated with solid mineral phases in this case. The amount of $CO_2$ dissolved in the formation water is 1–1.2 moles/kg (44–52.8 g/kg) water. This is somewhat higher than expected based on $CO_2$ solubility in pure water. The major increase is $CO_2$ in solution as $HCO_3^-$ and $MgHCO_3^+$ which is highest for Zones 2, 3, 4, and 6 that also contain the highest starting illite content. The level of magnesium bicarbonate in solution may be because of the lack of an assigned solid mineral phase for it to precipitate to. The total average amount of $CO_2$ reacting with the minerals and formation water is 6.7 kg/m$^3$ (0.4 lb/ft$^3$) of formation rock.

## Table B-11. Average Mineral and Porosity Values for the MT API 21152 Aquifer Zones

Well Name: MT API 21152
API Identification: 25-033-21152-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 7253.0 | 2210.7 | Average | 0.056 | 0.053 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.987 | 0.000 |
| End | 7357.0 | 2242.4 | Minimum | 0.016 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.854 | 0.000 |
| Thickness | 104.0 | 31.7 | Maximum | 0.113 | 0.108 | 0.000 | 0.000 | 0.000 | 0.146 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 | 0.016 | 1.000 | 0.000 |
| Number of Values | 209 | | Standard deviation | 0.023 | 0.023 | 0.000 | 0.000 | 0.000 | 0.012 | 0.000 | 0.021 | 0.000 | 0.000 | 0.000 | 0.002 | 0.025 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 7357.0 | 2242.4 | Average | 0.200 | 0.182 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.136 | 0.000 | 0.000 | 0.000 | 0.002 | 0.860 | 0.000 |
| End | 7384.0 | 2250.6 | Minimum | 0.033 | 0.031 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.568 | 0.000 |
| Thickness | 27.0 | 8.2 | Maximum | 0.441 | 0.398 | 0.000 | 0.000 | 0.000 | 0.000 | 0.057 | 0.432 | 0.000 | 0.000 | 0.000 | 0.027 | 1.000 | 0.000 |
| Number of Values | 54 | | Standard deviation | 0.110 | 0.101 | 0.000 | 0.000 | 0.000 | 0.000 | 0.009 | 0.125 | 0.000 | 0.000 | 0.000 | 0.006 | 0.122 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 7384.0 | 2250.6 | Average | 0.254 | 0.221 | 0.000 | 0.000 | 0.000 | 0.000 | 0.317 | 0.131 | 0.000 | 0.000 | 0.000 | 0.000 | 0.552 | 0.000 |
| End | 7385.5 | 2251.1 | Minimum | 0.246 | 0.203 | 0.000 | 0.000 | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.461 | 0.000 |
| Thickness | 1.5 | 0.5 | Maximum | 0.262 | 0.241 | 0.000 | 0.000 | 0.000 | 0.000 | 0.539 | 0.392 | 0.000 | 0.000 | 0.000 | 0.000 | 0.601 | 0.000 |
| Number of Values | 3 | | Standard deviation | 0.008 | 0.019 | 0.000 | 0.000 | 0.000 | 0.000 | 0.272 | 0.226 | 0.000 | 0.000 | 0.000 | 0.000 | 0.079 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 7385.5 | 2251.1 | Average | 0.161 | 0.144 | 0.000 | 0.000 | 0.000 | 0.000 | 0.014 | 0.101 | 0.000 | 0.000 | 0.006 | 0.001 | 0.878 | 0.000 |
| End | 7406.0 | 2257.4 | Minimum | 0.095 | 0.090 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.723 | 0.000 |
| Thickness | 20.5 | 6.2 | Maximum | 0.264 | 0.228 | 0.000 | 0.014 | 0.000 | 0.000 | 0.158 | 0.277 | 0.000 | 0.000 | 0.235 | 0.016 | 1.000 | 0.000 |
| Number of Values | 41 | | Standard deviation | 0.043 | 0.036 | 0.000 | 0.002 | 0.000 | 0.000 | 0.043 | 0.088 | 0.000 | 0.000 | 0.037 | 0.004 | 0.084 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 7406.0 | 2257.4 | Average | 0.054 | 0.049 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.997 | 0.000 |
| End | 7415.0 | 2260.1 | Minimum | 0.039 | 0.019 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.939 | 0.000 |
| Thickness | 9.0 | 2.7 | Maximum | 0.072 | 0.072 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.061 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 18 | | Standard deviation | 0.008 | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.014 | 0.000 |

Continued. . .

**Table B-11. Average Mineral and Porosity Values for the MT API 21152 Aquifer Zones (continued)**

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 7415.0 | 2260.1 | Average | 0.052 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.127 | 0.000 | 0.000 | 0.000 | 0.000 | 0.867 | 0.000 |
| End | 7420.0 | 2261.6 | Minimum | 0.036 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 0.000 | 0.000 | 0.000 | 0.000 | 0.818 | 0.000 |
| Thickness | 5.0 | 1.5 | Maximum | 0.060 | 0.044 | 0.000 | 0.000 | 0.000 | 0.000 | 0.031 | 0.182 | 0.000 | 0.000 | 0.000 | 0.000 | 0.922 | 0.000 |
| Number of Values | 10 | | Standard deviation | 0.007 | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.013 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.041 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 7253.0 | 2210.7 | Average | 0.094 | 0.085 | 0.000 | 0.000 | 0.000 | 0.001 | 0.005 | 0.046 | 0.000 | 0.000 | 0.001 | 0.001 | 0.946 | 0.000 |
| End | 7420.0 | 2261.6 | Minimum | 0.016 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.461 | 0.000 |
| Thickness | 167.0 | 50.9 | Maximum | 0.441 | 0.398 | 0.000 | 0.014 | 0.000 | 0.146 | 0.539 | 0.432 | 0.000 | 0.000 | 0.235 | 0.027 | 1.000 | 0.000 |
| Number of Values | 335 | | Standard deviation | 0.078 | 0.071 | 0.000 | 0.001 | 0.000 | 0.010 | 0.040 | 0.083 | 0.000 | 0.000 | 0.013 | 0.003 | 0.091 | 0.000 |

**Table B-12. Summary of MT API 21152 Aquifer Minerals and Conditions**

Well Name: MT API 21152
API Identification: 25-033-21152-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Start, ft | 7253 | 7357 | 7384 | 7385.5 | 7406 | 7415 | 7253 |
| End, ft | 7357 | 7384 | 7385.5 | 7406 | 7415 | 7420 | 7420 |
| Thickness, ft | 104.0 | 27.0 | 1.5 | 20.5 | 9.0 | 5.0 | 167.0 |
| Start, m | 2210.7 | 2242.4 | 2250.6 | 2251.1 | 2257.4 | 2260.1 | 2210.7 |
| End, m | 2242.4 | 2250.6 | 2251.1 | 2257.4 | 2260.1 | 2261.6 | 2261.6 |
| Thickness, m | 31.7 | 8.2 | 0.5 | 6.2 | 2.7 | 1.5 | 50.9 |
| Temperature, °F | 161.0 | 161.0 | 161.0 | 161.0 | 161.0 | 161.0 | 161.0 |
| Temperature, °C | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 |
| Pressure, psi | 4344 | 4344 | 4344 | 4344 | 4344 | 4344 | 4344 |
| Pressure, kPa | 29,953 | 29,953 | 29,953 | 29,953 | 29,953 | 29,953 | 29,953 |
| Effective Porosity, fraction | 0.053 | 0.182 | 0.221 | 0.144 | 0.049 | 0.030 | 0.085 |
| Mass Fraction | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Glauconite | 0.000 | 0.002 | 0.317 | 0.014 | 0.000 | 0.006 | 0.005 |
| Illite | 0.010 | 0.136 | 0.131 | 0.101 | 0.003 | 0.127 | 0.046 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.006 | 0.000 | 0.000 | 0.001 |
| Pyrite | 0.000 | 0.002 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 |
| Quartz | 0.987 | 0.860 | 0.552 | 0.878 | 0.997 | 0.867 | 0.946 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-13. Summary of MT API 21152 Aquifer Calculation Results

Well Name: MT API 21152
API Identification: 25-033-21152-0000

| Formation : Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Start, m | 2210.7 | 2242.4 | 2250.6 | 2251.1 | 2257.4 | 2260.1 | 2210.7 |
| End, m | 2242.4 | 2250.6 | 2251.1 | 2257.4 | 2260.1 | 2261.6 | 2261.6 |
| Thickness, m | 31.7 | 8.2 | 0.5 | 6.2 | 2.7 | 1.5 | 50.9 |
| Start, ft | 7253.0 | 7357.0 | 7384.0 | 7385.5 | 7406.0 | 7415.0 | 7253.0 |
| End, ft | 7357.0 | 7384.0 | 7385.5 | 7406.0 | 7415.0 | 7420.0 | 7420.0 |
| Thickness, ft | 104.0 | 27.0 | 1.5 | 20.5 | 9.0 | 5.0 | 167.0 |
| **Minerals Without $CO_2$** | | | | | | | |
| pH | 6.918 | 6.949 | 6.929 | 7.215 | 6.952 | 6.936 | 7.215 |
| pE | –3.260 | –3.295 | –1.313 | –3.599 | –1.295 | 8.357 | –3.599 |
| Activity | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 |
| Ionic Strength | 0.056 | 0.056 | 0.054 | 0.057 | 0.056 | 0.062 | 0.057 |
| Total Solution $CO_2$, moles | 3.914E-04 | 3.804E-04 | 4.196E-04 | 3.390E-04 | 3.816E-04 | 3.742E-04 | 3.390E-04 |
| Solution, moles | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0004 | 0.0004 | 0.0004 | 0.0003 | 0.0004 | 0.0003 | 0.0003 |
| Ca | 0.0087 | 0.0090 | 0.0091 | 0.0105 | 0.0090 | 0.0090 | 0.0105 |
| Cl | 0.0338 | 0.0338 | 0.0338 | 0.0338 | 0.0338 | 0.0338 | 0.0338 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0001 | 0.0001 | 0.0003 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Mg | 0.0024 | 0.0021 | 0.0020 | 0.0006 | 0.0021 | 0.0021 | 0.0006 |
| Na | 0.0247 | 0.0247 | 0.0247 | 0.0247 | 0.0247 | 0.0247 | 0.0247 |
| S | 0.0065 | 0.0065 | 0.0065 | 0.0065 | 0.0065 | 0.0065 | 0.0065 |
| Si | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0005 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.052 | 0.000 | 0.000 | 0.011 |
| Celadonite | 0.000 | 0.043 | 7.200 | 0.506 | 0.000 | 1.188 | 0.326 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21152 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.455 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.169 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation : Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Illite | 1.272 | 4.204 | 3.312 | 4.148 | 0.447 | 27.850 | 3.373 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.227 | 0.000 | 0.000 | 0.050 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.178 | 0.242 | 0.000 | 0.148 | 0.000 | 0.000 | 0.191 |
| Quartz | 777.000 | 169.600 | 89.560 | 230.100 | 835.500 | 1213.000 | 444.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.049 | 0.000 | 0.000 | 0.008 |
| Celadonite | 0.000 | 0.000 | 5.544 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21152 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.456 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.172 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.424 | 1.372 | 0.000 | 1.045 | 0.149 | 8.490 | 0.907 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.658 | 2.201 | 2.815 | 2.707 | 0.231 | 15.180 | 2.010 |
| Phlogopite | 0.106 | 0.365 | 0.828 | 0.514 | 0.037 | 2.716 | 0.389 |
| Pyrite | 0.178 | 0.242 | 0.000 | 0.148 | 0.000 | 0.000 | 0.191 |
| Quartz | 778.300 | 174.000 | 96.840 | 235.600 | 835.900 | 1244.000 | 448.400 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | –0.003 | 0.000 | 0.000 | –0.004 |
| Celadonite | 0.000 | –0.043 | –1.656 | –0.506 | 0.000 | –1.188 | –0.326 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| $CO_2$ MT API 21152 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.001 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.003 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –1.272 | –4.204 | –3.312 | –4.148 | –0.447 | –27.850 | –3.373 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.424 | 1.372 | 0.000 | 1.045 | 0.149 | 8.490 | 0.907 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.658 | 2.201 | 2.815 | 2.481 | 0.231 | 15.180 | 1.960 |
| Phlogopite | 0.106 | 0.365 | 0.828 | 0.514 | 0.037 | 2.716 | 0.389 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 1.315 | 4.445 | 7.287 | 5.467 | 0.462 | 31.550 | 4.246 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | 3.39E-06 | 3.73E-06 | 3.82E-06 | 7.34E-06 | 3.73E-06 | 3.73E-06 | 7.34E-06 |
| $CaHCO_3^+$ | 1.71E-05 | 1.75E-05 | 1.86E-05 | 1.87E-05 | 1.73E-05 | 1.81E-05 | 1.87E-05 |
| $CO_2$ | 5.64E-05 | 5.14E-05 | 5.93E-05 | 2.61E-05 | 5.14E-05 | 5.13E-05 | 2.61E-05 |
| $CO_3^{2-}$ | 3.92E-07 | 4.14E-07 | 4.30E-07 | 7.19E-07 | 4.17E-07 | 4.00E-07 | 7.18E-07 |
| $FeCO_3$ | 4.34E-10 | 4.39E-10 | 0.00E+00 | 6.80E-10 | 0.00E+00 | 0.00E+00 | 6.80E-10 |
| $FeCO_3^+$ | 9.19E-22 | 8.57E-22 | 0.00E+00 | 6.61E-22 | 0.00E+00 | 0.00E+00 | 6.61E-22 |
| $FeHCO_3^+$ | 1.37E-08 | 1.29E-08 | 0.00E+00 | 1.09E-08 | 0.00E+00 | 0.00E+00 | 1.08E-08 |
| $HCO_3^-$ | 3.07E-04 | 3.01E-04 | 3.31E-04 | 2.83E-04 | 3.03E-04 | 2.94E-04 | 2.83E-04 |
| $MgCO_3$ | 2.13E-07 | 1.94E-07 | 1.90E-07 | 9.86E-08 | 1.94E-07 | 1.94E-07 | 9.86E-08 |
| $MgHCO_3^+$ | 3.52E-06 | 2.99E-06 | 3.05E-06 | 8.23E-07 | 2.97E-06 | 3.11E-06 | 8.23E-07 |
| $NaCO_3^-$ | 3.00E-09 | 3.19E-09 | 3.22E-09 | 5.46E-09 | 3.18E-09 | 3.29E-09 | 5.46E-09 |
| $NaHCO_3$ | 3.02E-06 | 2.99E-06 | 3.17E-06 | 2.76E-06 | 2.96E-06 | 3.15E-06 | 2.76E-06 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | -3.032E-03 | 0.000E+00 | 0.000E+00 | −3.708E-03 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.549E-03 | 8.882E-04 | 8.320E-04 | 3.956E-03 | 8.810E-04 | 9.268E-04 | 5.310E-03 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation : Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.549E-03 | 8.882E-04 | 8.320E-04 | 9.240E-04 | 8.810E-04 | 9.268E-04 | 1.602E-03 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 5.641E-05 | 5.138E-05 | 5.931E-05 | 2.608E-05 | 5.139E-05 | 5.131E-05 | 2.608E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 3.350E-04 | 3.291E-04 | 3.603E-04 | 3.129E-04 | 3.302E-04 | 3.229E-04 | 3.129E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 1.940E-03 | 1.269E-03 | 1.252E-03 | 1.263E-03 | 1.263E-03 | 1.301E-03 | 1.941E-03 |
| Water, g/cm$^3$ | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 |
| Water, kg/m$^3$ | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 |
| Mineral $CO_2$, moles/m$^3$ | 1.124E-01 | 6.445E-02 | 6.037E-02 | 6.704E-02 | 6.392E-02 | 6.725E-02 | 1.162E-01 |
| Dissolved $CO_2$, moles/m$^3$ | 4.093E-03 | 3.728E-03 | 4.303E-03 | 1.892E-03 | 3.729E-03 | 3.723E-03 | 1.892E-03 |
| Solution $CO_2$, moles/m$^3$ | 2.431E-02 | 2.388E-02 | 2.614E-02 | 2.270E-02 | 2.396E-02 | 2.343E-02 | 2.270E-02 |
| Total $CO_2$, moles/m$^3$ | 1.408E-01 | 9.205E-02 | 9.081E-02 | 9.164E-02 | 9.161E-02 | 9.440E-02 | 1.408E-01 |
| Mineral $CO_2$, moles/ft$^3$ | 3.182E-03 | 1.825E-03 | 1.709E-03 | 1.898E-03 | 1.810E-03 | 1.904E-03 | 3.291E-03 |
| Dissolved $CO_2$, moles/ft$^3$ | 1.159E-04 | 1.056E-04 | 1.219E-04 | 5.358E-05 | 1.056E-04 | 1.054E-04 | 5.358E-05 |
| Solution $CO_2$, moles/ft$^3$ | 6.883E-04 | 6.761E-04 | 7.403E-04 | 6.429E-04 | 6.784E-04 | 6.634E-04 | 6.429E-04 |
| Total $CO_2$, moles/ft$^3$ | 3.986E-03 | 2.607E-03 | 2.572E-03 | 2.595E-03 | 2.594E-03 | 2.673E-03 | 3.988E-03 |
| Mineral $CO_2$, kg/m$^3$ | 4.945E-03 | 2.836E-03 | 2.657E-03 | 2.951E-03 | 2.813E-03 | 2.959E-03 | 5.116E-03 |
| Dissolved $CO_2$, kg/m$^3$ | 1.801E-04 | 1.641E-04 | 1.894E-04 | 8.328E-05 | 1.641E-04 | 1.638E-04 | 8.328E-05 |
| Solution $CO_2$, kg/m$^3$ | 1.070E-03 | 1.051E-03 | 1.150E-03 | 9.992E-04 | 1.054E-03 | 1.031E-03 | 9.992E-04 |
| Total $CO_2$, kg/m$^3$ | 6.195E-03 | 4.051E-03 | 3.997E-03 | 4.033E-03 | 4.032E-03 | 4.154E-03 | 6.198E-03 |
| Mineral $CO_2$, lb/ft$^3$ | 3.087E-04 | 1.771E-04 | 1.659E-04 | 1.842E-04 | 1.756E-04 | 1.848E-04 | 3.194E-04 |
| Dissolved $CO_2$, lb/ft$^3$ | 1.125E-05 | 1.024E-05 | 1.182E-05 | 5.199E-06 | 1.024E-05 | 1.023E-05 | 5.199E-06 |
| Solution $CO_2$, lb/ft$^3$ | 6.678E-05 | 6.560E-05 | 7.182E-05 | 6.238E-05 | 6.582E-05 | 6.437E-05 | 6.238E-05 |
| Total $CO_2$, lb/ft$^3$ | 3.867E-04 | 2.529E-04 | 2.495E-04 | 2.518E-04 | 2.517E-04 | 2.594E-04 | 3.869E-04 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation : Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Weighted Average of Zones | | | | | | | |
| Total Thickness, m | 50.9 | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 4.164E-03 | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.644E-04 | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 1.057E-03 | | | | | | |
| Total $CO_2$, kg/$m^3$ | 5.386E-03 | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 2.600E-04 | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 1.026E-05 | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 6.597E-05 | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 3.362E-04 | | | | | | |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | |
| pH | 5.555 | 6.011 | 5.999 | 6.026 | 5.203 | 6.037 | 6.026 |
| pE | –1.629 | –2.135 | –0.400 | –2.152 | 0.061 | –0.600 | –2.152 |
| Activity | 0.968 | 0.943 | 0.950 | 0.942 | 0.974 | 0.947 | 0.942 |
| Ionic Strength | 0.510 | 1.329 | 1.185 | 1.371 | 0.239 | 1.283 | 1.371 |
| Total Solution $CO_2$, moles | 1.69E+00 | 2.79E+00 | 2.72E+00 | 2.85E+00 | 1.42E+00 | 2.88E+00 | 2.85E+00 |
| Solution, moles | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.7100 | 2.9130 | 2.7450 | 3.0200 | 1.4130 | 2.5610 | 3.0170 |
| Ca | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Cl | 0.0338 | 0.0338 | 0.0338 | 0.0338 | 0.0338 | 0.0338 | 0.0338 |
| Fe | 0.0002 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0001 |
| K | 0.0041 | 0.0015 | 0.0038 | 0.0015 | 0.0085 | 0.0012 | 0.0015 |
| Mg | 0.3108 | 1.0870 | 0.8709 | 1.1460 | 0.1046 | 0.8485 | 1.1450 |
| Na | 0.0247 | 0.0247 | 0.0247 | 0.0247 | 0.0247 | 0.0247 | 0.0247 |
| S | 0.0435 | 0.2079 | 0.0065 | 0.2215 | 0.0065 | 0.0065 | 0.2212 |
| Si | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0005 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.052 | 0.000 | 0.000 | 0.011 |
| Celadonite | 0.000 | 0.043 | 7.200 | 0.506 | 0.000 | 1.188 | 0.326 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21152 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.455 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.169 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 1.272 | 4.204 | 3.312 | 4.148 | 0.447 | 27.850 | 3.373 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.227 | 0.000 | 0.000 | 0.050 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.178 | 0.242 | 0.000 | 0.148 | 0.000 | 0.000 | 0.191 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Quartz | 777.000 | 169.600 | 89.560 | 230.100 | 835.500 | 1213.000 | 444.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 5.975 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21152 | 298.300 | 297.000 | 297.200 | 296.800 | 298.600 | 297.400 | 296.800 |
| Dolomite | 0.464 | 0.009 | 0.009 | 0.061 | 0.009 | 0.009 | 0.190 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.324 | 1.010 | 0.000 | 0.646 | 0.125 | 8.207 | 0.521 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.759 | 2.564 | 2.817 | 3.107 | 0.260 | 15.460 | 2.396 |
| Phlogopite | 0.000 | 0.000 | 0.392 | 0.113 | 0.000 | 2.431 | 0.002 |
| Pyrite | 0.159 | 0.142 | 0.000 | 0.041 | 0.000 | 0.000 | 0.084 |
| Quartz | 778.500 | 174.800 | 96.420 | 236.400 | 836.000 | 1245.000 | 449.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.018 | 0.101 | 0.000 | 0.107 | 0.000 | 0.000 | 0.107 |
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | –0.052 | 0.000 | 0.000 | –0.011 |
| Celadonite | 0.000 | –0.043 | –1.225 | –0.506 | 0.000 | –1.188 | –0.326 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21152 | –1.745 | –3.031 | –2.762 | –3.197 | –1.430 | –2.579 | –3.153 |
| Dolomite | 0.009 | 0.009 | 0.009 | 0.061 | 0.009 | 0.009 | 0.021 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –1.272 | –4.204 | –3.312 | –4.148 | –0.447 | –27.850 | –3.373 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.324 | 1.010 | 0.000 | 0.646 | 0.125 | 8.207 | 0.521 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.759 | 2.564 | 2.817 | 2.881 | 0.260 | 15.460 | 2.346 |
| Phlogopite | 0.000 | 0.000 | 0.392 | 0.113 | 0.000 | 2.431 | 0.002 |
| Pyrite | –0.019 | –0.101 | 0.000 | –0.108 | 0.000 | 0.000 | –0.107 |
| Quartz | 1.526 | 5.175 | 6.866 | 6.270 | 0.536 | 32.120 | 5.021 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.018 | 0.101 | 0.000 | 0.107 | 0.000 | 0.000 | 0.107 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | 1.88E-09 | 1.57E-10 | 1.77E-10 | 1.45E-10 | 1.53E-08 | 1.45E-10 | 1.45E-10 |
| $CaHCO_3^+$ | 2.65E-07 | 7.94E-09 | 9.27E-09 | 7.07E-09 | 4.55E-06 | 6.93E-09 | 7.07E-09 |
| $CO_2$ | 1.15E+00 | 9.92E-01 | 1.02E+00 | 9.85E-01 | 1.22E+00 | 1.00E+00 | 9.85E-01 |
| $CO_3^{2-}$ | 3.69E-05 | 4.01E-04 | 3.71E-04 | 4.34E-04 | 5.47E-06 | 4.51E-04 | 4.34E-04 |
| $FeCO_3$ | 2.32E-07 | 2.32E-07 | 0.00E+00 | 2.32E-07 | | 0.00E+00 | 2.32E-07 |
| $FeCO_3^+$ | 2.55E-17 | 8.19E-18 | 0.00E+00 | 7.87E-18 | | | 7.87E-18 |
| $FeHCO_3^+$ | 2.05E-04 | 7.39E-05 | 0.00E+00 | 7.12E-05 | | | 7.12E-05 |
| $HCO_3^-$ | 3.54E-01 | 1.02E+00 | 9.95E-01 | 1.05E+00 | 1.49E-01 | 1.08E+00 | 1.05E+00 |
| $MgCO_3$ | 3.84E-04 | 4.62E-03 | 4.08E-03 | 5.01E-03 | 4.73E-05 | 4.99E-03 | 5.01E-03 |
| $MgHCO_3^+$ | 1.78E-01 | 7.70E-01 | 7.00E-01 | 8.05E-01 | 4.62E-02 | 7.83E-01 | 8.05E-01 |
| $NaCO_3^-$ | 1.13E-07 | 7.88E-07 | 7.43E-07 | 8.29E-07 | 2.36E-08 | 9.84E-07 | 8.30E-07 |
| $NaHCO_3$ | 2.17E-03 | 5.13E-03 | 4.96E-03 | 5.21E-03 | 1.08E-03 | 6.02E-03 | 5.21E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | -0.052 | 0.000 | 0.000 | -0.011 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.019 | 0.019 | 0.019 | 0.123 | 0.019 | 0.019 | 0.042 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.018 | 0.101 | 0.000 | 0.107 | 0.000 | 0.000 | 0.107 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.037 | 0.120 | 0.019 | 0.178 | 0.019 | 0.019 | 0.138 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.153 | 0.992 | 1.017 | 0.985 | 1.221 | 1.000 | 0.985 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.534 | 1.795 | 1.705 | 1.865 | 0.196 | 1.878 | 1.865 |
| Total $CO_2$, moles/kg $H_2O$ | 1.724 | 2.907 | 2.740 | 3.028 | 1.436 | 2.897 | 2.987 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation : Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Water, $g/cm^3$ | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 |
| Water, $kg/m^3$ | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 |
| Mineral $CO_2$, $moles/m^3$ | 2.704 | 8.674 | 1.375 | 12.942 | 1.374 | 1.375 | 9.987 |
| Dissolved $CO_2$, $moles/m^3$ | 83.658 | 71.977 | 73.791 | 71.454 | 88.592 | 72.550 | 71.454 |
| Solution $CO_2$, $moles/m^3$ | 38.738 | 130.271 | 123.674 | 135.291 | 14.225 | 136.238 | 135.292 |
| Total $CO_2$, $moles/m^3$ | 125.100 | 210.922 | 198.840 | 219.688 | 104.191 | 210.163 | 216.733 |
| Mineral $CO_2$, $moles/ft^3$ | 0.077 | 0.246 | 0.039 | 0.366 | 0.039 | 0.039 | 0.283 |
| Dissolved $CO_2$, $moles/ft^3$ | 2.369 | 2.038 | 2.090 | 2.023 | 2.509 | 2.054 | 2.023 |
| Solution $CO_2$, $moles/ft^3$ | 1.097 | 3.689 | 3.502 | 3.831 | 0.403 | 3.858 | 3.831 |
| Total $CO_2$, $moles/ft^3$ | 3.542 | 5.973 | 5.631 | 6.221 | 2.950 | 5.951 | 6.137 |
| Mineral $CO_2$, $kg/m^3$ | 0.119 | 0.382 | 0.061 | 0.570 | 0.060 | 0.061 | 0.440 |
| Dissolved $CO_2$, $kg/m^3$ | 3.682 | 3.168 | 3.248 | 3.145 | 3.899 | 3.193 | 3.145 |
| Solution $CO_2$, $kg/m^3$ | 1.705 | 5.733 | 5.443 | 5.954 | 0.626 | 5.996 | 5.954 |
| Total $CO_2$, $kg/m^3$ | 5.506 | 9.283 | 8.751 | 9.668 | 4.585 | 9.249 | 9.538 |
| Mineral $CO_2$, $lb/ft^3$ | 0.007 | 0.024 | 0.004 | 0.036 | 0.004 | 0.004 | 0.027 |
| Dissolved $CO^2$, $lb/ft^3$ | 0.230 | 0.198 | 0.203 | 0.196 | 0.243 | 0.199 | 0.196 |
| Solution $CO_2$, $lb/ft^3$ | 0.106 | 0.358 | 0.340 | 0.372 | 0.039 | 0.374 | 0.372 |
| Total $CO_2$, $lb/ft^3$ | 0.344 | 0.579 | 0.546 | 0.604 | 0.286 | 0.577 | 0.595 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation : Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | |
| pH | –1.363 | –0.938 | –0.930 | –1.189 | –1.749 | –0.899 | –1.189 |
| pE | 1.631 | 1.160 | 0.913 | 1.447 | 1.356 | –8.957 | 1.447 |
| Activity | –0.031 | –0.056 | –0.049 | –0.057 | –0.025 | –0.052 | –0.057 |
| Ionic Strength | 0.454 | 1.273 | 1.131 | 1.314 | 0.183 | 1.221 | 1.314 |
| Total Solution $CO_2$, moles | 1.687 | 2.787 | 2.722 | 2.850 | 1.417 | 2.878 | 2.850 |
| Solution, moles | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.710 | 2.913 | 2.745 | 3.020 | 1.413 | 2.561 | 3.017 |
| Ca | –0.009 | –0.009 | –0.009 | –0.011 | –0.009 | –0.009 | –0.011 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.004 | 0.001 | 0.003 | 0.001 | 0.008 | 0.001 | 0.001 |
| Mg | 0.308 | 1.085 | 0.869 | 1.145 | 0.102 | 0.846 | 1.144 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.037 | 0.201 | 0.000 | 0.215 | 0.000 | 0.000 | 0.215 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21152 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | –0.049 | 0.000 | 0.000 | –0.008 |
| Celadonite | 0.000 | 0.000 | 0.431 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21152 | 298.300 | 297.000 | 297.200 | 296.800 | 298.600 | 297.400 | 296.800 |
| Dolomite | 0.009 | 0.009 | 0.009 | 0.060 | 0.009 | 0.009 | 0.018 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | –0.100 | –0.362 | 0.000 | –0.399 | –0.025 | –0.283 | –0.385 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.102 | 0.363 | 0.002 | 0.400 | 0.029 | 0.280 | 0.386 |
| Phlogopite | –0.106 | –0.365 | –0.436 | –0.402 | –0.037 | –0.285 | –0.387 |
| Pyrite | –0.019 | –0.101 | 0.000 | –0.107 | 0.000 | 0.000 | –0.107 |
| Quartz | 0.200 | 0.800 | –0.420 | 0.800 | 0.100 | 1.000 | 0.800 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.018 | 0.101 | 0.000 | 0.107 | 0.000 | 0.000 | 0.107 |
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | –0.049 | 0.000 | 0.000 | –0.008 |
| Celadonite | 0.000 | 0.000 | 0.431 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21152 | 1.745 | 3.031 | 2.762 | 3.197 | 1.430 | 2.579 | 3.153 |
| Dolomite | 0.009 | 0.009 | 0.009 | 0.060 | 0.009 | 0.009 | 0.018 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | –0.100 | –0.362 | 0.000 | –0.399 | –0.025 | –0.283 | –0.385 |

Continued…

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation : Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.102 | 0.363 | 0.002 | 0.400 | 0.029 | 0.280 | 0.386 |
| Phlogopite | –0.106 | –0.365 | –0.436 | –0.402 | –0.037 | –0.285 | –0.387 |
| Pyrite | –0.019 | –0.101 | 0.000 | –0.107 | 0.000 | 0.000 | –0.107 |
| Quartz | 0.211 | 0.730 | –0.421 | 0.803 | 0.074 | 0.570 | 0.775 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.018 | 0.101 | 0.000 | 0.107 | 0.000 | 0.000 | 0.107 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | –3.39E-06 | –3.72E-06 | –3.81E-06 | –7.34E-06 | –3.71E-06 | –3.72E-06 | –7.34E-06 |
| $CaHCO_3^+$ | –1.68E-05 | –1.74E-05 | –1.86E-05 | –1.86E-05 | –1.28E-05 | –1.81E-05 | –1.86E-05 |
| $CO_2$ | 1.15E+00 | 9.92E-01 | 1.02E+00 | 9.85E-01 | 1.22E+00 | 1.00E+00 | 9.85E-01 |
| $CO_3^{2-}$ | 3.65E-05 | 4.01E-04 | 3.70E-04 | 4.33E-04 | 5.05E-06 | 4.51E-04 | 4.33E-04 |
| $FeCO_3$ | 2.32E-07 | 2.32E-07 | 0.00E+00 | 2.32E-07 | 0.00E+00 | 0.00E+00 | 2.32E-07 |
| $FeCO_3^+$ | 2.55E-17 | 8.19E-18 | 0.00E+00 | 7.87E-18 | 0.00E+00 | 0.00E+00 | 7.87E-18 |
| $FeHCO_3^+$ | 2.05E-04 | 7.39E-05 | 0.00E+00 | 7.12E-05 | 0.00E+00 | 0.00E+00 | 7.12E-05 |
| $HCO_3^-$ | 3.53E-01 | 1.01E+00 | 9.95E-01 | 1.05E+00 | 1.48E-01 | 1.08E+00 | 1.05E+00 |
| $MgCO_3$ | 3.84E-04 | 4.62E-03 | 4.08E-03 | 5.01E-03 | 4.71E-05 | 4.99E-03 | 5.01E-03 |
| $MgHCO_3^+$ | 1.78E-01 | 7.70E-01 | 7.00E-01 | 8.05E-01 | 4.62E-02 | 7.83E-01 | 8.05E-01 |
| $NaCO_3^-$ | 1.10E-07 | 7.85E-07 | 7.40E-07 | 8.23E-07 | 2.04E-08 | 9.81E-07 | 8.24E-07 |
| $NaHCO_3$ | 2.16E-03 | 5.13E-03 | 4.96E-03 | 5.20E-03 | 1.08E-03 | 6.02E-03 | 5.21E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | –0.049 | 0.000 | 0.000 | –0.008 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.017 | 0.018 | 0.018 | 0.119 | 0.018 | 0.018 | 0.036 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.018 | 0.101 | 0.000 | 0.107 | 0.000 | 0.000 | 0.107 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.036 | 0.119 | 0.018 | 0.177 | 0.018 | 0.018 | 0.136 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.153 | 0.992 | 1.017 | 0.985 | 1.221 | 1.000 | 0.985 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.534 | 1.795 | 1.704 | 1.864 | 0.196 | 1.877 | 1.864 |
| Total $CO_2$, moles/kg $H_2O$ | 1.722 | 2.906 | 2.739 | 3.027 | 1.435 | 2.895 | 2.985 |

Continued. . .

**Table B-13. Summary of MT API 21152 Aquifer Calculation Results (continued)**

| Formation : Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Water, $g/cm^3$ | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 | 0.073 |
| Water, $kg/m^3$ | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 | 72.557 |
| Mineral $CO_2$, $moles/m^3$ | 2.591 | 8.610 | 1.315 | 12.875 | 1.310 | 1.308 | 9.871 |
| Dissolved $CO_2$, $moles/m^3$ | 83.654 | 71.973 | 73.786 | 71.452 | 88.588 | 72.546 | 71.452 |
| Solution $CO_2$, $moles/m^3$ | 38.713 | 130.247 | 123.648 | 135.269 | 14.201 | 136.214 | 135.269 |
| Total $CO_2$, $moles/m^3$ | 124.959 | 210.830 | 198.749 | 219.596 | 104.099 | 210.068 | 216.592 |
| Mineral $CO_2$, $moles/ft^3$ | 0.073 | 0.244 | 0.037 | 0.365 | 0.037 | 0.037 | 0.280 |
| Dissolved $CO_2$, $moles/ft^3$ | 2.369 | 2.038 | 2.089 | 2.023 | 2.509 | 2.054 | 2.023 |
| Solution $CO_2$, $moles/ft^3$ | 1.096 | 3.688 | 3.501 | 3.830 | 0.402 | 3.857 | 3.830 |
| Total $CO_2$, $moles/ft^3$ | 3.538 | 5.970 | 5.628 | 6.218 | 2.948 | 5.949 | 6.133 |
| Mineral $CO_2$, $kg/m^3$ | 0.114 | 0.379 | 0.058 | 0.567 | 0.058 | 0.058 | 0.434 |
| Dissolved $CO_2$, $kg/m^3$ | 3.682 | 3.168 | 3.247 | 3.145 | 3.899 | 3.193 | 3.145 |
| Solution $CO_2$, $kg/m^3$ | 1.704 | 5.732 | 5.442 | 5.953 | 0.625 | 5.995 | 5.953 |
| Total $CO_2$, $kg/m^3$ | 5.499 | 9.279 | 8.747 | 9.664 | 4.581 | 9.245 | 9.532 |
| Mineral $CO_2$, $lb/ft^3$ | 0.007 | 0.024 | 0.004 | 0.035 | 0.004 | 0.004 | 0.027 |
| Dissolved $CO_2$, $lb/ft^3$ | 0.230 | 0.198 | 0.203 | 0.196 | 0.243 | 0.199 | 0.196 |
| Solution $CO_2$, $lb/ft^3$ | 0.106 | 0.358 | 0.340 | 0.372 | 0.039 | 0.374 | 0.372 |
| Total $CO_2$, $lb/ft^3$ | 0.343 | 0.579 | 0.546 | 0.603 | 0.286 | 0.577 | 0.595 |
| Weighted Average of Zones | | | | | | | |
| Total thickness, m | 50.9 | | | | | | |
| Mineral $CO_2$, $kg/m^3$ | 0.207 | | | | | | |
| Dissolved $CO_2$, $kg/m^3$ | 3.526 | | | | | | |
| Solution $CO_2$, $kg/m^3$ | 2.981 | | | | | | |
| Total $CO_2$, $kg/m^3$ | 6.714 | | | | | | |
| Mineral $CO_2$, $lb/ft^3$ | 0.013 | | | | | | |
| Dissolved $CO_2$, $lb/ft^3$ | 0.220 | | | | | | |
| Solution $CO_2$, $lb/ft^3$ | 0.186 | | | | | | |
| Total $CO_2$, $lb/ft^3$ | 0.419 | | | | | | |

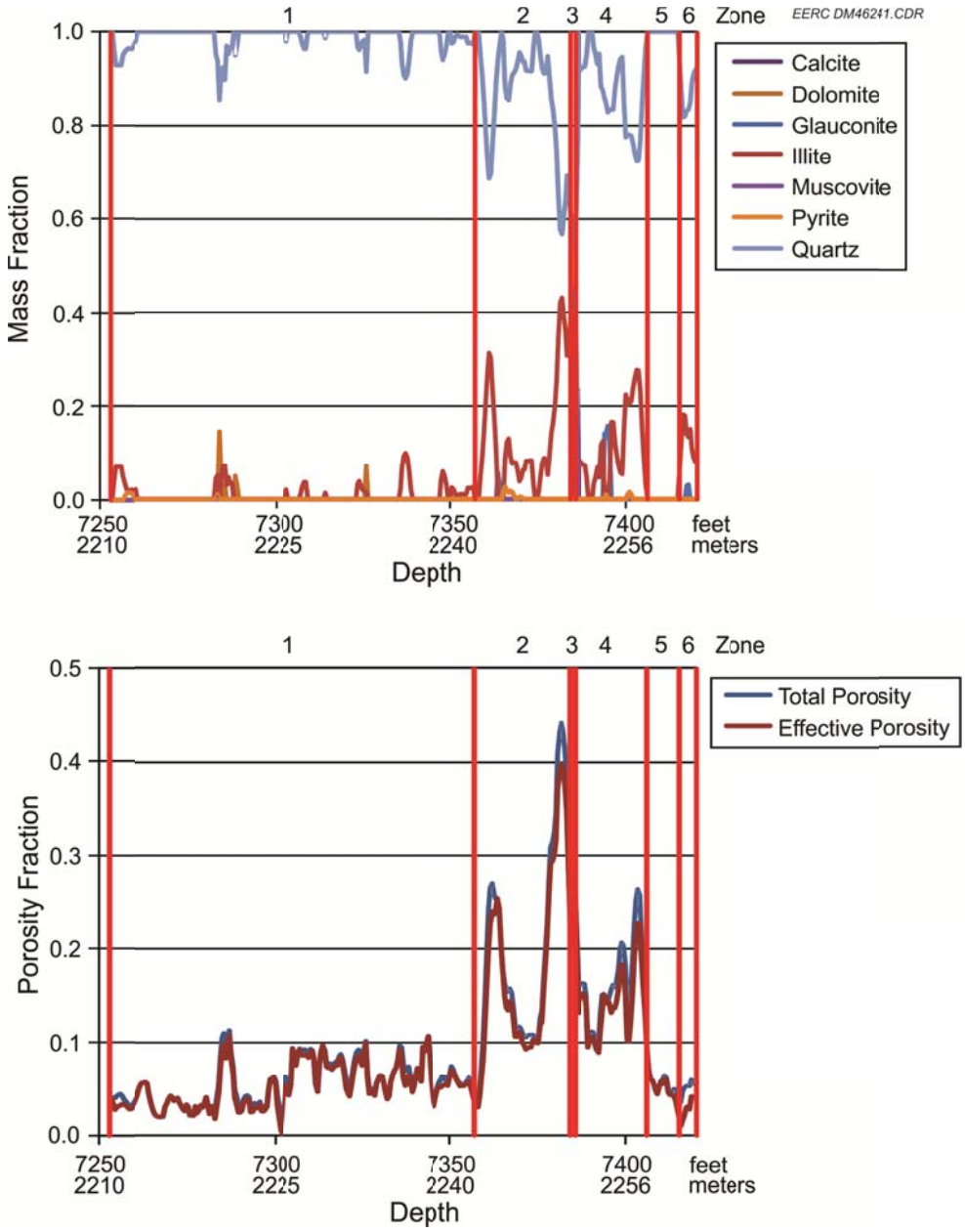



Figure B-1. MT API 21152 mineral composition and porosity as a function of depth.

**ND 7577**

The water composition used for ND7577 is from the aforementioned ND 6436 Well 22 miles (35 km) to the north. Mineral data were available for the complete COSS formation, with the well penetrating into the Precambrian.

Zones 3, 4, and 6 had very low porosities of 0.002–0.004, with the others ranging from 0.010 to 0.059. Quartz is predominant (88%) in Zone 1. The narrow zones, 2 and 6, contain large amounts of glauconite with the balance of the minerals mostly quartz. Zones 3, 4, and 5 are mostly calcite with the balance illite, and with little or no quartz or other minerals present.

The PHREEQC calculations for Zones 3, 4, and 5 did not converge to a solution. As a result these thicknesses have been omitted from the calculation of the weighted average for $CO_2$ interactions. The lack of convergence can be due to many factors relating to the database information and formation water chemistry available for this location. For the other zones, the celadonite (glauconite) dissolves both with and without $CO_2$ present, with a concurrent increase in quartz, microcline, and muscovite. A relatively small amount of dolomite is predicted to form with $CO_2$ present, and a small amount of siderite forms.

The amount of $CO_2$ dissolved in formation water in Zones 1 and 2 is approximately 0.76 moles/kg (33.4 g/kg). Dolomite is the major solid mineral phase containing $CO_2$, along with small amounts of siderite. Only small amounts of other species in solution contribute to the $CO_2$ interaction. In contrast, Zone 6 has a higher dissolved $CO_2$ concentration of 1.23 moles/kg. The amounts of other solution species and dolomite are similar to Zones 1 and 2. The total weighted average amount of $CO_2$ reacting with the mineral species and the formation water is 4.6 kg/m$^3$ (0.3 lb/ft$^3$). Note that due to the lack of convergence for Zones 3, 4, and 5, this is based on only 55% of the total COSS.

## Table B-14. Average Mineral and Porosity Values for the ND 7577 Aquifer Zone

Well Name: ND 7577
API Identification: 33-075-00798-0000
State Identification: ND 7577

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 9874.5 | 3009.8 | Average | 0.059 | 0.059 | 0.000 | 0.000 | 0.000 | 0.000 | 0.089 | 0.002 | 0.000 | 0.000 | 0.000 | 0.028 | 0.880 | 0.000 |
| End | 9971.5 | 3039.3 | Minimum | 0.018 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.601 | 0.000 |
| Thickness | 97.0 | 29.6 | Maximum | 0.127 | 0.127 | 0.000 | 0.017 | 0.000 | 0.000 | 0.348 | 0.062 | 0.000 | 0.000 | 0.000 | 0.100 | 1.000 | 0.000 |
| Number of Values | 255 | | Standard deviation | 0.027 | 0.027 | 0.000 | 0.001 | 0.000 | 0.000 | 0.077 | 0.008 | 0.000 | 0.000 | 0.000 | 0.025 | 0.077 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 9971.5 | 3039.3 | Average | 0.030 | 0.030 | 0.000 | 0.000 | 0.000 | 0.000 | 0.711 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.287 | 0.000 |
| End | 9979.5 | 3041.8 | Minimum | 0.022 | 0.022 | 0.000 | 0.000 | 0.000 | 0.000 | 0.219 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 8.0 | 2.4 | Maximum | 0.041 | 0.041 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.032 | 0.781 | 0.000 |
| Number of Values | 16 | | Standard deviation | 0.006 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.237 | 0.000 | 0.000 | 0.000 | 0.000 | 0.008 | 0.236 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 9979.5 | 3041.8 | Average | 0.016 | 0.003 | 0.000 | 0.655 | 0.000 | 0.000 | 0.000 | 0.253 | 0.000 | 0.000 | 0.000 | 0.093 | 0.000 | 0.000 |
| End | 10,008.0 | 3050.4 | Minimum | 0.010 | 0.001 | 0.000 | 0.603 | 0.000 | 0.000 | 0.000 | 0.159 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 28.5 | 8.7 | Maximum | 0.021 | 0.008 | 0.000 | 0.721 | 0.000 | 0.000 | 0.000 | 0.327 | 0.000 | 0.000 | 0.000 | 0.169 | 0.000 | 0.000 |
| Number of Values | 57 | | Standard deviation | 0.003 | 0.003 | 0.000 | 0.029 | 0.000 | 0.000 | 0.000 | 0.046 | 0.000 | 0.000 | 0.000 | 0.037 | 0.000 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 10,008.0 | 3050.4 | Average | 0.015 | 0.002 | 0.000 | 0.758 | 0.000 | 0.000 | 0.000 | 0.242 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| End | 10,088.0 | 3074.8 | Minimum | 0.008 | 0.001 | 0.000 | 0.599 | 0.000 | 0.000 | 0.000 | 0.131 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 80.0 | 24.4 | Maximum | 0.030 | 0.015 | 0.000 | 0.869 | 0.000 | 0.000 | 0.000 | 0.401 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Number of Values | 161 | | Standard deviation | 0.006 | 0.003 | 0.000 | 0.077 | 0.000 | 0.000 | 0.000 | 0.077 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 10,088.0 | 3074.8 | Average | 0.032 | 0.010 | 0.000 | 0.521 | 0.000 | 0.002 | 0.000 | 0.448 | 0.000 | 0.000 | 0.000 | 0.005 | 0.024 | 0.000 |
| End | 10,125.0 | 3086.1 | Minimum | 0.019 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.357 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 80.0 | 24.4 | Maximum | 0.085 | 0.061 | 0.000 | 0.643 | 0.000 | 0.101 | 0.000 | 0.659 | 0.000 | 0.000 | 0.000 | 0.106 | 0.643 | 0.000 |
| Number of Values | 75 | | Standard deviation | 0.015 | 0.014 | 0.000 | 0.138 | 0.000 | 0.013 | 0.000 | 0.078 | 0.000 | 0.000 | 0.000 | 0.020 | 0.118 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 10,125.0 | 3086.1 | Average | 0.014 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.399 | 0.106 | 0.000 | 0.079 | 0.000 | 0.000 | 0.415 | 0.000 |
| End | 10,136.0 | 3089.5 | Minimum | 0.008 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.141 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.148 | 0.000 |
| Thickness | 11.0 | 3.4 | Maximum | 0.021 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.700 | 0.299 | 0.000 | 0.321 | 0.000 | 0.000 | 0.632 | 0.000 |
| Number of Values | 21 | | Standard deviation | 0.005 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.192 | 0.104 | 0.000 | 0.132 | 0.000 | 0.000 | 0.163 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 9874.5 | 3009.8 | Average | 0.035 | 0.027 | 0.000 | 0.339 | 0.000 | 0.000 | 0.078 | 0.153 | 0.000 | 0.003 | 0.000 | 0.020 | 0.406 | 0.000 |
| End | 10,136 | 3089.5 | Minimum | 0.008 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 261.5 | 79.7 | Maximum | 0.127 | 0.127 | 0.000 | 0.869 | 0.000 | 0.101 | 1.000 | 0.659 | 0.000 | 0.321 | 0.000 | 0.169 | 1.000 | 0.000 |
| Number of Values | 585 | | Standard deviation | 0.027 | 0.031 | 0.000 | 0.352 | 0.000 | 0.005 | 0.152 | 0.167 | 0.000 | 0.028 | 0.000 | 0.034 | 0.427 | 0.000 |

**Table B-15. Summary of ND 7577 Aquifer Minerals and Conditions**

Well Name: ND 7577
API Identification: 33-075-00798-0000
State Identification: ND 7577

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Start, ft | 9874.5 | 9971.5 | 9979.5 | 10,008.0 | 10,088.0 | 10,125.0 | 9874.5 |
| End, ft | 9971.5 | 9979.5 | 10,008.0 | 10,088.0 | 10,125.0 | 10,136.0 | 10,136.0 |
| Thickness, ft | 97.0 | 8.0 | 28.5 | 80.0 | 37.0 | 11.0 | 261.5 |
| Start, m | 3009.8 | 3039.3 | 3041.8 | 3050.4 | 3074.8 | 3086.1 | 3009.8 |
| End, m | 3039.3 | 3041.8 | 3050.4 | 3074.8 | 3086.1 | 3089.5 | 3089.5 |
| Thickness, m | 29.6 | 2.4 | 8.7 | 24.4 | 11.3 | 3.4 | 79.7 |
| Temperature, °F | 241.0 | 241.0 | 241.0 | 241.0 | 241.0 | 241.0 | 241.0 |
| Temperature, °C | 116.1 | 116.1 | 116.1 | 116.1 | 116.1 | 116.1 | 116.1 |
| Pressure, psi | 6449 | 6458 | 6461 | 6471 | 6481 | 6485 | 6463 |
| Pressure, kPa | 44,462 | 44,526 | 44,548 | 44,615 | 44,686 | 44,715 | 44,562 |
| Effective Porosity, fraction | 0.059 | 0.030 | 0.003 | 0.002 | 0.010 | 0.004 | 0.027 |
| Mass Fraction | | | | | | | |
| Ankerite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.655 | 0.758 | 0.521 | 0.000 | 0.339 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 |
| Glauconite | 0.089 | 0.711 | 0.000 | 0.000 | 0.000 | 0.399 | 0.078 |
| Illite | 0.002 | 0.000 | 0.253 | 0.242 | 0.448 | 0.106 | 0.153 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.079 | 0.003 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.028 | 0.002 | 0.093 | 0.000 | 0.005 | 0.000 | 0.020 |
| Quartz | 0.880 | 0.287 | 0.000 | 0.000 | 0.024 | 0.415 | 0.406 |
| Smectite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-16. Summary of ND 7577 Aquifer Calculation Results

Well Name: ND 7577
API Identification: 33-075-00798-0000
State Identification: ND 7577

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3* | Aquifer Zone 4* | Aquifer Zone 5* | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Start, m | 3009.8 | 3039.3 | 3041.8 | 3050.4 | 3074.8 | 3086.1 | 3009.8 |
| End, m | 3039.3 | 3041.8 | 3050.4 | 3074.8 | 3086.1 | 3089.5 | 3089.5 |
| Thickness, m | 29.6 | 2.4 | 8.7 | 24.4 | 11.3 | 3.4 | 79.7 |
| Start, ft | 9874.5 | 9971.5 | 9979.5 | 10,008.0 | 10,088.0 | 10,125.0 | 9874.5 |
| End, ft | 9971.5 | 9979.5 | 10,008.0 | 10,088.0 | 10,125.0 | 10,136.0 | 10,136.0 |
| Thickness, ft | 97.0 | 8.0 | 28.5 | 80.0 | 37.0 | 11.0 | 261.5 |
| **Minerals Without $CO_2$** | | | | | | | |
| pH | 5.252 | 5.378 | NA | NA | NA | 5.710 | 5.935 |
| pE | −1.913 | -2.052 | NA | NA | NA | 8.386 | −2.643 |
| Activity | 0.848 | 0.847 | NA | NA | NA | 0.983 | 0.875 |
| Ionic Strength | 4.117 | 4.113 | NA | NA | NA | 0.583 | 3.631 |
| Total Solution $CO_2$, moles | 2.517E-04 | 2.499E-04 | NA | NA | NA | 2.458E-05 | 5.069E-04 |
| Solution, moles | | | | | | | |
| Al | 0.0000 | 0.0000 | NA | NA | NA | 0.0000 | 0.0000 |
| C | 0.0003 | 0.0003 | NA | NA | NA | 0.0003 | 0.0007 |
| Ca | 0.5320 | 0.5320 | NA | NA | NA | 0.5320 | 0.7495 |
| Cl | 5.9200 | 5.9200 | NA | NA | NA | 5.9200 | 5.9200 |
| Fe | 0.0000 | 0.0000 | NA | NA | NA | 0.0000 | 0.0000 |
| K | 0.1427 | 0.1948 | NA | NA | NA | 0.2029 | 0.0011 |
| Mg | 0.1702 | 0.1442 | NA | NA | NA | 0.1401 | 0.0238 |
| Na | 4.3740 | 4.3740 | NA | NA | NA | 4.3740 | 4.3740 |
| S | 0.0008 | 0.0008 | NA | NA | NA | 0.0008 | 0.0008 |
| Si | 0.0012 | 0.0012 | NA | NA | NA | 0.0124 | 0.0015 |
| Ti | 0.0000 | 0.0000 | NA | NA | NA | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 330.200 |
| Celadonite | 9.064 | 154.300 | NA | NA | NA | 682.900 | 17.710 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.144 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3* | Aquifer<br>Zone 4* | Aquifer<br>Zone 5* | Aquifer<br>Zone 6 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | 0.208 | 0.000 | NA | NA | NA | 203.600 | 38.870 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | 225.600 | 1.075 |
| Maximum Microcline | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Pyrite | 10.320 | 1.546 | NA | NA | NA | 0.000 | 16.230 |
| Quartz | 636.800 | 444.400 | NA | NA | NA | 5070.000 | 658.700 |
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 329.700 |
| Celadonite | 9.090 | 154.300 | NA | NA | NA | 242.700 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.361 |
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 1.904 |
| Maximum Microcline | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Muscovite | 0.151 | 0.000 | NA | NA | NA | 398.700 | 32.110 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | 163.700 | 9.109 |
| Pyrite | 10.320 | 1.546 | NA | NA | NA | 0.000 | 16.230 |
| Quartz | 637.000 | 444.400 | NA | NA | NA | 6307.000 | 740.300 |
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3* | Aquifer<br>Zone 4* | Aquifer<br>Zone 5* | Aquifer<br>Zone 6 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | −0.434 |
| Celadonite | 0.026 | 0.000 | NA | NA | NA | −440.200 | −17.710 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.217 |
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | −0.208 | 0.000 | NA | NA | NA | −203.600 | −38.870 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | −225.600 | 0.829 |
| Maximum Microcline | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Muscovite | 0.151 | 0.000 | NA | NA | NA | 398.700 | 32.110 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | 163.700 | 9.109 |
| Pyrite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Quartz | 0.171 | −0.001 | NA | NA | NA | 1238.000 | 81.540 |
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | 2.31E-07 | 3.70E-07 | NA | NA | NA | 2.40E-08 | 5.72E-06 |
| $CaHCO_3^+$ | 3.95E-05 | 4.74E-05 | NA | NA | NA | 1.66E-06 | 2.11E-04 |
| $CO_2$ | 1.65E-04 | 1.48E-04 | NA | NA | NA | 1.67E-05 | 1.48E-04 |
| $CO_3^{2-}$ | 2.68E-09 | 4.31E-09 | NA | NA | NA | 1.01E-09 | 5.44E-08 |
| $FeCO_3$ | 4.93E-13 | 7.82E-13 | NA | NA | NA | 0.00E+00 | 2.63E-11 |
| $FeCO_3^+$ | 1.95E-23 | 2.24E-23 | NA | NA | NA | 0.00E+00 | 2.01E-22 |
| $FeHCO_3^+$ | 8.00E-10 | 9.51E-10 | NA | NA | NA | 0.00E+00 | 9.22E-09 |
| $HCO_3^-$ | 2.34E-05 | 2.81E-05 | NA | NA | NA | 5.41E-06 | 1.02E-04 |
| $MgCO_3$ | 1.80E-08 | 2.45E-08 | NA | NA | NA | 1.64E-09 | 4.34E-08 |
| $MgHCO_3^+$ | 1.41E-05 | 1.44E-05 | NA | NA | NA | 5.19E-07 | 7.35E-06 |
| $NaCO_3^-$ | 9.63E-11 | 1.55E-10 | NA | NA | NA | 7.94E-12 | 1.68E-09 |
| $NaHCO_3$ | 9.53E-06 | 1.14E-05 | NA | NA | NA | 2.37E-07 | 3.32E-05 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3* | Zone 4* | Zone 5* | Zone 6 | Total |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | NA | NA | NA | 0.000E+00 | −4.344E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | NA | NA | NA | 0.000E+00 | 4.338E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | NA | NA | NA | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | NA | NA | NA | 0.000E+00 | −6.000E-04 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.650E-04 | 1.483E-04 | NA | NA | NA | 1.673E-05 | 1.477E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 8.678E-05 | 1.016E-04 | NA | NA | NA | 7.849E-06 | 3.592E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 2.518E-04 | 2.499E-04 | NA | NA | NA | 2.458E-05 | −9.312E-05 |
| Water, g/cm$^3$ | 0.059 | 0.030 | 0.003 | 0.002 | 0.010 | 0.004 | 0.027 |
| Water, kg/m$^3$ | 58.934 | 30.156 | 3.082 | 2.495 | 9.650 | 3.779 | 27.439 |
| Mineral $CO_2$, moles/m$^3$ | 0.000E+00 | 0.000E+00 | NA | NA | NA | 0.000E+00 | −1.646E-02 |
| Dissolved $CO_2$, moles/m$^3$ | 9.724E-03 | 4.472E-03 | NA | NA | NA | 6.322E-05 | 4.053E-03 |
| Solution $CO_2$, moles/m$^3$ | 5.114E-03 | 3.065E-03 | NA | NA | NA | 2.966E-05 | 9.856E-03 |
| Total $CO_2$, moles/m$^3$ | 1.484E-02 | 7.537E-03 | NA | NA | NA | 9.288E-05 | −2.555E-03 |
| Mineral $CO_2$, moles/ft$^3$ | 0.000E+00 | 0.000E+00 | NA | NA | NA | 0.000E+00 | −4.662E-04 |
| Dissolved $CO_2$, moles/ft$^3$ | 2.754E-04 | 1.266E-04 | NA | NA | NA | 1.790E-06 | 1.148E-04 |
| Solution $CO_2$, moles/ft$^3$ | 1.448E-04 | 8.679E-05 | NA | NA | NA | 8.398E-07 | 2.791E-04 |
| Total $CO_2$, moles/ft$^3$ | 4.202E-04 | 2.134E-04 | NA | NA | NA | 2.630E-06 | −7.235E-05 |
| Mineral $CO_2$, kg/m$^3$ | 0.000E+00 | 0.000E+00 | NA | NA | NA | 0.000E+00 | −7.246E-04 |
| Dissolved $CO_2$, kg/m$^3$ | 4.280E-04 | 1.968E-04 | NA | NA | NA | 2.782E-06 | 1.784E-04 |
| Solution $CO_2$, kg/m$^3$ | 2.251E-04 | 1.349E-04 | NA | NA | NA | 1.305E-06 | 4.337E-04 |
| Total $CO_2$, kg/m$^3$ | 6.530E-04 | 3.317E-04 | NA | NA | NA | 4.087E-06 | −1.124E-04 |
| Mineral $CO_2$, lb/ft$^3$ | 0.000E+00 | 0.000E+00 | NA | NA | NA | 0.000E+00 | −4.523E-05 |
| Dissolved $CO_2$, lb/ft$^3$ | 2.672E-05 | 1.229E-05 | NA | NA | NA | 1.737E-07 | 1.113E-05 |
| Solution $CO_2$, lb/ft$^3$ | 1.405E-05 | 8.421E-06 | NA | NA | NA | 8.148E-08 | 2.708E-05 |
| Total $CO_2$, lb/ft$^3$ | 4.077E-05 | 2.071E-05 | NA | NA | NA | 2.552E-07 | −7.020E-06 |
| Weighted Average of Zones | | | | | | | |
| Total Thickness, meters | 35.4 | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 0.000E+00 | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 3.717E-04 | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 1.976E-04 | | | | | | |
| Total $CO_2$, kg/m$^3$ | 5.693E-04 | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.000E+00 | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 2.320E-05 | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 1.234E-05 | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 3.554E-05 | | | | | | |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3* | Aquifer Zone 4* | Aquifer Zone 5* | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | |
| pH | 4.957 | 4.957 | NA | NA | NA | 5.318 | 4.574 |
| pE | −1.314 | −1.314 | NA | NA | NA | 8.787 | −0.872 |
| Activity | 0.831 | 0.831 | NA | NA | NA | 0.956 | 0.863 |
| Ionic Strength | 4.043 | 4.042 | NA | NA | NA | 0.751 | 3.110 |
| Total Solution $CO_2$, moles | 9.35E-01 | 9.37E-01 | NA | NA | NA | 1.50E+00 | 8.98E-01 |
| Solution, moles | | | | | | | |
| Al | 0.0000 | 0.0000 | NA | NA | NA | 0.0000 | 0.0000 |
| C | 0.9594 | 0.9618 | NA | NA | NA | 15.9000 | 1.2880 |
| Ca | 0.0000 | 0.0000 | NA | NA | NA | 0.0000 | 0.0893 |
| Cl | 5.9200 | 5.9200 | NA | NA | NA | 5.9200 | 5.9200 |
| Fe | 0.0009 | 0.0009 | NA | NA | NA | 0.0000 | 0.0010 |
| K | 0.4124 | 0.4124 | NA | NA | NA | 0.5326 | 1.4170 |
| Mg | 0.6668 | 0.6670 | NA | NA | NA | 1.9400 | 0.0029 |
| Na | 4.3740 | 4.3740 | NA | NA | NA | 4.3740 | 4.3740 |
| S | 0.0115 | 0.0115 | NA | NA | NA | 0.0008 | 0.0027 |
| Si | 0.0012 | 0.0012 | NA | NA | NA | 0.0124 | 0.0017 |
| Ti | 0.0000 | 0.0000 | NA | NA | NA | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 330.200 |
| Celadonite | 9.064 | 154.300 | NA | NA | NA | 682.900 | 17.710 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | 300.000 | 300.000 | NA | NA | NA | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.144 |
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | 0.208 | 0.000 | NA | NA | NA | 203.600 | 38.870 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | 225.600 | 1.075 |
| Maximum Microcline | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Pyrite | 10.320 | 1.546 | NA | NA | NA | 0.000 | 16.230 |
| Quartz | 636.800 | 444.400 | NA | NA | NA | 5070.000 | 658.700 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3* | Aquifer<br>Zone 4* | Aquifer<br>Zone 5* | Aquifer<br>Zone 6 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 303.100 |
| Celadonite | 8.061 | 153.300 | NA | NA | NA | 243.100 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | 298.000 | 298.000 | NA | NA | NA | 283.000 | 270.700 |
| Dolomite | 0.532 | 0.532 | NA | NA | NA | 0.532 | 27.710 |
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Maximum Microcline | 0.624 | 0.728 | NA | NA | NA | 0.000 | 5.081 |
| Muscovite | 0.286 | 0.109 | NA | NA | NA | 398.800 | 34.730 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | 162.800 | 0.000 |
| Pyrite | 10.320 | 1.541 | NA | NA | NA | 0.000 | 16.220 |
| Quartz | 638.800 | 446.100 | NA | NA | NA | 6308.000 | 748.300 |
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.004 | 0.004 | NA | NA | NA | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | −27.120 |
| Celadonite | −1.003 | −1.055 | NA | NA | NA | −439.800 | −17.710 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | −2.028 | −2.030 | NA | NA | NA | −16.960 | −29.300 |
| Dolomite | 0.532 | 0.532 | NA | NA | NA | 0.532 | 27.570 |
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | −0.208 | 0.000 | NA | NA | NA | −203.600 | −38.870 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | −225.600 | −1.075 |
| Maximum Microcline | 0.624 | 0.728 | NA | NA | NA | 0.000 | 5.081 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3* | Aquifer Zone 4* | Aquifer Zone 5* | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Muscovite | 0.286 | 0.109 | NA | NA | NA | 398.800 | 34.730 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | 162.800 | 0.000 |
| Pyrite | −0.005 | −0.005 | NA | NA | NA | 0.000 | −0.001 |
| Quartz | 2.008 | 1.707 | NA | NA | NA | 1238.000 | 89.600 |
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.004 | 0.004 | NA | NA | NA | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | 3.78E-09 | 3.77E-09 | NA | NA | NA | 1.99E-09 | 5.72E-06 |
| $CaHCO_3^+$ | 1.28E-06 | 1.28E-06 | NA | NA | NA | 3.42E-07 | 5.04E-03 |
| $CO_2$ | 7.58E-01 | 7.60E-01 | NA | NA | NA | 1.23E+00 | 8.61E-01 |
| $CO_3^{2-}$ | 3.08E-06 | 3.09E-06 | NA | NA | NA | 1.35E-05 | 5.55E-07 |
| $FeCO_3$ | 4.69E-08 | 4.69E-08 | NA | NA | NA | 0.00E+00 | 1.56E-08 |
| $FeCO_3^+$ | 7.41E-18 | 7.41E-18 | NA | NA | NA | 0.00E+00 | 7.29E-18 |
| $FeHCO_3^+$ | 1.51E-04 | 1.51E-04 | NA | NA | NA | 0.00E+00 | 1.30E-04 |
| $HCO_3^-$ | 5.32E-02 | 5.33E-02 | NA | NA | NA | 1.65E-01 | 2.47E-02 |
| $MgCO_3$ | 6.58E-05 | 6.59E-05 | NA | NA | NA | 1.25E-04 | 4.34E-08 |
| $MgHCO_3^+$ | 1.02E-01 | 1.03E-01 | NA | NA | NA | 9.87E-02 | 1.75E-04 |
| $NaCO_3^-$ | 1.08E-07 | 1.09E-07 | NA | NA | NA | 9.57E-08 | 1.55E-08 |
| $NaHCO_3$ | 2.10E-02 | 2.11E-02 | NA | NA | NA | 6.95E-03 | 6.77E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | NA | NA | NA | 0.000 | −27.120 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.064 | 1.064 | NA | NA | NA | 1.064 | 55.140 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.004 | 0.004 | NA | NA | NA | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.068 | 1.068 | NA | NA | NA | 1.064 | 28.020 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.758 | 0.760 | NA | NA | NA | 1.233 | 0.861 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.177 | 0.177 | NA | NA | NA | 0.271 | 0.037 |
| Total $CO_2$, moles/kg $H_2O$ | 2.003 | 2.005 | NA | NA | NA | 2.568 | 28.918 |
| Water, g/$cm^3$ | 0.059 | 0.030 | 0.003 | 0.002 | 0.010 | 0.004 | 0.027 |
| Water, kg/$m^3$ | 58.934 | 30.156 | 3.082 | 2.495 | 9.650 | 3.779 | 27.439 |
| Mineral $CO_2$, moles/$m^3$ | 62.964 | 32.219 | NA | NA | NA | 4.021 | 768.847 |
| Dissolved $CO_2$, moles/$m^3$ | 44.678 | 22.913 | NA | NA | NA | 4.659 | 23.636 |
| Solution $CO_2$, moles/$m^3$ | 10.421 | 5.343 | NA | NA | NA | 1.024 | 1.010 |
| Total $CO_2$, moles/$m^3$ | 118.063 | 60.475 | NA | NA | NA | 9.703 | 793.494 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3* | Aquifer Zone 4* | Aquifer Zone 5* | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$ft^3$ | 1.783 | 0.912 | NA | NA | NA | 0.114 | 21.771 |
| Dissolved $CO_2$, moles/$ft^3$ | 1.265 | 0.649 | NA | NA | NA | 0.132 | 0.669 |
| Solution $CO_2$, moles/$ft^3$ | 0.295 | 0.151 | NA | NA | NA | 0.029 | 0.029 |
| Total $CO_2$, moles/$ft^3$ | 3.343 | 1.712 | NA | NA | NA | 0.275 | 22.469 |
| Mineral $CO_2$, kg/$m^3$ | 2.771 | 1.418 | NA | NA | NA | 0.177 | 33.837 |
| Dissolved $CO_2$, kg/$m^3$ | 1.966 | 1.008 | NA | NA | NA | 0.205 | 1.040 |
| Solution $CO_2$, kg/$m^3$ | 0.459 | 0.235 | NA | NA | NA | 0.045 | 0.044 |
| Total $CO_2$, kg/$m^3$ | 5.196 | 2.661 | NA | NA | NA | 0.427 | 34.922 |
| Mineral $CO_2$, lb/$ft^3$ | 0.173 | 0.089 | NA | NA | NA | 0.011 | 2.112 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.123 | 0.063 | NA | NA | NA | 0.013 | 0.065 |
| Solution $CO_2$, lb/$ft^3$ | 0.029 | 0.015 | NA | NA | NA | 0.003 | 0.003 |
| Total $CO_2$, lb/$ft^3$ | 0.324 | 0.166 | NA | NA | NA | 0.027 | 2.180 |
| Weighted Average of Zones | | | | | | | |
| Total Thickness, m | 35.4 | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 2.432 | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.733 | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.404 | | | | | | |
| Total $CO_2$, kg/$m^3$ | 4.569 | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.152 | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.108 | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.025 | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.285 | | | | | | |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3* | Aquifer Zone 4* | Aquifer Zone 5* | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | |
| pH | −0.295 | −0.421 | NA | NA | NA | −0.392 | −1.361 |
| pE | 0.599 | 0.738 | NA | NA | NA | 0.401 | 1.771 |
| Activity | −0.017 | −0.016 | NA | NA | NA | −0.027 | −0.012 |
| Ionic Strength | −0.074 | −0.071 | NA | NA | NA | 0.169 | −0.521 |
| Total Solution $CO_2$, moles | 0.935 | 0.937 | NA | NA | NA | 1.504 | 0.898 |
| Solution, moles | | | | | | | |
| Al | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| C | 0.959 | 0.962 | NA | NA | NA | 15.900 | 1.287 |
| Ca | −0.532 | −0.532 | NA | NA | NA | −0.532 | −0.660 |
| Cl | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Fe | 0.001 | 0.001 | NA | NA | NA | 0.000 | 0.001 |
| K | 0.270 | 0.218 | NA | NA | NA | 0.330 | 1.416 |
| Mg | 0.497 | 0.523 | NA | NA | NA | 1.800 | −0.021 |
| Na | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| S | 0.011 | 0.011 | NA | NA | NA | 0.000 | 0.002 |
| Si | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | 300.000 | 300.000 | NA | NA | NA | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3* | Aquifer<br>Zone 4* | Aquifer<br>Zone 5* | Aquifer<br>Zone 6 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | −26.600 |
| Celadonite | −1.029 | −1.000 | NA | NA | NA | 0.400 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | 298.000 | 298.000 | NA | NA | NA | 283.000 | 270.700 |
| Dolomite | 0.532 | 0.532 | NA | NA | NA | 0.532 | 27.349 |
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | 0.000 | −1.904 |
| Maximum Microcline | 0.624 | 0.728 | NA | NA | NA | 0.000 | 5.081 |
| Muscovite | 0.135 | 0.109 | NA | NA | NA | 0.100 | 2.620 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | −0.900 | −9.109 |
| Pyrite | 0.000 | −0.005 | NA | NA | NA | 0.000 | −0.010 |
| Quartz | 1.800 | 1.700 | NA | NA | NA | 1.000 | 8.000 |
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.004 | 0.004 | NA | NA | NA | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | NA | NA | NA | 0.000 | −26.686 |
| Celadonite | −1.029 | −1.055 | NA | NA | NA | 0.400 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| $CO_2$ ND 7577 | 2.028 | 2.030 | NA | NA | NA | 16.960 | 29.300 |
| Dolomite | 0.532 | 0.532 | NA | NA | NA | 0.532 | 27.353 |
| Goethite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | NA | NA | NA | 0.000 | −1.904 |
| Maximum Microcline | 0.624 | 0.728 | NA | NA | NA | 0.000 | 5.081 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3* | Aquifer Zone 4* | Aquifer Zone 5* | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Muscovite | 0.135 | 0.109 | NA | NA | NA | 0.100 | 2.620 |
| Phlogopite | 0.000 | 0.000 | NA | NA | NA | −0.900 | −9.109 |
| Pyrite | −0.005 | −0.005 | NA | NA | NA | 0.000 | −0.001 |
| Quartz | 1.838 | 1.708 | NA | NA | NA | 0.000 | 8.060 |
| Rutile | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | NA | NA | NA | 0.000 | 0.000 |
| Siderite | 0.004 | 0.004 | NA | NA | NA | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | −2.27E-07 | −3.66E-07 | NA | NA | NA | −2.21E-08 | 0.00E+00 |
| $CaHCO_3^+$ | −3.82E-05 | −4.61E-05 | NA | NA | NA | −1.31E-06 | 4.83E-03 |
| $CO_2$ | 7.58E-01 | 7.60E-01 | NA | NA | NA | 1.23E+00 | 8.61E-01 |
| $CO_3^{2-}$ | 3.08E-06 | 3.08E-06 | NA | NA | NA | 1.35E-05 | 5.01E-07 |
| $FeCO_3$ | 4.69E-08 | 4.69E-08 | NA | NA | NA | 0.00E+00 | 1.55E-08 |
| $FeCO_3^+$ | 7.41E-18 | 7.41E-18 | NA | NA | NA | 0.00E+00 | 7.29E-18 |
| $FeHCO_3^+$ | 1.51E-04 | 1.51E-04 | NA | NA | NA | 0.00E+00 | 1.30E-04 |
| $HCO_3^-$ | 5.32E-02 | 5.33E-02 | NA | NA | NA | 1.65E-01 | 2.46E-02 |
| $MgCO_3$ | 6.58E-05 | 6.59E-05 | NA | NA | NA | 1.25E-04 | 0.00E+00 |
| $MgHCO_3^+$ | 1.02E-01 | 1.03E-01 | NA | NA | NA | 9.87E-02 | 1.68E-04 |
| $NaCO_3^-$ | 1.08E-07 | 1.08E-07 | NA | NA | NA | 9.57E-08 | 1.39E-08 |
| $NaHCO_3$ | 2.10E-02 | 2.10E-02 | NA | NA | NA | 6.95E-03 | 6.73E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | NA | NA | NA | 0.000 | −26.686 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.064 | 1.064 | NA | NA | NA | 1.064 | 54.706 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.004 | 0.004 | NA | NA | NA | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.068 | 1.068 | NA | NA | NA | 1.064 | 28.021 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.758 | 0.760 | NA | NA | NA | 1.233 | 0.861 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.177 | 0.177 | NA | NA | NA | 0.271 | 0.036 |
| Total $CO_2$, moles/kg $H_2O$ | 2.003 | 2.005 | NA | NA | NA | 2.568 | 28.918 |
| Water, $g/cm^3$ | 0.059 | 0.030 | 0.003 | 0.002 | 0.010 | 0.004 | 0.027 |
| Water, $kg/m^3$ | 58.934 | 30.156 | 3.082 | 2.495 | 9.650 | 3.779 | 27.439 |
| Mineral $CO_2$, $moles/m^3$ | 62.964 | 32.219 | NA | NA | NA | 4.021 | 768.864 |
| Dissolved $CO_2$, $moles/m^3$ | 44.668 | 22.908 | NA | NA | NA | 4.659 | 23.632 |
| Solution $CO_2$, $moles/m^3$ | 10.416 | 5.340 | NA | NA | NA | 1.024 | 1.000 |
| Total $CO_2$, $moles/m^3$ | 118.049 | 60.467 | NA | NA | NA | 9.703 | 793.496 |

* Calculation did not converge to a solution.

Continued…

**Table B-16. Summary of ND 7577 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3* | Aquifer<br>Zone 4* | Aquifer<br>Zone 5* | Aquifer<br>Zone 6 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$ft^3$ | 1.783 | 0.912 | NA | NA | NA | 0.114 | 21.772 |
| Dissolved $CO_2$, moles/$ft^3$ | 1.265 | 0.649 | NA | NA | NA | 0.132 | 0.669 |
| Solution $CO_2$, moles/$ft^3$ | 0.295 | 0.151 | NA | NA | NA | 0.029 | 0.028 |
| Total $CO_2$, moles/$ft^3$ | 3.343 | 1.712 | NA | NA | NA | 0.275 | 22.469 |
| Mineral $CO_2$, kg/$m^3$ | 2.771 | 1.418 | NA | NA | NA | 0.177 | 33.838 |
| Dissolved $CO_2$, kg/$m^3$ | 1.966 | 1.008 | NA | NA | NA | 0.205 | 1.040 |
| Solution $CO_2$, kg/$m^3$ | 0.458 | 0.235 | NA | NA | NA | 0.045 | 0.044 |
| Total $CO_2$, kg/$m^3$ | 5.195 | 2.661 | NA | NA | NA | 0.427 | 34.922 |
| Mineral $CO_2$, lb/$ft^3$ | 0.173 | 0.089 | NA | NA | NA | 0.011 | 2.112 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.123 | 0.063 | NA | NA | NA | 0.013 | 0.065 |
| Solution $CO_2$, lb/$ft^3$ | 0.029 | 0.015 | NA | NA | NA | 0.003 | 0.003 |
| Total $CO_2$, lb/$ft^3$ | 0.324 | 0.166 | NA | NA | NA | 0.027 | 2.180 |
| Weighted Average of Zones | | | | | | | |
| Total Thickness, m | 35.4 | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 2.432 | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.733 | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.404 | | | | | | |
| Total $CO_2$, kg/$m^3$ | 4.568 | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.152 | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.108 | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.025 | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.285 | | | | | | |

* Calculation did not converge to a solution.

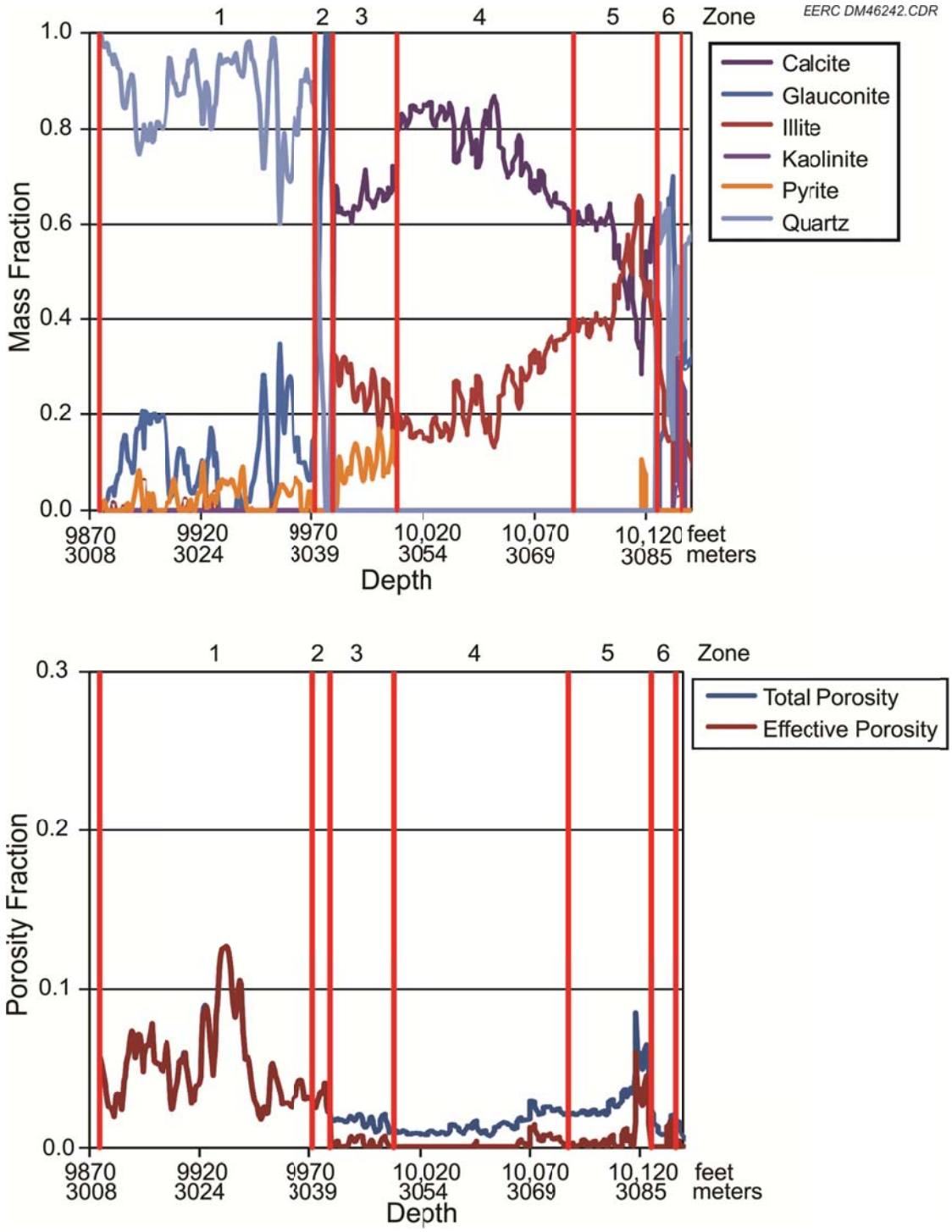



Figure B-2. ND 7577 mineral composition and porosity as a function of depth.

**ND 6436**

ND 6436 was previously discussed in the report; however, the summary is included in the appendix for the sake of completeness. Please note that the data presented in the main text tables were average data for the calculations whereas some of the data presented in this summary are specific to a zone within the well. The water composition was available along with the mineral composition for the ND 6436 well. Mineral data were available for the complete COSS thickness. The total COSS thickness is 176 feet (53.6 meters), with the well penetrating into the Precambrian.

Zones 1 and 6 are dominated by quartz, with a modest amount of kaolinite present. Zone 2 contains moderate amounts of muscovite and kaolinite, with modest amounts of illite and pyrite. This zone has exceptionally high pyrite content. The majority of the mineral content of Zone 3 is muscovite, with moderate amounts of kaolinite and quartz. Zones 4, 5, and 7 contain quartz, kaolinite, and muscovite, along with modest amounts of pyrite. The porosity ranges from 0.028 for Zones 4 and 5 to 0.146 for Zone 2.

The zones are similar in the interaction with $CO_2$. Small additional amounts of kaolinite and phlogophyte dissolve, with corresponding small increases in dolomite, quartz, and muscovite. Little or no siderite is formed. The amount of $CO_2$ dissolved in the formation water is approximately 0.8 moles/kg. Zones 1 and 2 also contain other aqueous species containing an equal amount of $CO_2$. The total average amount of $CO_2$ reacting with the minerals and formation water is 7.4 $kg/m^3$ (0.5 $lb/ft^3$) of formation rock.

## Table B-17. Average Mineral and Porosity Values for the ND 6436 Aquifer Zone

Well Name: ND 6436
API Identification: 33-075-00744-0000
State Identification: ND 6436

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 9380.5 | 2859.2 | Average | 0.082 | 0.073 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.013 | 0.003 | 0.143 | 0.065 | 0.066 | 0.704 | 0.000 |
| End | 9412.0 | 2868.8 | Minimum | 0.048 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.152 | 0.000 |
| Thickness | 31.5 | 9.6 | Maximum | 0.160 | 0.128 | 0.293 | 0.000 | 0.000 | 0.000 | 0.000 | 0.101 | 0.186 | 0.552 | 0.389 | 0.251 | 0.952 | 0.000 |
| Number of Values | 64 | | Standard deviation | 0.019 | 0.017 | 0.037 | 0.000 | 0.000 | 0.000 | 0.000 | 0.029 | 0.023 | 0.134 | 0.114 | 0.055 | 0.197 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 9412.0 | 2868.8 | Average | 0.169 | 0.146 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.175 | 0.000 | 0.256 | 0.316 | 0.170 | 0.083 | 0.000 |
| End | 9450.0 | 2880.4 | Minimum | 0.045 | 0.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.114 | 0.154 | 0.000 | 0.000 | 0.000 |
| Thickness | 38.0 | 11.6 | Maximum | 0.256 | 0.231 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.411 | 0.000 | 0.531 | 0.523 | 0.284 | 0.553 | 0.000 |
| Number of Values | 76 | | Standard deviation | 0.066 | 0.065 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.123 | 0.000 | 0.103 | 0.076 | 0.080 | 0.163 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 9450.0 | 2880.4 | Average | 0.078 | 0.068 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 | 0.050 | 0.156 | 0.616 | 0.002 | 0.169 | 0.000 |
| End | 9478.0 | 2888.9 | Minimum | 0.045 | 0.033 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.384 | 0.000 | 0.000 | 0.000 |
| Thickness | 28.0 | 8.5 | Maximum | 0.108 | 0.108 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.102 | 0.319 | 0.382 | 0.865 | 0.025 | 0.344 | 0.000 |
| Number of Values | 56 | | Standard deviation | 0.018 | 0.022 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.025 | 0.088 | 0.131 | 0.127 | 0.006 | 0.101 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 9478.0 | 2888.9 | Average | 0.052 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 | 0.221 | 0.290 | 0.058 | 0.428 | 0.000 |
| End | 9499.0 | 2895.3 | Minimum | 0.044 | 0.027 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.148 | 0.183 | 0.005 | 0.299 | 0.000 |
| Thickness | 21.0 | 6.4 | Maximum | 0.060 | 0.044 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.062 | 0.000 | 0.310 | 0.436 | 0.122 | 0.562 | 0.000 |
| Number of Values | 42 | | Standard deviation | 0.004 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.012 | 0.000 | 0.045 | 0.071 | 0.027 | 0.071 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 9499.0 | 2895.3 | Average | 0.061 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.365 | 0.261 | 0.111 | 0.260 | 0.000 |
| End | 9515.0 | 2900.2 | Minimum | 0.048 | 0.024 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.215 | 0.145 | 0.030 | 0.107 | 0.000 |
| Thickness | 16.0 | 4.9 | Maximum | 0.088 | 0.066 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.043 | 0.000 | 0.512 | 0.381 | 0.212 | 0.387 | 0.000 |
| Number of Values | 32 | | Standard deviation | 0.008 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.009 | 0.000 | 0.078 | 0.072 | 0.062 | 0.075 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 9515.0 | 2900.2 | Average | 0.093 | 0.082 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.024 | 0.004 | 0.166 | 0.090 | 0.040 | 0.676 | 0.000 |
| End | 9546.0 | 2909.6 | Minimum | 0.036 | 0.024 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.332 | 0.000 |
| Thickness | 31.0 | 9.4 | Maximum | 0.157 | 0.157 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.285 | 0.105 | 0.442 | 0.442 | 0.174 | 0.980 | 0.000 |
| Number of Values | 62 | | Standard deviation | 0.031 | 0.035 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.064 | 0.019 | 0.123 | 0.122 | 0.046 | 0.155 | 0.000 |

Continued. . .

## Table B-17. Average Mineral and Porosity Values for the ND 6436 Aquifer Zone (continued)

| Depth | Feet | Meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 9546.5 | 2909.8 | Average | 0.081 | 0.059 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 | 0.344 | 0.298 | 0.126 | 0.228 | 0.000 |
| End | 9557.0 | 2913.0 | Minimum | 0.047 | 0.028 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.241 | 0.059 | 0.033 | 0.000 |
| Thickness | 11.0 | 3.4 | Maximum | 0.176 | 0.173 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.069 | 0.000 | 0.563 | 0.446 | 0.221 | 0.387 | 0.000 |
| Number of Values | 22 | | Standard deviation | 0.032 | 0.035 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.015 | 0.000 | 0.124 | 0.049 | 0.048 | 0.105 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 9380.5 | 2859.2 | Average | 0.096 | 0.081 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.046 | 0.009 | 0.215 | 0.269 | 0.080 | 0.379 | 0.000 |
| End | 9557.0 | 2913.0 | Minimum | 0.036 | 0.024 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 176.5 | 53.8 | Maximum | 0.256 | 0.231 | 0.293 | 0.000 | 0.000 | 0.000 | 0.000 | 0.411 | 0.319 | 0.563 | 0.865 | 0.284 | 0.980 | 0.000 |
| Number of Values | 354 | | Standard deviation | 0.054 | 0.052 | 0.016 | 0.000 | 0.000 | 0.000 | 0.000 | 0.094 | 0.041 | 0.133 | 0.207 | 0.078 | 0.289 | 0.000 |

## Table B-18. Summary of Dueree Aquifer and Cap Rock Minerals and Conditions

Well Name: ND 6436
API Identification: 33-075-00744-0000
State Identification: ND 6436

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total | Cap Rock Zone 1 | Cap Rock Zone 2 | Cap Rock Zone 3 | Cap Rock Zone 4 | Cap Rock Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, ft | 9380.5 | 9412.0 | 9450.0 | 9478.0 | 9499.0 | 9515.0 | 9546.0 | 9380.5 | 9254.0 | 9315.0 | 9329.0 | 9354.0 | 9254.0 |
| End, ft | 9412.0 | 9450.0 | 9478.0 | 9499.0 | 9515.0 | 9546.0 | 9557.0 | 9557.0 | 9315.0 | 9329.0 | 9354.0 | 9380.0 | 9380.0 |
| Thickness, ft | 31.5 | 38.0 | 28.0 | 21.0 | 16.0 | 31.0 | 11.0 | 176.5 | 61.0 | 14.0 | 25.0 | 26.0 | 126.0 |
| Start, m | 2859.2 | 2868.8 | 2880.4 | 2888.9 | 2895.3 | 2900.2 | 2909.6 | 2859.2 | 2820.6 | 2839.2 | 2843.5 | 2851.1 | 2820.6 |
| End, m | 2868.8 | 2880.4 | 2888.9 | 2895.3 | 2900.2 | 2909.6 | 2913.0 | 2913.0 | 2839.2 | 2843.5 | 2851.1 | 2859.0 | 2859.0 |
| Thickness, m | 9.6 | 11.6 | 8.5 | 6.4 | 4.9 | 9.4 | 3.4 | 53.8 | 18.6 | 4.3 | 7.6 | 7.9 | 38.4 |
| Temperature, °F | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 | 188.0 |
| Temperature, °C | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 | 86.7 |
| Pressure, psi | 5987 | 5993 | 5999 | 6003 | 6006 | 6010 | 6014 | 5999 | 5967 | 5973 | 5977 | 5981 | 5973 |
| Pressure, kPa | 41,276 | 41,318 | 41,358 | 41,388 | 414,11 | 41,439 | 41,465 | 41,364 | 41,140 | 41,186 | 41,209 | 41,240 | 41,179 |
| Effective Porosity, fraction | 0.073 | 0.146 | 0.068 | 0.038 | 0.038 | 0.082 | 0.059 | 0.081 | 0.123 | 0.143 | 0.136 | 0.148 | 0.133 |
| Mass Fraction | | | | | | | | | | | | | |
| Biotite | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Glauconite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.013 | 0.175 | 0.007 | 0.003 | 0.002 | 0.024 | 0.003 | 0.046 | 0.239 | 0.229 | 0.177 | 0.101 | 0.197 |
| K-Feldspar | 0.003 | 0.000 | 0.050 | 0.000 | 0.000 | 0.004 | 0.000 | 0.009 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.143 | 0.256 | 0.156 | 0.221 | 0.365 | 0.166 | 0.344 | 0.215 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.065 | 0.316 | 0.616 | 0.290 | 0.261 | 0.090 | 0.298 | 0.269 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.066 | 0.170 | 0.002 | 0.058 | 0.111 | 0.040 | 0.126 | 0.080 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.704 | 0.083 | 0.169 | 0.428 | 0.260 | 0.676 | 0.228 | 0.379 | 0.132 | 0.196 | 0.250 | 0.125 | 0.161 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.629 | 0.575 | 0.573 | 0.773 | 0.641 |

## Table B-19. Summary of ND 6436 Aquifer Calculation Results

Well Name: ND 6436
API Index: 33-075-00744-0000
State Identification: ND 6436

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Start, m | 2859.2 | 2868.8 | 2880.4 | 2888.9 | 2895.3 | 2900.2 | 2909.6 | 2859.2 |
| End, m | 2868.8 | 2880.4 | 2888.9 | 2895.3 | 2900.2 | 2909.6 | 2913.0 | 2913.0 |
| Thickness, m | 9.6 | 11.6 | 8.5 | 6.4 | 4.9 | 9.4 | 3.4 | 53.8 |
| Start, ft | 9380.5 | 9412.0 | 9450.0 | 9478.0 | 9499.0 | 9515.0 | 9546.0 | 9380.5 |
| End, ft | 9412.0 | 9450.0 | 9478.0 | 9499.0 | 9515.0 | 9546.0 | 9557.0 | 9557.0 |
| Thickness, ft | 31.5 | 38.0 | 28.0 | 21.0 | 16.0 | 31.0 | 11.0 | 176.5 |
| **Minerals Without $CO_2$** | | | | | | | | |
| pH | 5.847 | 5.843 | 5.860 | 5.847 | 5.847 | 5.847 | 5.847 | 5.847 |
| pE | –2.382 | –2.376 | –2.399 | –2.381 | –2.382 | –2.382 | –2.382 | –2.382 |
| Activity | 0.847 | 0.842 | 0.861 | 0.847 | 0.847 | 0.847 | 0.847 | 0.847 |
| Ionic Strength | 4.334 | 4.445 | 4.039 | 4.343 | 4.342 | 4.337 | 4.341 | 4.334 |
| Total Solution $CO_2$, moles | 2.321E-04 | 2.414E-04 | 2.089E-04 | 2.329E-04 | 2.328E-04 | 2.324E-04 | 2.327E-04 | 2.321E-04 |
| Solution, moles | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |
| Ca | 0.5320 | 0.5320 | 0.5320 | 0.5320 | 0.5320 | 0.5320 | 0.5320 | 0.5320 |
| Cl | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0015 | 0.0014 | 0.0016 | 0.0015 | 0.0015 | 0.0015 | 0.0015 | 0.0015 |
| Mg | 0.2409 | 0.2409 | 0.2408 | 0.2409 | 0.2409 | 0.2409 | 0.2409 | 0.2409 |
| Na | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 |
| S | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 |
| Si | 0.0007 | 0.0007 | 0.0008 | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Illite | 1.248 | 8.330 | 0.730 | 0.562 | 0.455 | 1.927 | 0.387 | 3.912 |
| K-Feldspar | 0.373 | 0.000 | 6.795 | 0.000 | 0.000 | 0.493 | 0.000 | 1.084 |
| Kaolinite | 19.800 | 18.080 | 22.650 | 60.840 | 104.700 | 19.640 | 62.920 | 27.060 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 5.855 | 14.430 | 57.840 | 51.580 | 48.390 | 6.879 | 35.300 | 21.910 |
| Phlogopite | 0.389 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.064 |
| Pyrite | 19.650 | 25.820 | 0.568 | 34.320 | 68.620 | 10.120 | 49.670 | 21.770 |
| Quartz | 418.100 | 25.090 | 105.100 | 504.700 | 319.800 | 344.100 | 178.900 | 204.400 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 19.520 | 20.540 | 15.780 | 60.710 | 104.500 | 19.470 | 62.730 | 26.960 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 7.097 | 18.960 | 65.230 | 52.100 | 48.850 | 8.594 | 35.730 | 25.240 |
| Phlogopite | 0.461 | 0.662 | 0.029 | 0.015 | 0.006 | 0.128 | 0.000 | 0.358 |
| Pyrite | 19.650 | 25.820 | 0.567 | 34.320 | 68.620 | 10.120 | 49.670 | 21.770 |
| Quartz | 420.200 | 33.760 | 119.500 | 505.300 | 320.300 | 347.100 | 179.400 | 210.700 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –1.248 | –8.330 | –0.730 | –0.562 | –0.455 | –1.927 | –0.387 | –3.912 |
| K-Feldspar | –0.373 | 0.000 | –6.795 | 0.000 | 0.000 | –0.493 | 0.000 | –1.084 |
| Kaolinite | –0.279 | 2.454 | –6.874 | –0.135 | –0.171 | –0.173 | –0.193 | –0.102 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 1.243 | 4.529 | 7.398 | 0.516 | 0.461 | 1.715 | 0.426 | 3.331 |
| Phlogopite | 0.072 | 0.662 | 0.029 | 0.015 | 0.006 | 0.128 | 0.000 | 0.294 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 2.098 | 8.672 | 14.410 | 0.645 | 0.534 | 3.042 | 0.464 | 6.274 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 1.15E-06 | 1.20E-06 | 1.02E-06 | 1.15E-06 | 1.15E-06 | 1.15E-06 | 1.15E-06 | 1.15E-06 |
| $CaHCO_3^+$ | 5.83E-05 | 6.09E-05 | 5.15E-05 | 5.85E-05 | 5.85E-05 | 5.83E-05 | 5.84E-05 | 5.83E-05 |
| $CO_2$ | 5.95E-05 | 6.13E-05 | 5.51E-05 | 5.97E-05 | 5.96E-05 | 5.96E-05 | 5.96E-05 | 5.95E-05 |
| $CO_3^{2-}$ | 1.89E-08 | 1.91E-08 | 1.82E-08 | 1.89E-08 | 1.89E-08 | 1.89E-08 | 1.89E-08 | 1.89E-08 |
| $FeCO_3$ | 1.72E-11 | 1.66E-11 | 1.87E-11 | 1.71E-11 | 1.72E-11 | 1.72E-11 | 1.72E-11 | 1.72E-11 |
| $FeCO_3^+$ | 2.42E-22 | 2.36E-22 | 2.59E-22 | 2.42E-22 | 2.42E-22 | 2.42E-22 | 2.42E-22 | 2.42E-22 |
| $FeHCO_3^+$ | 6.71E-09 | 6.51E-09 | 7.25E-09 | 6.69E-09 | 6.70E-09 | 6.71E-09 | 6.70E-09 | 6.71E-09 |
| $HCO_3^-$ | 4.58E-05 | 4.67E-05 | 4.35E-05 | 4.59E-05 | 4.59E-05 | 4.58E-05 | 4.59E-05 | 4.58E-05 |
| $MgCO_3$ | 1.66E-07 | 1.74E-07 | 1.45E-07 | 1.66E-07 | 1.66E-07 | 1.66E-07 | 1.66E-07 | 1.66E-07 |
| $MgHCO_3^+$ | 3.12E-05 | 3.28E-05 | 2.72E-05 | 3.13E-05 | 3.13E-05 | 3.12E-05 | 3.13E-05 | 3.12E-05 |
| $NaCO_3^-$ | 2.54E-09 | 2.65E-09 | 2.26E-09 | 2.55E-09 | 2.54E-09 | 2.54E-09 | 2.54E-09 | 2.54E-09 |
| $NaHCO_3$ | 3.60E-05 | 3.84E-05 | 3.04E-05 | 3.62E-05 | 3.62E-05 | 3.61E-05 | 3.62E-05 | 3.60E-05 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 5.952E-05 | 6.125E-05 | 5.509E-05 | 5.966E-05 | 5.964E-05 | 5.957E-05 | 5.963E-05 | 5.952E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 1.726E-04 | 1.801E-04 | 1.538E-04 | 1.732E-04 | 1.731E-04 | 1.728E-04 | 1.731E-04 | 1.726E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 2.321E-04 | 2.414E-04 | 2.089E-04 | 2.329E-04 | 2.328E-04 | 2.324E-04 | 2.327E-04 | 2.321E-04 |
| Water, g/cm$^3$ | 0.073 | 0.146 | 0.068 | 0.038 | 0.038 | 0.082 | 0.059 | 0.081 |
| Water, kg/m$^3$ | 72.557 | 145.663 | 68.207 | 38.142 | 38.133 | 82.031 | 59.322 | 81.206 |
| Mineral $CO_2$, moles/m$^3$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, moles/m$^3$ | 4.319E-03 | 8.922E-03 | 3.758E-03 | 2.276E-03 | 2.274E-03 | 4.887E-03 | 3.537E-03 | 4.833E-03 |
| Solution $CO_2$, moles/m$^3$ | 1.252E-02 | 2.624E-02 | 1.049E-02 | 6.607E-03 | 6.602E-03 | 1.418E-02 | 1.027E-02 | 1.402E-02 |
| Total $CO_2$, moles/m$^3$ | 1.684E-02 | 3.516E-02 | 1.425E-02 | 8.882E-03 | 8.876E-03 | 1.906E-02 | 1.380E-02 | 1.885E-02 |
| Mineral $CO_2$, moles/ft$^3$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, moles/ft$^3$ | 1.223E-04 | 2.526E-04 | 1.064E-04 | 6.444E-05 | 6.440E-05 | 1.384E-04 | 1.002E-04 | 1.369E-04 |
| Solution $CO_2$, moles/ft$^3$ | 3.546E-04 | 7.429E-04 | 2.970E-04 | 1.871E-04 | 1.869E-04 | 4.014E-04 | 2.907E-04 | 3.969E-04 |
| Total $CO_2$, moles/ft$^3$ | 4.769E-04 | 9.956E-04 | 4.034E-04 | 2.515E-04 | 2.513E-04 | 5.398E-04 | 3.909E-04 | 5.338E-04 |
| Mineral $CO_2$, kg/m$^3$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, kg/m$^3$ | 1.901E-04 | 3.927E-04 | 1.654E-04 | 1.001E-04 | 1.001E-04 | 2.151E-04 | 1.557E-04 | 2.127E-04 |
| Solution $CO_2$, kg/m$^3$ | 5.512E-04 | 1.155E-03 | 4.617E-04 | 2.908E-04 | 2.905E-04 | 6.238E-04 | 4.518E-04 | 6.168E-04 |
| Total $CO_2$, kg/m$^3$ | 7.412E-04 | 1.547E-03 | 6.270E-04 | 3.909E-04 | 3.906E-04 | 8.389E-04 | 6.075E-04 | 8.296E-04 |
| Mineral $CO_2$, lb/ft$^3$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, lb/ft$^3$ | 1.187E-05 | 2.451E-05 | 1.032E-05 | 6.252E-06 | 6.248E-06 | 1.343E-05 | 9.719E-06 | 1.328E-05 |
| Solution $CO_2$, lb/ft$^3$ | 3.441E-05 | 7.208E-05 | 2.882E-05 | 1.815E-05 | 1.814E-05 | 3.895E-05 | 2.821E-05 | 3.851E-05 |
| Total $CO_2$, lb/ft$^3$ | 4.627E-05 | 9.660E-05 | 3.914E-05 | 2.440E-05 | 2.439E-05 | 5.237E-05 | 3.793E-05 | 5.179E-05 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 53.8 | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 0.000E+00 | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 2.132E-04 | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 6.189E-04 | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 8.320E-04 | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.000E+00 | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 1.331E-05 | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 3.863E-05 | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 5.194E-05 | | | | | | | |

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**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | | |
| pH | 5.240 | 5.615 | 3.929 | 3.916 | 3.919 | 3.906 | 3.921 | 4.342 |
| pE | –1.410 | –1.817 | 0.002 | 0.015 | 0.012 | 0.021 | 0.011 | –0.440 |
| Activity | 0.826 | 0.809 | 0.845 | 0.831 | 0.831 | 0.832 | 0.831 | 0.833 |
| Ionic Strength | 4.408 | 4.749 | 4.032 | 4.342 | 4.343 | 4.306 | 4.344 | 4.262 |
| Total Solution $CO_2$, moles | 1.323 | 2.006 | 0.839 | 0.804 | 0.804 | 0.809 | 0.806 | 0.859 |
| Solution, moles | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.3860 | 2.0710 | 0.9436 | 0.8063 | 0.8071 | 0.8168 | 0.8086 | 0.8793 |
| Ca | 0.0000 | 0.0000 | 0.4628 | 0.4868 | 0.5005 | 0.3153 | 0.5091 | 0.0032 |
| Cl | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 |
| Fe | 0.0004 | 0.0001 | 0.0008 | 0.0007 | 0.0007 | 0.0008 | 0.0007 | 0.0019 |
| K | 0.0058 | 0.0022 | 0.1356 | 0.1206 | 0.1198 | 0.1246 | 0.1193 | 0.0464 |
| Mg | 1.0910 | 1.5090 | 0.2576 | 0.2396 | 0.2264 | 0.4092 | 0.2181 | 0.7855 |
| Na | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 |
| S | 0.0393 | 0.1154 | 0.0023 | 0.0022 | 0.0022 | 0.0025 | 0.0022 | 0.0046 |
| Si | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 1.248 | 8.330 | 0.730 | 0.562 | 0.455 | 1.927 | 0.387 | 3.912 |
| K-Feldspar | 0.373 | 0.000 | 6.795 | 0.000 | 0.000 | 0.493 | 0.000 | 1.084 |
| Kaolinite | 19.800 | 18.080 | 22.650 | 60.840 | 104.700 | 19.640 | 62.920 | 27.060 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 5.855 | 14.430 | 57.840 | 51.580 | 48.390 | 6.879 | 35.300 | 21.910 |
| Phlogopite | 0.389 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.064 |
| Pyrite | 19.650 | 25.820 | 0.568 | 34.320 | 68.620 | 10.120 | 49.670 | 21.770 |
| Quartz | 418.100 | 25.090 | 105.100 | 504.700 | 319.800 | 344.100 | 178.900 | 204.400 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 297.500 | 296.800 | 298.900 | 299.100 | 299.100 | 298.700 | 299.100 | 298.100 |
| Dolomite | 0.532 | 0.532 | 0.069 | 0.045 | 0.032 | 0.217 | 0.023 | 0.529 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 19.060 | 19.940 | 15.950 | 60.870 | 104.700 | 19.520 | 62.900 | 26.670 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 7.554 | 19.550 | 65.130 | 51.990 | 48.740 | 8.599 | 35.610 | 25.550 |
| Phlogopite | 0.000 | 0.062 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 19.630 | 25.760 | 0.567 | 34.320 | 68.620 | 10.120 | 49.670 | 21.760 |
| Quartz | 421.100 | 34.960 | 119.600 | 505.400 | 320.400 | 347.400 | 179.400 | 211.400 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.019 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | –2.469 | –3.192 | –1.082 | –0.896 | –0.870 | –1.250 | –0.854 | –1.937 |
| Dolomite | 0.532 | 0.532 | 0.069 | 0.045 | 0.032 | 0.217 | 0.023 | 0.529 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –1.248 | –8.330 | –0.730 | –0.562 | –0.455 | –1.927 | -0.387 | –3.912 |
| K-Feldspar | –0.373 | 0.000 | –6.795 | 0.000 | 0.000 | –0.493 | 0.000 | –1.084 |
| Kaolinite | –0.733 | 1.856 | –6.701 | 0.029 | 0.001 | –0.117 | –0.016 | –0.392 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 1.699 | 5.129 | 7.293 | 0.412 | 0.348 | 1.720 | 0.308 | 3.644 |
| Phlogopite | –0.389 | 0.062 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.064 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Pyrite | –0.019 | –0.057 | –0.001 | –0.001 | –0.001 | –0.001 | –0.001 | –0.002 |
| Quartz | 3.020 | 9.872 | 14.470 | 0.674 | 0.545 | 3.299 | 0.464 | 6.990 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.019 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 1.31E-09 | 2.33E-10 | 1.73E-06 | 1.83E-06 | 1.90E-06 | 1.13E-06 | 1.96E-06 | 8.24E-08 |
| $CaHCO_3^+$ | 2.68E-07 | 1.96E-08 | 7.47E-03 | 7.91E-03 | 8.20E-03 | 5.00E-03 | 8.39E-03 | 1.35E-04 |
| $CO_2$ | 7.69E-01 | 7.32E-01 | 8.14E-01 | 7.79E-01 | 7.79E-01 | 7.84E-01 | 7.81E-01 | 7.87E-01 |
| $CO_3^{2-}$ | 1.46E-05 | 7.96E-05 | 3.61E-08 | 3.33E-08 | 3.38E-08 | 3.19E-08 | 3.41E-08 | 2.37E-07 |
| $FeCO_3$ | 1.34E-07 | 1.34E-07 | 2.02E-09 | 1.50E-09 | 1.51E-09 | 1.67E-09 | 1.52E-09 | 2.56E-08 |
| $FeCO_3^+$ | 1.76E-17 | 6.69E-18 | 7.05E-18 | 5.28E-18 | 5.28E-18 | 5.97E-18 | 5.28E-18 | 3.17E-17 |
| $FeHCO_3^+$ | 2.10E-04 | 8.62E-05 | 6.69E-05 | 5.01E-05 | 5.00E-05 | 5.72E-05 | 5.00E-05 | 3.22E-04 |
| $HCO_3^-$ | 1.43E-01 | 3.24E-01 | 7.39E-03 | 6.90E-03 | 6.95E-03 | 6.77E-03 | 6.99E-03 | 1.85E-02 |
| $MgCO_3$ | 3.98E-04 | 2.23E-03 | 3.01E-07 | 2.85E-07 | 2.73E-07 | 4.63E-07 | 2.66E-07 | 6.31E-06 |
| $MgHCO_3^+$ | 3.01E-01 | 6.92E-01 | 4.82E-03 | 4.58E-03 | 4.36E-03 | 7.63E-03 | 4.22E-03 | 3.83E-02 |
| $NaCO_3^-$ | 1.89E-06 | 1.02E-05 | 4.49E-09 | 4.49E-09 | 4.56E-09 | 4.28E-09 | 4.60E-09 | 3.15E-08 |
| $NaHCO_3$ | 1.09E-01 | 2.55E-01 | 5.15E-03 | 5.44E-03 | 5.49E-03 | 5.29E-03 | 5.52E-03 | 1.42E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.064 | 1.064 | 0.138 | 0.090 | 0.063 | 0.433 | 0.046 | 1.058 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.019 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.083 | 1.121 | 0.138 | 0.090 | 0.063 | 0.433 | 0.046 | 1.058 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.769 | 0.732 | 0.814 | 0.779 | 0.779 | 0.784 | 0.781 | 0.787 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.554 | 1.274 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.072 |
| Total $CO_2$, moles/kg $H_2O$ | 2.406 | 3.127 | 0.977 | 0.894 | 0.867 | 1.242 | 0.852 | 1.916 |
| Water, g/cm$^3$ | 0.073 | 0.146 | 0.068 | 0.038 | 0.038 | 0.082 | 0.059 | 0.081 |
| Water, kg/m$^3$ | 72.557 | 145.663 | 68.207 | 38.142 | 38.133 | 82.031 | 59.322 | 81.206 |
| Mineral $CO_2$, moles/m$^3$ | 78.571 | 163.313 | 9.440 | 3.449 | 2.407 | 35.552 | 2.723 | 85.883 |
| Dissolved $CO_2$, moles/m$^3$ | 55.760 | 106.684 | 55.527 | 29.705 | 29.717 | 64.329 | 46.307 | 63.933 |
| Solution $CO_2$, moles/m$^3$ | 40.213 | 185.517 | 1.698 | 0.949 | 0.955 | 2.031 | 1.493 | 5.808 |
| Total $CO_2$, moles/m$^3$ | 174.544 | 455.514 | 66.665 | 34.103 | 33.079 | 101.912 | 50.523 | 155.625 |
| Mineral $CO_2$, moles/ft$^3$ | 2.225 | 4.625 | 0.267 | 0.098 | 0.068 | 1.007 | 0.077 | 2.432 |
| Dissolved $CO_2$, moles/ft$^3$ | 1.579 | 3.021 | 1.572 | 0.841 | 0.842 | 1.822 | 1.311 | 1.810 |
| Solution $CO_2$, moles/ft$^3$ | 1.139 | 5.253 | 0.048 | 0.027 | 0.027 | 0.058 | 0.042 | 0.164 |
| Total $CO_2$, moles/ft$^3$ | 4.943 | 12.899 | 1.888 | 0.966 | 0.937 | 2.886 | 1.431 | 4.407 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, kg/m$^3$ | 3.458 | 7.187 | 0.415 | 0.152 | 0.106 | 1.565 | 0.120 | 3.780 |
| Dissolved $CO_2$, kg/m$^3$ | 2.454 | 4.695 | 2.444 | 1.307 | 1.308 | 2.831 | 2.038 | 2.814 |
| Solution $CO_2$, kg/m$^3$ | 1.770 | 8.165 | 0.075 | 0.042 | 0.042 | 0.089 | 0.066 | 0.256 |
| Total $CO_2$, kg/m$^3$ | 7.682 | 20.047 | 2.934 | 1.501 | 1.456 | 4.485 | 2.224 | 6.849 |
| Mineral $CO_2$, lb/ft$^3$ | 0.216 | 0.449 | 0.026 | 0.009 | 0.007 | 0.098 | 0.007 | 0.236 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.153 | 0.293 | 0.153 | 0.082 | 0.082 | 0.177 | 0.127 | 0.176 |
| Solution $CO_2$, lb/ft$^3$ | 0.110 | 0.510 | 0.005 | 0.003 | 0.003 | 0.006 | 0.004 | 0.016 |
| Total $CO_2$, lb/ft$^3$ | 0.480 | 1.251 | 0.183 | 0.094 | 0.091 | 0.280 | 0.139 | 0.428 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 53.8 | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 2.540 | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 2.735 | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 2.114 | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 7.389 | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.159 | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.171 | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.132 | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 0.461 | | | | | | | |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | |
| pH | –0.607 | –0.228 | –1.931 | –1.931 | –1.928 | –1.941 | –1.926 | –1.505 |
| pE | 0.972 | 0.559 | 2.401 | 2.396 | 2.394 | 2.403 | 2.393 | 1.942 |
| Activity | –0.021 | –0.033 | –0.016 | –0.016 | –0.016 | –0.015 | –0.016 | –0.014 |
| Ionic Strength | 0.074 | 0.304 | –0.007 | –0.001 | 0.001 | –0.031 | 0.003 | –0.072 |
| Total Solution $CO_2$,moles | 1.323 | 2.006 | 0.839 | 0.803 | 0.804 | 0.809 | 0.806 | 0.859 |
| Solution, moles | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.386 | 2.071 | 0.943 | 0.806 | 0.807 | 0.817 | 0.808 | 0.879 |
| Ca | –0.532 | –0.532 | –0.069 | –0.045 | –0.032 | –0.217 | –0.023 | –0.529 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 |
| K | 0.004 | 0.001 | 0.134 | 0.119 | 0.118 | 0.123 | 0.118 | 0.045 |
| Mg | 0.850 | 1.268 | 0.017 | –0.001 | –0.015 | 0.168 | –0.023 | 0.545 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.038 | 0.115 | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 | 0.004 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 298.100 | 298.100 | 298.100 | 298.100 | 298.100 | 298.100 | 298.100 | 298.100 |
| Dolomite | 0.532 | 0.532 | 0.069 | 0.045 | 0.032 | 0.217 | 0.023 | 0.529 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.460 | −0.600 | 0.170 | 0.160 | 0.200 | 0.050 | 0.170 | –0.290 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.457 | 0.590 | –0.100 | –0.110 | –0.110 | 0.005 | –0.120 | 0.310 |
| Phlogopite | –0.461 | –0.600 | –0.029 | –0.015 | –0.006 | –0.128 | 0.000 | –0.358 |
| Pyrite | –0.020 | –0.060 | –0.001 | 0.000 | 0.000 | 0.000 | 0.000 | –0.010 |
| Quartz | 0.900 | 1.200 | 0.100 | 0.100 | 0.100 | 0.300 | 0.000 | 0.700 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.019 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 2.469 | 3.192 | 1.082 | 0.896 | 0.870 | 1.250 | 0.854 | 1.937 |
| Dolomite | 0.532 | 0.532 | 0.069 | 0.045 | 0.032 | 0.217 | 0.023 | 0.529 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | –0.454 | –0.598 | 0.173 | 0.164 | 0.172 | 0.056 | 0.177 | –0.290 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.456 | 0.600 | –0.105 | –0.105 | –0.113 | 0.005 | –0.118 | 0.313 |
| Phlogopite | –0.461 | –0.600 | –0.029 | –0.015 | –0.006 | –0.128 | 0.000 | –0.358 |
| Pyrite | –0.019 | –0.057 | –0.001 | –0.001 | –0.001 | –0.001 | –0.001 | –0.002 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Quartz | 0.922 | 1.200 | 0.060 | 0.029 | 0.011 | 0.257 | 0.000 | 0.716 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.019 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | –1.14E-06 | –1.20E-06 | 7.09E-07 | 6.75E-07 | 7.54E-07 | –2.30E-08 | 8.07E-07 | –1.06E-06 |
| $CaHCO_3^+$ | –5.80E-05 | –6.09E-05 | 7.42E-03 | 7.85E-03 | 8.14E-03 | 4.95E-03 | 8.33E-03 | 7.68E-05 |
| $CO_2$ | 7.68E-01 | 7.32E-01 | 8.14E-01 | 7.79E-01 | 7.79E-01 | 7.84E-01 | 7.81E-01 | 7.87E-01 |
| $CO_3^{2-}$ | 1.46E-05 | 7.96E-05 | 1.79E-08 | 1.44E-08 | 1.49E-08 | 1.30E-08 | 1.53E-08 | 2.18E-07 |
| $FeCO_3$ | 1.34E-07 | 1.34E-07 | 2.00E-09 | 1.49E-09 | 1.49E-09 | 1.65E-09 | 1.50E-09 | 2.56E-08 |
| $FeCO_3^+$ | 1.76E-17 | 6.69E-18 | 7.05E-18 | 5.28E-18 | 5.28E-18 | 5.97E-18 | 5.28E-18 | 3.17E-17 |
| $FeHCO_3^+$ | 2.10E-04 | 8.62E-05 | 6.69E-05 | 5.01E-05 | 5.00E-05 | 5.72E-05 | 5.00E-05 | 3.22E-04 |
| $HCO_3^-$ | 1.43E-01 | 3.24E-01 | 7.34E-03 | 6.85E-03 | 6.90E-03 | 6.73E-03 | 6.95E-03 | 1.85E-02 |
| $MgCO_3$ | 3.97E-04 | 2.23E-03 | 1.56E-07 | 1.19E-07 | 1.07E-07 | 2.97E-07 | 9.99E-08 | 6.15E-06 |
| $MgHCO_3^+$ | 3.01E-01 | 6.92E-01 | 4.79E-03 | 4.55E-03 | 4.33E-03 | 7.60E-03 | 4.19E-03 | 3.83E-02 |
| $MgHCO_3^+$ | 3.01E-01 | 6.92E-01 | 4.79E-03 | 4.55E-03 | 4.33E-03 | 7.60E-03 | 4.19E-03 | 3.83E-02 |
| $NaCO_3^-$ | 1.88E-06 | 1.02E-05 | 2.23E-09 | 1.95E-09 | 2.01E-09 | 1.74E-09 | 2.06E-09 | 2.89E-08 |
| $NaHCO_3$ | 1.09E-01 | 2.55E-01 | 5.12E-03 | 5.41E-03 | 5.45E-03 | 5.26E-03 | 5.48E-03 | 1.42E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.064 | 1.064 | 0.138 | 0.090 | 0.063 | 0.433 | 0.046 | 1.058 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.019 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.083 | 1.121 | 0.138 | 0.090 | 0.063 | 0.433 | 0.046 | 1.058 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.768 | 0.732 | 0.814 | 0.779 | 0.779 | 0.784 | 0.781 | 0.787 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.554 | 1.273 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.071 |
| Total $CO_2$, moles/kg$H_2O$ | 2.405 | 3.127 | 0.977 | 0.894 | 0.867 | 1.242 | 0.851 | 1.916 |
| Water, g/$cm^3$ | 0.073 | 0.146 | 0.068 | 0.038 | 0.038 | 0.082 | 0.059 | 0.081 |
| Water, kg/$m^3$ | 72.557 | 145.663 | 68.207 | 38.142 | 38.133 | 82.031 | 59.322 | 81.206 |
| Mineral $CO_2$, moles/$m^3$ | 78.571 | 163.313 | 9.440 | 3.449 | 2.407 | 35.552 | 2.723 | 85.883 |
| Dissolved $CO_2$, moles/$m^3$ | 55.756 | 106.675 | 55.524 | 29.703 | 29.715 | 64.324 | 46.303 | 63.929 |
| Solution $CO_2$, moles/$m^3$ | 40.200 | 185.491 | 1.688 | 0.942 | 0.948 | 2.017 | 1.483 | 5.794 |
| Total $CO_2$, moles/$m^3$ | 174.528 | 455.479 | 66.651 | 34.094 | 33.070 | 101.893 | 50.509 | 155.606 |
| Mineral $CO_2$, moles/$ft^3$ | 2.225 | 4.625 | 0.267 | 0.098 | 0.068 | 1.007 | 0.077 | 2.432 |
| Dissolved $CO_2$, moles/$ft^3$ | 1.579 | 3.021 | 1.572 | 0.841 | 0.841 | 1.821 | 1.311 | 1.810 |
| Solution $CO_2$, moles/$ft^3$ | 1.138 | 5.253 | 0.048 | 0.027 | 0.027 | 0.057 | 0.042 | 0.164 |
| Total $CO_2$, moles/$ft^3$ | 4.942 | 12.898 | 1.887 | 0.965 | 0.936 | 2.885 | 1.430 | 4.406 |

Continued…

**Table B-19. Summary of ND 6436 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, kg/m$^3$ | 3.458 | 7.187 | 0.415 | 0.152 | 0.106 | 1.565 | 0.120 | 3.780 |
| Dissolved $CO_2$, kg/m$^3$ | 2.454 | 4.695 | 2.444 | 1.307 | 1.308 | 2.831 | 2.038 | 2.813 |
| Solution $CO_2$, kg/m$^3$ | 1.769 | 8.163 | 0.074 | 0.041 | 0.042 | 0.089 | 0.065 | 0.255 |
| Total $CO_2$, kg/m$^3$ | 7.681 | 20.046 | 2.933 | 1.500 | 1.455 | 4.484 | 2.223 | 6.848 |
| Mineral $CO_2$, lb/ft$^3$ | 0.216 | 0.449 | 0.026 | 0.009 | 0.007 | 0.098 | 0.007 | 0.236 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.153 | 0.293 | 0.153 | 0.082 | 0.082 | 0.177 | 0.127 | 0.176 |
| Solution $CO_2$, lb/ft$^3$ | 0.110 | 0.510 | 0.005 | 0.003 | 0.003 | 0.006 | 0.004 | 0.016 |
| Total $CO_2$, lb/ft$^3$ | 0.480 | 1.251 | 0.183 | 0.094 | 0.091 | 0.280 | 0.139 | 0.428 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 53.8 | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 2.540 | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 2.735 | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 2.113 | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 7.389 | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.159 | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.171 | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.132 | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 0.461 | | | | | | | |

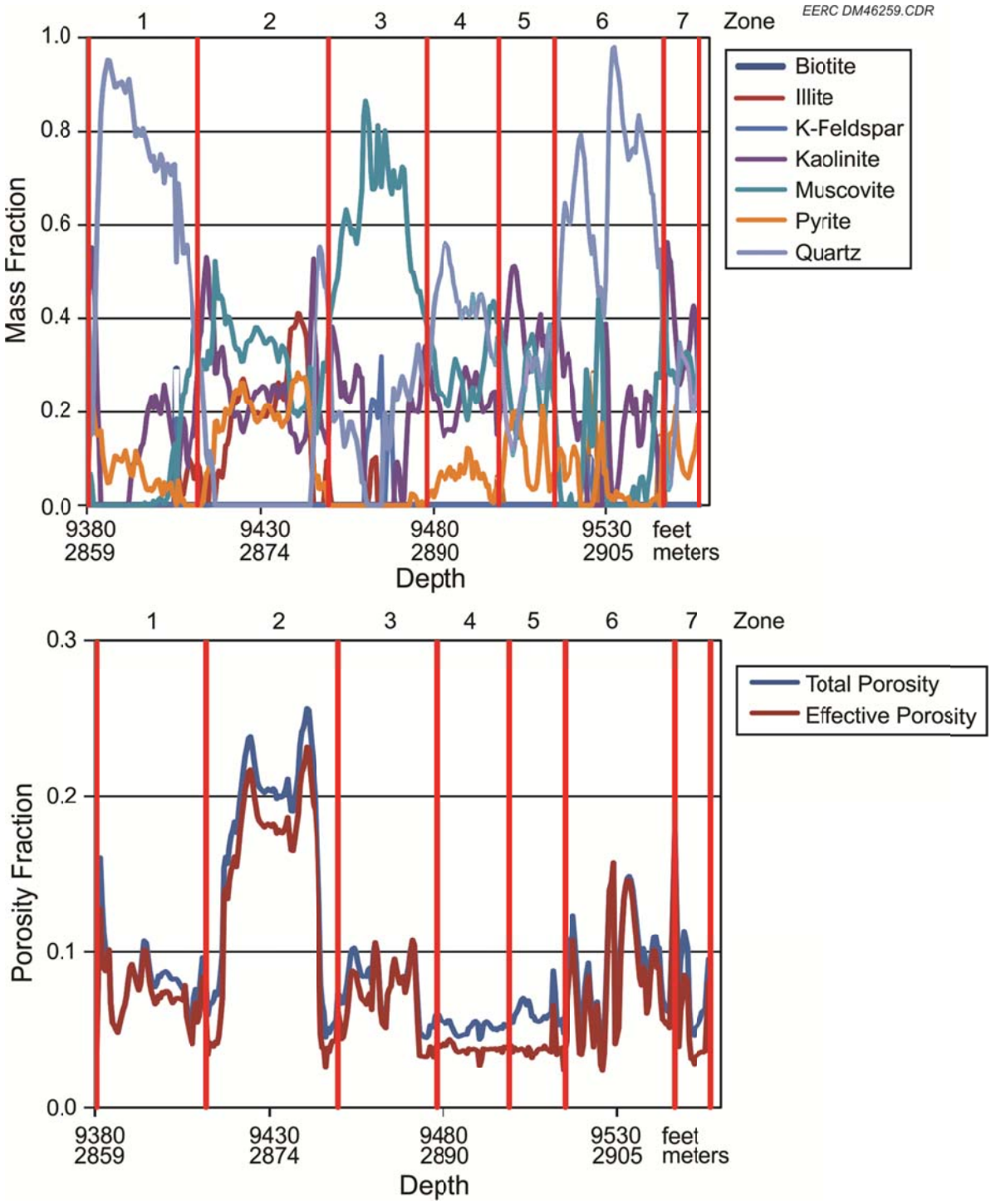



Figure B-3. ND 6436 mineral composition and porosity as a function of depth.

**ND 6436 CAP ROCK**

For the ND 6436 well, 126 feet (38 meters) of cap rock data was available from the top of the formation upward. The same water composition was used in the cap rock calculations.

The majority of the cap rock minerals in all four zones is fairly uniform, the majority being shale, with moderate amounts of illite and quartz present. The porosity is quite high, ranging from 0.123 to 0.148.

A modest amount of dolomite forms, with the dissolution of corresponding amounts of kaolinite and phlogophyte. There is an increase in quartz and muscovite as well.

The amount of $CO_2$ dissolved in the formation water is approximately 0.76 moles/kg water (33.4 g/kg). The major increase is $CO_2$ in solution is as $HCO_3^-$, $NaHCO_3^+$and $MgHCO_3^+$. The $CO_2$ in solution is about twice that of the dolomite. The level of magnesium bicarbonate in solution may be because of the lack of an assigned solid mineral phase for it to precipitate to. The total average amount of $CO_2$ shown reacting with the minerals and formation water is 5.8 kg/m$^3$ (0.4 lb/ft$^3$) of formation rock. It is noted that the total amount of $CO_2$ reacting in the cap rock is nearly 80% that of the COSS. This appears to be because of the higher cap rock porosity and, possibly, because of the substitutions made for the calculations involving shale. More robust information for the shale comprising the cap rock is needed to make more definitive claims regarding this interaction.

## Table B-20. Average Mineral and Porosity Values for the ND 6436 Cap Rock Zones

Well Name: ND 6436
API Identification: 33-075-00744-0000
State Identification: ND 6436

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 9254.0 | 2820.6 | Average | 0.185 | 0.123 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.239 | 0.000 | 0.000 | 0.000 | 0.000 | 0.132 | 0.629 |
| End | 9315.0 | 2839.2 | Minimum | 0.076 | 0.028 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.153 | 0.000 | 0.000 | 0.000 | 0.000 | 0.019 | 0.293 |
| Thickness | 61.0 | 18.6 | Maximum | 0.224 | 0.161 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.370 | 0.000 | 0.000 | 0.000 | 0.000 | 0.500 | 0.798 |
| Number of Values | 123 | | Standard deviation | 0.025 | 0.023 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.051 | 0.000 | 0.000 | 0.000 | 0.000 | 0.075 | 0.089 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 9315.0 | 2839.2 | Average | 0.199 | 0.143 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.229 | 0.000 | 0.000 | 0.000 | 0.000 | 0.196 | 0.575 |
| End | 9329.0 | 2843.5 | Minimum | 0.183 | 0.127 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.202 | 0.000 | 0.000 | 0.000 | 0.000 | 0.156 | 0.538 |
| Thickness | 14.0 | 4.3 | Maximum | 0.212 | 0.155 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.247 | 0.000 | 0.000 | 0.000 | 0.000 | 0.232 | 0.643 |
| Number of Values | 28 | | Standard deviation | 0.008 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.021 | 0.027 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 9329.0 | 2843.5 | Average | 0.186 | 0.136 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.177 | 0.000 | 0.000 | 0.000 | 0.000 | 0.250 | 0.573 |
| End | 9354.0 | 2851.1 | Minimum | 0.159 | 0.106 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.159 | 0.000 | 0.000 | 0.000 | 0.000 | 0.214 | 0.514 |
| Thickness | 25.0 | 7.6 | Maximum | 0.209 | 0.161 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.207 | 0.000 | 0.000 | 0.000 | 0.000 | 0.304 | 0.615 |
| Number of Values | 50 | | Standard deviation | 0.014 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.022 | 0.026 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 9354.0 | 2851.1 | Average | 0.196 | 0.148 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.101 | 0.000 | 0.000 | 0.000 | 0.000 | 0.125 | 0.773 |
| End | 9380.0 | 2859.0 | Minimum | 0.105 | 0.072 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.063 |
| Thickness | 26.0 | 7.9 | Maximum | 0.228 | 0.179 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.194 | 0.000 | 0.000 | 0.000 | 0.000 | 0.743 | 0.955 |
| Number of Values | 52 | | Standard deviation | 0.023 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.043 | 0.000 | 0.000 | 0.000 | 0.000 | 0.189 | 0.223 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 9254.0 | 2820.6 | Average | 0.189 | 0.133 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.197 | 0.000 | 0.000 | 0.000 | 0.000 | 0.161 | 0.641 |
| End | 9380.0 | 2859.0 | Minimum | 0.076 | 0.028 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.063 |
| Thickness | 126.0 | 38.4 | Maximum | 0.228 | 0.179 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.370 | 0.000 | 0.000 | 0.000 | 0.000 | 0.743 | 0.955 |
| Number of Values | 253 | | Standard deviation | 0.022 | 0.023 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.068 | 0.000 | 0.000 | 0.000 | 0.000 | 0.112 | 0.138 |

## Table B-21. Summary of ND 6436 Cap Rock Calculation Results

Well Name: ND 6436
API Index: 33-075-00744-0000
State ID: ND 6436

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Start, m | 2820.6 | 2839.2 | 2843.5 | 2851.1 | 2820.6 |
| End, m | 2839.2 | 2843.5 | 2851.1 | 2859.0 | 2859.0 |
| Thickness, m | 18.6 | 4.3 | 7.6 | 7.9 | 38.4 |
| Start, ft | 9254.0 | 9315.0 | 9329.0 | 9354.0 | 9254.0 |
| End, ft | 9315.0 | 9329.0 | 9354.0 | 9380.0 | 9380.0 |
| Thickness, ft | 61.0 | 14.0 | 25.0 | 26.0 | 126.0 |
| **Minerals Without $CO_2$** | | | | | |
| pH | 5.845 | 5.846 | 5.847 | 5.849 | 5.847 |
| pE | 9.936 | 9.936 | 9.933 | 9.925 | 9.933 |
| Activity | 0.845 | 0.845 | 0.846 | 0.849 | 0.846 |
| Ionic Strength | 4.384 | 4.379 | 4.351 | 4.284 | 4.353 |
| Total Solution $CO_2$, moles | 2.629E-04 | 2.624E-04 | 2.597E-04 | 2.534E-04 | 2.599E-04 |
| Solution, moles | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |
| Ca | 0.5320 | 0.5320 | 0.5320 | 0.5320 | 0.5320 |
| Cl | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0014 | 0.0014 | 0.0015 | 0.0015 | 0.0015 |
| Mg | 0.2409 | 0.2409 | 0.2409 | 0.2409 | 0.2409 |
| Na | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 |
| S | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 |
| Si | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 16.750 | 13.340 | 11.710 | 8.800 | 13.470 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 13.660 | 10.510 | 11.010 | 13.460 | 12.710 |
| Maximum Microcline | 2.707 | 2.083 | 2.183 | 2.668 | 2.519 |
| Muscovite | 4.339 | 3.340 | 3.499 | 4.277 | 4.039 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 105.200 | 101.100 | 121.400 | 94.100 | 105.500 |
| Rutile | 2.583 | 1.988 | 2.083 | 2.546 | 2.404 |
| Sanidine High | 0.773 | 0.595 | 0.623 | 0.762 | 0.719 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 15.440 | 11.960 | 11.790 | 12.640 | 13.640 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 16.700 | 13.130 | 12.580 | 12.480 | 14.460 |
| Phlogopite | 1.364 | 1.079 | 0.943 | 0.701 | 1.091 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 129.500 | 120.300 | 139.100 | 110.100 | 126.000 |
| Rutile | 2.583 | 1.988 | 2.083 | 2.546 | 2.404 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Change (initial – final), moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −16.750 | −13.340 | −11.710 | −8.800 | −13.470 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 1.782 | 1.446 | 0.775 | −0.818 | 0.931 |
| Maximum Microcline | −2.707 | −2.083 | −2.183 | −2.668 | −2.519 |
| Muscovite | 12.360 | 9.795 | 9.080 | 8.202 | 10.430 |
| Phlogopite | 1.364 | 1.079 | 0.943 | 0.701 | 1.091 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 24.330 | 19.200 | 17.770 | 16.020 | 20.470 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | −0.773 | −0.595 | −0.623 | −0.762 | −0.719 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | |
| $CaCO_3$ | 1.30E-06 | 1.30E-06 | 1.28E-06 | 1.25E-06 | 1.29E-06 |
| $CaHCO_3^+$ | 6.62E-05 | 6.60E-05 | 6.53E-05 | 6.34E-05 | 6.53E-05 |
| $CO_2$ | 6.71E-05 | 6.70E-05 | 6.65E-05 | 6.53E-05 | 6.65E-05 |
| $CO_3^{2-}$ | 2.11E-08 | 2.11E-08 | 2.10E-08 | 2.08E-08 | 2.10E-08 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $HCO_3^-$ | 5.14E-05 | 5.14E-05 | 5.11E-05 | 5.05E-05 | 5.11E-05 |
| $MgCO_3$ | 1.88E-07 | 1.88E-07 | 1.85E-07 | 1.80E-07 | 1.86E-07 |
| $MgHCO_3^+$ | 3.55E-05 | 3.54E-05 | 3.49E-05 | 3.38E-05 | 3.50E-05 |
| $NaCO_3^-$ | 2.88E-09 | 2.87E-09 | 2.84E-09 | 2.76E-09 | 2.84E-09 |
| $NaHCO_3$ | 4.12E-05 | 4.11E-05 | 4.05E-05 | 3.89E-05 | 4.05E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 6.710E-05 | 6.700E-05 | 6.649E-05 | 6.527E-05 | 6.653E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 1.958E-04 | 1.954E-04 | 1.932E-04 | 1.881E-04 | 1.934E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 2.629E-04 | 2.624E-04 | 2.597E-04 | 2.533E-04 | 2.599E-04 |
| Water, g/cm$^3$ | 0.123 | 0.143 | 0.136 | 0.148 | 0.133 |
| Water, kg/m$^3$ | 122.940 | 142.544 | 136.250 | 148.443 | 132.982 |
| Mineral $CO_2$, moles/m$^3$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, moles/m$^3$ | 8.249E-03 | 9.550E-03 | 9.059E-03 | 9.689E-03 | 8.847E-03 |
| Solution $CO_2$, moles/m$^3$ | 2.407E-02 | 2.785E-02 | 2.633E-02 | 2.792E-02 | 2.572E-02 |
| Total $CO_2$, moles/m$^3$ | 3.232E-02 | 3.740E-02 | 3.539E-02 | 3.761E-02 | 3.456E-02 |
| Mineral $CO_2$, moles/ft$^3$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, moles/ft$^3$ | 2.336E-04 | 2.704E-04 | 2.565E-04 | 2.744E-04 | 2.505E-04 |
| Solution $CO_2$, moles/ft$^3$ | 6.816E-04 | 7.886E-04 | 7.455E-04 | 7.906E-04 | 7.282E-04 |
| Total $CO_2$, moles/ft$^3$ | 9.152E-04 | 1.059E-03 | 1.002E-03 | 1.065E-03 | 9.787E-04 |
| Mineral $CO_2$, kg/m$^3$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, kg/m$^3$ | 3.630E-04 | 4.203E-04 | 3.987E-04 | 4.264E-04 | 3.894E-04 |
| Solution $CO_2$, kg/m$^3$ | 1.059E-03 | 1.226E-03 | 1.159E-03 | 1.229E-03 | 1.132E-03 |
| Total $CO_2$, kg/m$^3$ | 1.422E-03 | 1.646E-03 | 1.557E-03 | 1.655E-03 | 1.521E-03 |
| Mineral $CO_2$, lb/ft$^3$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Dissolved $CO_2$, lb/ft$^3$ | 2.266E-05 | 2.624E-05 | 2.489E-05 | 2.662E-05 | 2.431E-05 |
| Solution $CO_2$, lb/ft$^3$ | 6.613E-05 | 7.651E-05 | 7.233E-05 | 7.670E-05 | 7.065E-05 |
| Total $CO_2$, lb/ft$^3$ | 8.880E-05 | 1.027E-04 | 9.722E-05 | 1.033E-04 | 9.496E-05 |
| Weighted Average of Zones | | | | | |
| Total Thickness, m | 38.4 | | | | |
| Mineral $CO_2$, kg/m$^3$ | 0.000E+00 | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 3.896E-04 | | | | |
| Solution $CO_2$, kg/m$^3$ | 1.132E-03 | | | | |
| Total $CO_2$, kg/m$^3$ | 1.522E-03 | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.000E+00 | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 2.432E-05 | | | | |
| Solution $CO_2$, lb/ft$^3$ | 7.070E-05 | | | | |
| Total $CO_2$, lb/ft$^3$ | 9.502E-05 | | | | |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| **Minerals with $CO_2$** | | | | | |
| pH | 5.620 | 5.621 | 5.622 | 5.624 | 5.622 |
| pE | 10.172 | 10.171 | 10.169 | 10.162 | 10.169 |
| Activity | 0.815 | 0.816 | 0.817 | 0.820 | 0.817 |
| Ionic Strength | 4.653 | 4.648 | 4.621 | 4.556 | 4.623 |
| Total Solution $CO_2$, moles | 2.01E+00 | 2.01E+00 | 2.02E+00 | 2.03E+00 | 2.01E+00 |
| Solution, moles | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 2.0060 | 2.0130 | 2.0380 | 2.0990 | 2.0350 |
| Ca | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Cl | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0023 | 0.0023 | 0.0023 | 0.0024 | 0.0023 |
| Mg | 1.4080 | 1.4100 | 1.4170 | 1.4340 | 1.4160 |
| Na | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 |
| S | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 |
| Si | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0007 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 16.750 | 13.340 | 11.710 | 8.800 | 13.470 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 13.660 | 10.510 | 11.010 | 13.460 | 12.710 |
| Maximum Microcline | 2.707 | 2.083 | 2.183 | 2.668 | 2.519 |
| Muscovite | 4.339 | 3.340 | 3.499 | 4.277 | 4.039 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 105.200 | 101.100 | 121.400 | 94.100 | 105.500 |
| Rutile | 2.583 | 1.988 | 2.083 | 2.546 | 2.404 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Sanidine High | 0.773 | 0.595 | 0.623 | 0.762 | 0.719 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 296.900 | 296.900 | 296.900 | 296.800 | 296.900 |
| Dolomite | 0.532 | 0.532 | 0.532 | 0.532 | 0.532 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 14.870 | 11.390 | 11.220 | 12.070 | 13.070 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 17.260 | 13.700 | 13.150 | 13.050 | 15.030 |
| Phlogopite | 0.798 | 0.512 | 0.374 | 0.126 | 0.522 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 130.600 | 121.500 | 140.300 | 111.300 | 127.100 |
| Rutile | 2.583 | 1.988 | 2.083 | 2.546 | 2.404 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | −3.070 | −3.077 | −3.102 | −3.162 | −3.099 |
| Dolomite | 0.532 | 0.532 | 0.532 | 0.532 | 0.532 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −16.750 | −13.340 | −11.710 | −8.800 | −13.470 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 1.217 | 0.880 | 0.207 | −1.392 | 0.363 |
| Maximum Microcline | −2.707 | −2.083 | −2.183 | −2.668 | −2.519 |
| Muscovite | 12.930 | 10.360 | 9.649 | 8.776 | 10.990 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Phlogopite | 0.798 | 0.512 | 0.374 | 0.126 | 0.522 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 25.470 | 20.340 | 18.910 | 17.170 | 21.600 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | −0.773 | −0.595 | −0.623 | −0.762 | −0.719 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | |
| $CaCO_3$ | 2.36E-10 | 2.36E-10 | 2.36E-10 | 2.36E-10 | 2.36E-10 |
| $CaHCO_3^+$ | 1.97E-08 | 1.97E-08 | 1.97E-08 | 1.97E-08 | 1.97E-08 |
| $CO_2$ | 7.38E-01 | 7.40E-01 | 7.44E-01 | 7.51E-01 | 7.43E-01 |
| $CO_3^{2-}$ | 8.20E-05 | 8.22E-05 | 8.29E-05 | 8.44E-05 | 8.28E-05 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $HCO_3^-$ | 3.31E-01 | 3.32E-01 | 3.34E-01 | 3.39E-01 | 3.34E-01 |
| $MgCO_3$ | 2.21E-03 | 2.21E-03 | 2.21E-03 | 2.21E-03 | 2.21E-03 |
| $MgHCO_3^+$ | 6.82E-01 | 6.83E-01 | 6.83E-01 | 6.82E-01 | 6.82E-01 |
| $NaCO_3^-$ | 1.03E-05 | 1.03E-05 | 1.03E-05 | 1.03E-05 | 1.03E-05 |
| $NaHCO_3$ | 2.54E-01 | 2.54E-01 | 2.53E-01 | 2.50E-01 | 2.53E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.064 | 1.064 | 1.064 | 1.064 | 1.064 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.064 | 1.064 | 1.064 | 1.064 | 1.064 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.738 | 0.740 | 0.744 | 0.751 | 0.743 |
| Solution $CO_2$, moles/kg $H_2O$ | 1.269 | 1.271 | 1.272 | 1.274 | 1.271 |
| Total $CO_2$, moles/kg $H_2O$ | 3.071 | 3.075 | 3.080 | 3.089 | 3.077 |
| Water, g/cm$^3$ | 0.123 | 0.143 | 0.136 | 0.148 | 0.133 |
| Water, kg/m$^3$ | 122.940 | 142.544 | 136.250 | 148.443 | 132.982 |
| Mineral $CO_2$, moles/m$^3$ | 130.808 | 151.666 | 144.970 | 157.943 | 141.492 |
| Dissolved $CO_2$, moles/m$^3$ | 90.779 | 105.482 | 101.302 | 111.525 | 98.752 |
| Solution $CO_2$, moles/m$^3$ | 156.010 | 181.159 | 173.310 | 189.057 | 168.993 |
| Total $CO_2$, moles/m$^3$ | 377.597 | 438.307 | 419.582 | 458.526 | 409.237 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Mineral $CO_2$, moles/$ft^3$ | 3.704 | 4.295 | 4.105 | 4.472 | 4.007 |
| Dissolved $CO_2$, moles/$ft^3$ | 2.571 | 2.987 | 2.869 | 3.158 | 2.796 |
| Solution $CO_2$, moles/$ft^3$ | 4.418 | 5.130 | 4.908 | 5.354 | 4.785 |
| Total $CO_2$, moles/$ft^3$ | 10.692 | 12.412 | 11.881 | 12.984 | 11.588 |
| Mineral $CO_2$, kg/$m^3$ | 5.757 | 6.675 | 6.380 | 6.951 | 6.227 |
| Dissolved $CO_2$, kg/$m^3$ | 3.995 | 4.642 | 4.458 | 4.908 | 4.346 |
| Solution $CO_2$, kg/$m^3$ | 6.866 | 7.973 | 7.627 | 8.320 | 7.437 |
| Total $CO_2$, kg/$m^3$ | 16.618 | 19.290 | 18.466 | 20.180 | 18.011 |
| Mineral $CO_2$, lb/$ft^3$ | 0.359 | 0.417 | 0.398 | 0.434 | 0.389 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.249 | 0.290 | 0.278 | 0.306 | 0.271 |
| Solution $CO_2$, lb/$ft^3$ | 0.429 | 0.498 | 0.476 | 0.519 | 0.464 |
| Total $CO_2$, lb/$ft^3$ | 1.037 | 1.204 | 1.153 | 1.260 | 1.124 |
| Weighted Average of Zones | | | | | |
| Total Thickness, m | 38.4 | | | | |
| Mineral $CO_2$, kg/$m^3$ | 6.229 | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 4.347 | | | | |
| Solution $CO_2$, kg/$m^3$ | 7.440 | | | | |
| Total $CO_2$, kg/$m^3$ | 18.016 | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.389 | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.271 | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.464 | | | | |
| Total $CO_2$, lb/$ft^3$ | 1.125 | | | | |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | |
| pH | −0.225 | −0.225 | −0.225 | −0.225 | −0.225 |
| pE | 0.236 | 0.235 | 0.236 | 0.237 | 0.236 |
| Activity | −0.030 | −0.029 | −0.029 | −0.029 | −0.029 |
| Ionic Strength | 0.269 | 0.269 | 0.270 | 0.272 | 0.270 |
| Total Solution $CO_2$,moles | 2.007 | 2.011 | 2.015 | 2.025 | 2.013 |
| Solution, moles | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 2.006 | 2.013 | 2.038 | 2.099 | 2.035 |
| Ca | −0.532 | −0.532 | −0.532 | −0.532 | −0.532 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Mg | 1.167 | 1.169 | 1.176 | 1.193 | 1.175 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | | | | | |
| Initial Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 296.900 | 296.900 | 296.900 | 296.800 | 296.900 |
| Dolomite | 0.532 | 0.532 | 0.532 | 0.532 | 0.532 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.570 | −0.570 | −0.570 | −0.570 | −0.570 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.560 | 0.570 | 0.570 | 0.570 | 0.570 |
| Phlogopite | −0.567 | −0.567 | −0.569 | −0.575 | −0.569 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 1.100 | 1.200 | 1.200 | 1.200 | 1.100 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 3.070 | 3.077 | 3.102 | 3.162 | 3.099 |
| Dolomite | 0.532 | 0.532 | 0.532 | 0.532 | 0.532 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.565 | −0.566 | −0.568 | −0.574 | −0.568 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.570 | 0.565 | 0.569 | 0.574 | 0.560 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Phlogopite | −0.567 | −0.567 | −0.569 | −0.575 | −0.569 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 1.140 | 1.140 | 1.140 | 1.150 | 1.130 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | |
| $CaCO_3$ | −1.30E-06 | −1.30E-06 | −1.28E-06 | −1.25E-06 | −1.28E-06 |
| $CaHCO_3^+$ | −6.61E-05 | −6.60E-05 | −6.52E-05 | −6.34E-05 | −6.53E-05 |
| $CO_2$ | 7.38E-01 | 7.40E-01 | 7.43E-01 | 7.51E-01 | 7.43E-01 |
| $CO_3^{2-}$ | 8.20E-05 | 8.22E-05 | 8.29E-05 | 8.44E-05 | 8.27E-05 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $HCO_3^-$ | 3.31E-01 | 3.32E-01 | 3.34E-01 | 3.39E-01 | 3.33E-01 |
| $MgCO_3$ | 2.20E-03 | 2.21E-03 | 2.21E-03 | 2.20E-03 | 2.21E-03 |
| $MgHCO_3^+$ | 6.82E-01 | 6.83E-01 | 6.83E-01 | 6.82E-01 | 6.82E-01 |
| $NaCO_3^-$ | 1.03E-05 | 1.03E-05 | 1.03E-05 | 1.03E-05 | 1.03E-05 |
| $NaHCO_3$ | 2.54E-01 | 2.54E-01 | 2.53E-01 | 2.50E-01 | 2.53E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.064 | 1.064 | 1.064 | 1.064 | 1.064 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.064 | 1.064 | 1.064 | 1.064 | 1.064 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.738 | 0.740 | 0.743 | 0.751 | 0.743 |
| Solution $CO_2$, moles/kg $H_2O$ | 1.269 | 1.271 | 1.272 | 1.273 | 1.271 |
| Total $CO_2$, moles/kg $H_2O$ | 3.071 | 3.075 | 3.079 | 3.089 | 3.077 |
| Water, g/cm$^3$ | 0.123 | 0.143 | 0.136 | 0.148 | 0.133 |
| Water, kg/m$^3$ | 122.940 | 142.544 | 136.250 | 148.443 | 132.982 |
| Mineral $CO_2$, moles/m$^3$ | 130.808 | 151.666 | 144.970 | 157.943 | 141.492 |
| Dissolved $CO_2$, moles/m$^3$ | 90.770 | 105.473 | 101.293 | 111.516 | 98.743 |
| Solution $CO_2$, moles/m$^3$ | 155.986 | 181.131 | 173.284 | 189.029 | 168.967 |
| Total $CO_2$, moles/m$^3$ | 377.564 | 438.270 | 419.547 | 458.488 | 409.203 |

Continued…

**Table B-21. Summary of ND 6436 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Mineral $CO_2$, moles/$ft^3$ | 3.704 | 4.295 | 4.105 | 4.472 | 4.007 |
| Dissolved $CO_2$, moles/$ft^3$ | 2.570 | 2.987 | 2.868 | 3.158 | 2.796 |
| Solution $CO_2$, moles/$ft^3$ | 4.417 | 5.129 | 4.907 | 5.353 | 4.785 |
| Total $CO_2$, moles/$ft^3$ | 10.691 | 12.410 | 11.880 | 12.983 | 11.587 |
| Mineral $CO_2$, kg/$m^3$ | 5.757 | 6.675 | 6.380 | 6.951 | 6.227 |
| Dissolved $CO_2$, kg/$m^3$ | 3.995 | 4.642 | 4.458 | 4.908 | 4.346 |
| Solution $CO_2$, kg/$m^3$ | 6.865 | 7.972 | 7.626 | 8.319 | 7.436 |
| Total $CO_2$, kg/$m^3$ | 16.617 | 19.288 | 18.464 | 20.178 | 18.009 |
| Mineral $CO_2$, lb/$ft^3$ | 0.359 | 0.417 | 0.398 | 0.434 | 0.389 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.249 | 0.290 | 0.278 | 0.306 | 0.271 |
| Solution $CO_2$, lb/$ft^3$ | 0.429 | 0.498 | 0.476 | 0.519 | 0.464 |
| Total $CO_2$, lb/$ft^3$ | 1.037 | 1.204 | 1.153 | 1.260 | 1.124 |
| Weighted Average of Zones | | | | | |
| Total Thickness, m | 38.4 | | | | |
| Mineral $CO_2$, kg/$m^3$ | 6.229 | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 4.347 | | | | |
| Solution $CO_2$, kg/$m^3$ | 7.439 | | | | |
| Total $CO_2$, kg/$m^3$ | 18.015 | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.389 | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.271 | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.464 | | | | |
| Total $CO_2$, lb/$ft^3$ | 1.125 | | | | |

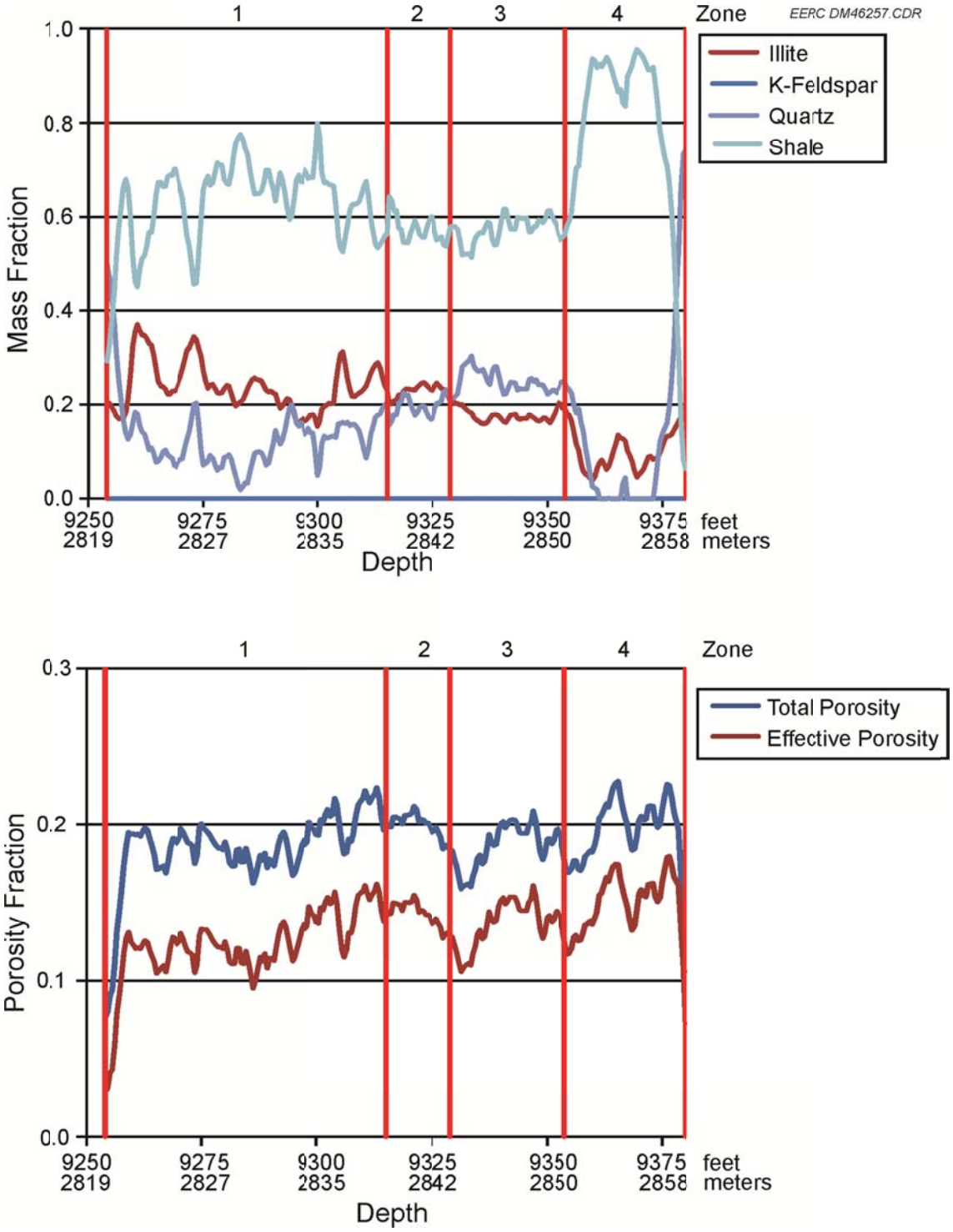



Figure B-4. ND 6436 mineral composition and porosity as a function of depth.

**ND 6264**

The water composition used for ND 6264 is from the ND 0151 well 27 miles (43 km) west. Mineral data were available for 90% of the total COSS thickness represented in this well. The total thickness of the COSS is not known, as the ND 6264 well did not penetrate to the Precambrian.

Quartz is the dominant mineral (92% to 97%) in Zones 1, 3, and 5. These are also zones with high porosity. Zones 2 and 7 have moderate amounts of glauconite and illite. Zone 4 contains moderate glauconite along with quartz, and Zone 5 has approximately equal amounts of illite and quartz.

The celadonite (glauconite) and illite dissolve both with and without $CO_2$ present, with a concurrent increase in quartz, phlogophite (biotite), and muscovite. A moderate amount of dolomite is predicted to form with $CO_2$ present, and a small amount of siderite forms for Zones 6 and 7. The amount of siderite is high for Zone 7.

The amount of $CO_2$ dissolved in formation water is approximately 0.8 moles/kg (35.2 g/kg) for all zones. Other aqueous forms containing $CO_2$ are $HCO_3^-$, $NaHCO_3^+$, and $MgHCO_3^+$. The amount of $CO_2$ interacting with the COSS is highest for Zones 1 and 4. The total average amount of $CO_2$ reacting with the minerals and formation water is 10.0 kg/m$^3$ (0.6 lb/ft$^3$) of formation rock.

## Table B-22. Average Mineral and Porosity Values for the ND 6264 Aquifer Zones

Well Name: ND 6264
API Identification: 33-015-00032-0000
State Identification: ND 6264

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 6072.0 | 1850.7 | Average | 0.198 | 0.179 | 0.000 | 0.000 | 0.000 | 0.012 | 0.024 | 0.042 | 0.000 | 0.000 | 0.000 | 0.000 | 0.922 | 0.000 |
| End | 6088.0 | 1855.6 | Minimum | 0.125 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.456 | 0.000 |
| Thickness | 16.0 | 4.9 | Maximum | 0.223 | 0.222 | 0.000 | 0.000 | 0.000 | 0.208 | 0.117 | 0.342 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 33 | | Standard deviation | 0.024 | 0.061 | 0.000 | 0.000 | 0.000 | 0.050 | 0.040 | 0.088 | 0.000 | 0.000 | 0.000 | 0.000 | 0.128 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 6088.0 | 1855.6 | Average | 0.100 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.235 | 0.144 | 0.000 | 0.000 | 0.000 | 0.000 | 0.620 | 0.000 |
| End | 6123.0 | 1866.3 | Minimum | 0.019 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.104 | 0.000 |
| Thickness | 35.0 | 10.7 | Maximum | 0.206 | 0.206 | 0.000 | 0.000 | 0.000 | 0.000 | 0.803 | 0.366 | 0.000 | 0.000 | 0.000 | 0.000 | 0.881 | 0.000 |
| Number of Values | 70 | | Standard deviation | 0.042 | 0.041 | 0.000 | 0.000 | 0.000 | 0.000 | 0.151 | 0.081 | 0.000 | 0.000 | 0.000 | 0.000 | 0.181 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 6123.0 | 1866.3 | Average | 0.140 | 0.122 | 0.000 | 0.000 | 0.000 | 0.000 | 0.038 | 0.033 | 0.000 | 0.000 | 0.000 | 0.000 | 0.929 | 0.000 |
| End | 6150.5 | 1874.7 | Minimum | 0.035 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.831 | 0.000 |
| Thickness | 27.5 | 8.4 | Maximum | 0.234 | 0.234 | 0.000 | 0.000 | 0.000 | 0.000 | 0.165 | 0.117 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 55 | | Standard deviation | 0.071 | 0.078 | 0.000 | 0.000 | 0.000 | 0.000 | 0.054 | 0.036 | 0.000 | 0.000 | 0.000 | 0.000 | 0.052 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 6150.5 | 1874.7 | Average | 0.181 | 0.160 | 0.000 | 0.000 | 0.000 | 0.000 | 0.207 | 0.040 | 0.000 | 0.000 | 0.000 | 0.000 | 0.754 | 0.000 |
| End | 6179.0 | 1883.4 | Minimum | 0.144 | 0.066 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.555 | 0.000 |
| Thickness | 28.5 | 8.7 | Maximum | 0.222 | 0.222 | 0.000 | 0.000 | 0.000 | 0.000 | 0.445 | 0.169 | 0.000 | 0.000 | 0.000 | 0.000 | 0.966 | 0.000 |
| Number of Values | 58 | | Standard deviation | 0.017 | 0.035 | 0.000 | 0.000 | 0.000 | 0.000 | 0.134 | 0.047 | 0.000 | 0.000 | 0.000 | 0.000 | 0.108 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 6179.0 | 1883.4 | Average | 0.213 | 0.204 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.977 | 0.000 |
| End | 6193.0 | 1887.6 | Minimum | 0.153 | 0.116 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.931 | 0.000 |
| Thickness | 14.0 | 4.3 | Maximum | 0.227 | 0.227 | 0.000 | 0.000 | 0.000 | 0.000 | 0.048 | 0.069 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 27 | | Standard deviation | 0.019 | 0.025 | 0.000 | 0.000 | 0.000 | 0.000 | 0.012 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 6193.0 | 1887.6 | Average | 0.163 | 0.051 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.544 | 0.000 | 0.000 | 0.000 | 0.000 | 0.425 | 0.000 |
| End | 6251.0 | 1905.3 | Minimum | 0.098 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 58.0 | 17.7 | Maximum | 0.231 | 0.231 | 0.000 | 0.000 | 0.000 | 0.000 | 0.358 | 0.845 | 0.000 | 0.000 | 0.000 | 0.013 | 0.921 | 0.000 |
| Number of Values | 116 | | Standard deviation | 0.026 | 0.059 | 0.000 | 0.000 | 0.000 | 0.000 | 0.081 | 0.223 | 0.000 | 0.000 | 0.000 | 0.001 | 0.197 | 0.000 |

Continued…

## Table B-22. Average Mineral and Porosity Values for the ND 6264 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 6251.0 | 1905.3 | Average | 0.092 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.297 | 0.362 | 0.000 | 0.000 | 0.000 | 0.007 | 0.334 | 0.000 |
| End | 6285.0 | 1915.7 | Minimum | 0.029 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.117 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 34.0 | 10.4 | Maximum | 0.167 | 0.058 | 0.000 | 0.000 | 0.000 | 0.000 | 0.883 | 0.551 | 0.000 | 0.000 | 0.000 | 0.079 | 0.565 | 0.000 |
| Number of Values | 68 | | Standard deviation | 0.040 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.305 | 0.146 | 0.000 | 0.000 | 0.000 | 0.021 | 0.182 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 6072.0 | 1850.7 | Average | 0.147 | 0.083 | 0.000 | 0.000 | 0.000 | 0.001 | 0.129 | 0.243 | 0.000 | 0.000 | 0.000 | 0.001 | 0.626 | 0.000 |
| End | 6285.0 | 1915.7 | Minimum | 0.019 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 213.0 | 64.9 | Maximum | 0.234 | 0.234 | 0.000 | 0.000 | 0.000 | 0.208 | 0.883 | 0.845 | 0.000 | 0.000 | 0.000 | 0.079 | 1.000 | 0.000 |
| Number of Values | 427 | | Standard deviation | 0.055 | 0.083 | 0.000 | 0.000 | 0.000 | 0.014 | 0.189 | 0.255 | 0.000 | 0.000 | 0.000 | 0.009 | 0.278 | 0.000 |

**Table B-23. Summary of ND 6264 Aquifer Minerals and Conditions**

Well Name: ND 6264
API Identification: 33-015-00032-0000
State Identification: ND 6264

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Start, ft | 6072 | 6088 | 6123 | 6150.5 | 6179 | 6193 | 6251 | 6072 |
| End, ft | 6088 | 6123 | 6150.5 | 6179 | 6193 | 6251 | 6285 | 6285 |
| Thickness, ft | 16.0 | 35.0 | 27.5 | 28.5 | 14.0 | 58.0 | 34.0 | 213.0 |
| Start, m | 1850.7 | 1855.6 | 1866.3 | 1874.7 | 1883.4 | 1887.6 | 1905.3 | 1850.7 |
| End, m | 1855.6 | 1866.3 | 1874.7 | 1883.4 | 1887.6 | 1905.3 | 1915.7 | 1915.7 |
| Thickness, m | 4.9 | 10.7 | 8.4 | 8.7 | 4.3 | 17.7 | 10.4 | 64.9 |
| Temperature, °F | 138.0 | 138.0 | 138.0 | 138.0 | 138.0 | 138.0 | 138.0 | 138.0 |
| Temperature, °C | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 | 58.9 |
| Pressure, psi | 3837 | 3841 | 3847 | 3852 | 3856 | 3862 | 3870 | 3854 |
| Pressure, kPa | 26,454 | 26,485 | 26,523 | 26,557 | 26,583 | 26,627 | 26,683 | 26,574 |
| Effective Porosity, fraction | 0.179 | 0.017 | 0.122 | 0.160 | 0.204 | 0.051 | 0.013 | 0.083 |
| Mass Fraction | | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Glauconite | 0.024 | 0.235 | 0.038 | 0.207 | 0.005 | 0.030 | 0.297 | 0.129 |
| Illite | 0.042 | 0.144 | 0.033 | 0.040 | 0.018 | 0.544 | 0.362 | 0.243 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 | 0.001 |
| Quartz | 0.922 | 0.620 | 0.929 | 0.754 | 0.977 | 0.425 | 0.334 | 0.626 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-24. Summary of ND 6264 Aquifer Calculation Results

Well Name: ND 6264
API Identification: 33-015-00032-0000
State Identification.: ND 6264

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Start, m | 2210.7 | 2210.7 | 2210.7 | 2210.7 | 2210.7 | 2210.7 | 2210.7 | 2210.7 |
| End, m | 2242.4 | 2242.4 | 2242.4 | 2242.4 | 2242.4 | 2242.4 | 2242.4 | 2242.4 |
| Thickness, m | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 |
| Start, ft | 6072.0 | 6088.0 | 6123.0 | 6150.5 | 6179.0 | 6193.0 | 6251.0 | 6072.0 |
| End, ft | 6088.0 | 6123.0 | 6150.5 | 6179.0 | 6193.0 | 6251.0 | 6285.0 | 6285.0 |
| Thickness, ft | 16.0 | 35.0 | 27.5 | 28.5 | 14.0 | 58.0 | 34.0 | 213.0 |
| **Minerals Without $CO_2$** | | | | | | | | |
| pH | 6.818 | 6.873 | 6.818 | 6.818 | 6.839 | 6.798 | 6.961 | 6.856 |
| pE | −1.291 | −0.827 | −1.199 | −1.235 | −1.250 | −3.088 | −3.309 | −3.158 |
| Activity | 0.923 | 0.944 | 0.923 | 0.923 | 0.922 | 0.898 | 0.967 | 0.930 |
| Ionic Strength | 2.204 | 1.627 | 2.200 | 2.202 | 2.221 | 2.824 | 0.981 | 2.010 |
| Total Solution $CO_2$, moles | 3.351E-04 | 2.571E-04 | 3.352E-04 | 3.351E-04 | 3.164E-04 | 3.070E-04 | 1.444E-04 | 3.210E-04 |
| Solution, moles | | | | | | | | |
| Al | 7.110E-08 | 1.108E-07 | 7.130E-08 | 7.120E-08 | 8.676E-08 | 6.209E-08 | 2.244E-07 | 9.955E-08 |
| C | 3.383E-04 | 3.684E-04 | 3.391E-04 | 3.387E-04 | 3.165E-04 | 2.294E-04 | 3.632E-04 | 3.632E-04 |
| Ca | 7.373E-02 | 7.374E-02 | 7.373E-02 | 7.373E-02 | 7.372E-02 | 7.368E-02 | 7.374E-02 | 7.374E-02 |
| Cl | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 |
| Fe | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 5.078E-07 | 1.581E-06 | 9.989E-07 |
| K | 4.708E-04 | 5.689E-04 | 4.713E-04 | 4.710E-04 | 2.737E-04 | 2.127E-04 | 7.589E-04 | 3.005E-04 |
| Mg | 2.083E-02 | 2.079E-02 | 2.083E-02 | 2.083E-02 | 2.093E-02 | 2.096E-02 | 2.069E-02 | 2.092E-02 |
| Na | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 |
| S | 1.011E-02 | 1.011E-02 | 1.011E-02 | 1.011E-02 | 1.011E-02 | 1.011E-02 | 1.011E-02 | 1.011E-02 |
| Si | 3.537E-04 | 4.969E-04 | 3.544E-04 | 3.540E-04 | 3.518E-04 | 2.647E-04 | 8.541E-04 | 3.943E-04 |
| Ti | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.675 | 87.870 | 1.684 | 6.830 | 0.111 | 3.563 | 152.000 | 9.026 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ Funston | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.818 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.156 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

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**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Illite | 1.315 | 60.120 | 1.628 | 1.470 | 0.490 | 71.070 | 207.500 | 18.980 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 13.250 | 0.300 |
| Quartz | 185.900 | 1654.000 | 294.900 | 177.800 | 166.700 | 355.100 | 1221.000 | 312.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.017 | 57.810 | 0.869 | 6.094 | 0.000 | 0.000 | 48.210 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ Funston | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.818 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.156 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.089 | 21.320 | 0.000 | 0.310 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 1.118 | 51.100 | 1.384 | 1.249 | 0.327 | 39.100 | 176.400 | 15.820 |
| Phlogopite | 0.329 | 15.030 | 0.407 | 0.368 | 0.078 | 7.110 | 51.880 | 4.590 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 13.250 | 0.300 |
| Quartz | 188.800 | 1786.000 | 298.400 | 181.000 | 167.400 | 436.900 | 1678.000 | 352.700 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | −0.659 | −30.060 | −0.815 | −0.736 | −0.111 | −3.563 | −103.800 | −9.026 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

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**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| $CO_2$ Funston | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −1.315 | −60.120 | −1.628 | −1.470 | −0.490 | −71.070 | −207.500 | −18.980 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.089 | 21.320 | 0.000 | 0.310 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 1.118 | 51.100 | 1.384 | 1.249 | 0.327 | 39.100 | 176.400 | 15.820 |
| Phlogopite | 0.329 | 15.030 | 0.407 | 0.368 | 0.078 | 7.110 | 51.880 | 4.590 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 2.895 | 132.300 | 3.583 | 3.235 | 0.765 | 81.750 | 456.600 | 40.670 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 1.62E-04 | 2.15E-06 | 2.93E-06 | 2.93E-06 | 2.92E-06 | 2.93E-06 | 1.12E-06 | 2.91E-06 |
| $CaHCO_3^+$ | 1.11E-04 | 1.86E-05 | 2.80E-05 | 2.80E-05 | 2.66E-05 | 2.82E-05 | 7.95E-06 | 2.58E-05 |
| $CO_2$ | 2.80E-05 | 1.81E-05 | 2.20E-05 | 2.20E-05 | 1.97E-05 | 1.74E-05 | 1.06E-05 | 2.06E-05 |
| $CO_3^{2-}$ | 2.20E-05 | 3.78E-07 | 4.09E-07 | 4.09E-07 | 4.05E-07 | 3.28E-07 | 2.67E-07 | 4.38E-07 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.01E-10 | 1.56E-10 | 2.35E-10 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.54E-22 | 4.55E-22 | 9.44E-22 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.81E-09 | 5.51E-09 | 1.03E-08 |
| $HCO_3^-$ | 8.93E-06 | 1.43E-04 | 1.62E-04 | 1.62E-04 | 1.52E-04 | 1.28E-04 | 9.46E-05 | 1.63E-04 |
| $MgCO_3$ | 2.93E-06 | 2.35E-07 | 3.16E-07 | 3.16E-07 | 3.17E-07 | 3.16E-07 | 1.23E-07 | 3.18E-07 |
| $MgHCO_3^+$ | 4.09E-07 | 6.00E-06 | 8.92E-06 | 8.93E-06 | 8.52E-06 | 9.00E-06 | 2.58E-06 | 8.30E-06 |
| $NaCO_3^-$ | 3.16E-07 | 8.65E-08 | 1.20E-07 | 1.20E-07 | 1.20E-07 | 1.20E-07 | 4.20E-08 | 1.19E-07 |
| $NaHCO_3$ | 1.20E-07 | 6.88E-05 | 1.11E-04 | 1.11E-04 | 1.06E-04 | 1.21E-04 | 2.70E-05 | 9.98E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 2.498E-05 | 0.000E+00 | 2.416E-05 | 2.458E-05 | 4.672E-05 | 1.338E-04 | 0.000E+00 | 5.168E-06 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 2.498E-05 | 0.000E+00 | 2.416E-05 | 2.458E-05 | 4.672E-05 | 1.338E-04 | 0.000E+00 | 5.168E-06 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 2.800E-05 | 1.806E-05 | 2.200E-05 | 2.200E-05 | 1.973E-05 | 1.743E-05 | 1.063E-05 | 2.062E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 3.071E-04 | 2.389E-04 | 3.132E-04 | 3.131E-04 | 2.967E-04 | 2.895E-04 | 1.337E-04 | 3.003E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 3.601E-04 | 2.570E-04 | 3.593E-04 | 3.597E-04 | 3.631E-04 | 4.408E-04 | 1.444E-04 | 3.261E-04 |

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**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Water, $g/cm^3$ | 0.179 | 0.017 | 0.122 | 0.160 | 0.204 | 0.051 | 0.013 | 0.083 |
| Water, $kg/m^3$ | 178.766 | 16.752 | 121.585 | 160.158 | 203.821 | 51.127 | 12.564 | 82.755 |
| Mineral $CO_2$, $moles/m^3$ | 4.466E-03 | 0.000E+00 | 2.937E-03 | 3.937E-03 | 9.523E-03 | 6.843E-03 | 0.000E+00 | 4.277E-04 |
| Dissolved $CO_2$, $moles/m^3$ | 5.005E-03 | 3.025E-04 | 2.675E-03 | 3.523E-03 | 4.021E-03 | 8.911E-04 | 1.336E-04 | 1.706E-03 |
| Solution $CO_2$, $moles/m^3$ | 5.490E-02 | 4.003E-03 | 3.808E-02 | 5.014E-02 | 6.047E-02 | 1.480E-02 | 1.680E-03 | 2.485E-02 |
| Total $CO_2$, $moles/m^3$ | 6.437E-02 | 4.305E-03 | 4.369E-02 | 5.760E-02 | 7.401E-02 | 2.254E-02 | 1.814E-03 | 2.699E-02 |
| Mineral $CO_2$, $moles/ft^3$ | 1.265E-04 | 0.000E+00 | 8.318E-05 | 1.115E-04 | 2.696E-04 | 1.938E-04 | 0.000E+00 | 1.211E-05 |
| Dissolved $CO_2$, $moles/ft^3$ | 1.417E-04 | 8.567E-06 | 7.574E-05 | 9.977E-05 | 1.139E-04 | 2.523E-05 | 3.782E-06 | 4.832E-05 |
| Solution $CO_2$, $moles/ft^3$ | 1.555E-03 | 1.134E-04 | 1.078E-03 | 1.420E-03 | 1.712E-03 | 4.192E-04 | 4.759E-05 | 7.038E-04 |
| Total $CO_2$, $moles/ft^3$ | 1.823E-03 | 1.219E-04 | 1.237E-03 | 1.631E-03 | 2.096E-03 | 6.382E-04 | 5.137E-05 | 7.642E-04 |
| Mineral $CO_2$, $kg/m^3$ | 1.965E-04 | 0.000E+00 | 1.293E-04 | 1.733E-04 | 4.191E-04 | 3.012E-04 | 0.000E+00 | 1.882E-05 |
| Dissolved $CO_2$, $kg/m^3$ | 2.203E-04 | 1.332E-05 | 1.177E-04 | 1.551E-04 | 1.770E-04 | 3.922E-05 | 5.878E-06 | 7.510E-05 |
| Solution $CO_2$, $kg/m^3$ | 2.416E-03 | 1.762E-04 | 1.676E-03 | 2.207E-03 | 2.661E-03 | 6.515E-04 | 7.396E-05 | 1.094E-03 |
| Total $CO_2$, $kg/m^3$ | 2.833E-03 | 1.895E-04 | 1.923E-03 | 2.535E-03 | 3.257E-03 | 9.918E-04 | 7.983E-05 | 1.188E-03 |
| Mineral $CO_2$, $lb/ft^3$ | 1.227E-05 | 0.000E+00 | 8.071E-06 | 1.082E-05 | 2.616E-05 | 1.880E-05 | 0.000E+00 | 1.175E-06 |
| Dissolved $CO_2$, $lb/ft^3$ | 1.375E-05 | 8.312E-07 | 7.349E-06 | 9.680E-06 | 1.105E-05 | 2.448E-06 | 3.669E-07 | 4.688E-06 |
| Solution $CO_2$, $lb/ft^3$ | 1.508E-04 | 1.100E-05 | 1.046E-04 | 1.378E-04 | 1.661E-04 | 4.067E-05 | 4.617E-06 | 6.829E-05 |
| Total $CO_2$, $lb/ft^3$ | 1.768E-04 | 1.183E-05 | 1.200E-04 | 1.583E-04 | 2.033E-04 | 6.192E-05 | 4.984E-06 | 7.415E-05 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 221.9 | | | | | | | |
| Mineral $CO_2$, $kg/m^3$ | 1.742E-04 | | | | | | | |
| Dissolved $CO_2$, $kg/m^3$ | 1.041E-04 | | | | | | | |
| Solution $CO_2$, $kg/m^3$ | 1.409E-03 | | | | | | | |
| Total $CO_2$, $kg/m^3$ | 1.687E-03 | | | | | | | |
| Mineral $CO_2$, $lb/ft^3$ | 1.087E-05 | | | | | | | |
| Dissolved $CO_2$, $lb/ft^3$ | 6.497E-06 | | | | | | | |
| Solution $CO_2$, $lb/ft^3$ | 8.795E-05 | | | | | | | |
| Total $CO_2$, $lb/ft^3$ | 1.053E-04 | | | | | | | |

Continued…

**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| **Minerals with $CO_2$** | | | | | | | | |
| pH | 5.811 | 6.195 | 5.841 | 5.821 | 4.974 | 6.193 | 6.195 | 6.168 |
| pE | −0.529 | −1.085 | −0.201 | −0.168 | 0.929 | −2.178 | −2.211 | −2.178 |
| Activity | 0.885 | 0.877 | 0.884 | 0.885 | 0.904 | 0.827 | 0.887 | 0.855 |
| Ionic Strength | 2.905 | 3.234 | 2.956 | 2.923 | 2.313 | 4.346 | 2.911 | 3.696 |
| Total Solution $CO_2$, moles | 2.27E+00 | 4.18E+00 | 2.40E+00 | 2.32E+00 | 1.08E+00 | 4.45E+00 | 4.10E+00 | 4.11E+00 |
| Solution, moles | | | | | | | | |
| Al | 4.170E-09 | 2.424E-08 | 4.702E-09 | 4.336E-09 | 4.890E-08 | 1.676E-08 | 4.091E-08 | 1.805E-08 |
| C | 2.270E+00 | 5.816E+00 | 2.394E+00 | 2.315E+00 | 1.084E+00 | 3.424E+00 | 1.085E+01 | 4.936E+00 |
| Ca | 8.220E-08 | 4.856E-09 | 6.116E-08 | 7.432E-08 | 1.821E-04 | 2.129E-09 | 8.775E-09 | 4.219E-09 |
| Cl | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 | 2.530E+00 |
| Fe | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 4.873E-05 | 1.745E-04 | 8.027E-05 |
| K | 9.612E-02 | 2.774E-03 | 6.708E-02 | 8.537E-02 | 1.940E-02 | 7.038E-04 | 4.990E-03 | 2.480E-03 |
| Mg | 7.823E-01 | 2.484E+00 | 8.618E-01 | 8.102E-01 | 1.813E-01 | 1.658E+00 | 5.078E+00 | 2.410E+00 |
| Na | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 | 2.361E+00 |
| S | 1.011E-02 | 1.011E-02 | 1.011E-02 | 1.011E-02 | 1.011E-02 | 1.653E-01 | 1.030E+00 | 4.599E-01 |
| Si | 3.281E-04 | 4.582E-04 | 3.282E-04 | 3.281E-04 | 3.271E-04 | 2.438E-04 | 7.871E-04 | 3.601E-04 |
| Ti | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.675 | 87.870 | 1.684 | 6.830 | 0.111 | 3.563 | 152.000 | 9.026 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ Funston | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.818 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.156 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 1.315 | 60.120 | 1.628 | 1.470 | 0.490 | 71.070 | 207.500 | 18.980 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 13.250 | 0.300 |
| Quartz | 185.900 | 1654.000 | 294.900 | 177.800 | 166.700 | 355.100 | 1221.000 | 312.000 |

Continued…

**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.169 | 59.070 | 1.177 | 6.335 | 0.000 | 0.000 | 50.770 | 0.762 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ Funston | 297.600 | 294.000 | 297.500 | 297.500 | 298.800 | 296.400 | 288.500 | 294.700 |
| Dolomite | 0.892 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.230 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 20.750 | 0.000 | 0.000 |
| Maximum Microcline | 0.033 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 1.166 | 51.100 | 1.417 | 1.292 | 0.386 | 39.670 | 176.400 | 16.130 |
| Phlogopite | 0.000 | 13.760 | 0.000 | 0.000 | 0.000 | 6.540 | 49.320 | 3.515 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 12.740 | 0.075 |
| Quartz | 188.900 | 1785.000 | 298.300 | 181.100 | 167.600 | 438.000 | 1675.000 | 352.500 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 0.510 | 0.225 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | −0.506 | −28.800 | −0.508 | −0.496 | −0.111 | −3.563 | −101.200 | −8.264 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ Funston | −2.417 | −5.963 | −2.541 | −2.462 | −1.231 | −3.649 | −11.510 | −5.308 |
| Dolomite | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −1.315 | −60.120 | −1.628 | −1.470 | −0.490 | −71.070 | −207.500 | −18.980 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 20.750 | 0.000 | 0.000 |
| Maximum Microcline | 0.033 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 1.166 | 51.100 | 1.417 | 1.292 | 0.386 | 39.670 | 176.400 | 16.130 |

Continued…

**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Phlogopite | 0.000 | 13.760 | 0.000 | 0.000 | 0.000 | 6.540 | 49.320 | 3.515 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.078 | -0.510 | –0.225 |
| Quartz | 3.030 | 131.000 | 3.476 | 3.250 | 0.921 | 82.900 | 454.000 | 40.530 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 0.510 | 0.225 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 5.18E-10 | 7.11E-11 | 4.26E-10 | 4.84E-10 | 4.96E-08 | 5.91E-11 | 7.06E-11 | 7.09E-11 |
| $CaHCO_3^+$ | 4.83E-08 | 2.68E-09 | 3.69E-08 | 4.41E-08 | 3.30E-05 | 2.05E-09 | 2.72E-09 | 2.75E-09 |
| $CO_2$ | 8.01E-01 | 7.59E-01 | 7.96E-01 | 8.02E-01 | 8.91E-01 | 6.32E-01 | 8.07E-01 | 7.04E-01 |
| $CO_3^{2-}$ | 1.60E-04 | 9.33E-04 | 1.84E-04 | 1.68E-04 | 3.40E-06 | 8.61E-04 | 9.48E-04 | 8.02E-04 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.77E-07 | 3.77E-07 | 3.77E-07 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.23E-17 | 1.27E-17 | 1.30E-17 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.48E-05 | 7.18E-05 | 7.23E-05 |
| $HCO_3^-$ | 6.01E-01 | 1.41E+00 | 6.43E-01 | 6.15E-01 | 9.29E-02 | 1.22E+00 | 1.47E+00 | 1.25E+00 |
| $MgCO_3$ | 1.79E-03 | 1.30E-02 | 2.17E-03 | 1.91E-03 | 1.87E-05 | 1.57E-02 | 1.31E-02 | 1.31E-02 |
| $MgHCO_3^+$ | 4.91E-01 | 1.45E+00 | 5.55E-01 | 5.13E-01 | 3.66E-02 | 1.61E+00 | 1.49E+00 | 1.49E+00 |
| $NaCO_3^-$ | 3.85E-05 | 1.34E-04 | 4.37E-05 | 4.02E-05 | 9.74E-07 | 2.14E-04 | 8.01E-05 | 1.42E-04 |
| $NaHCO_3$ | 3.78E-01 | 5.54E-01 | 4.01E-01 | 3.86E-01 | 6.33E-02 | 9.68E-01 | 3.25E-01 | 6.49E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 0.510 | 0.225 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 | 0.225 | 0.657 | 0.372 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.801 | 0.759 | 0.796 | 0.802 | 0.891 | 0.632 | 0.807 | 0.704 |
| Solution $CO_2$, moles/kg $H_2O$ | 1.472 | 3.424 | 1.601 | 1.517 | 0.193 | 3.814 | 3.295 | 3.407 |
| Total $CO_2$, moles/kg $H_2O$ | 2.420 | 4.331 | 2.545 | 2.466 | 1.231 | 4.671 | 4.759 | 4.483 |
| Water, $g/cm^3$ | 0.179 | 0.017 | 0.122 | 0.160 | 0.204 | 0.051 | 0.013 | 0.083 |
| Water, $kg/m^3$ | 178.766 | 16.752 | 121.585 | 160.158 | 203.821 | 51.127 | 12.564 | 82.755 |
| Mineral $CO_2$, moles/$m^3$ | 26.364 | 2.471 | 17.931 | 23.620 | 29.986 | 11.504 | 8.257 | 30.808 |
| Dissolved $CO_2$, moles/$m^3$ | 143.263 | 12.708 | 96.818 | 128.382 | 181.564 | 32.302 | 10.136 | 58.218 |
| Solution $CO_2$, moles/$m^3$ | 263.069 | 57.368 | 194.681 | 242.898 | 39.314 | 195.012 | 41.397 | 281.936 |
| Total $CO_2$, moles/$m^3$ | 432.697 | 72.547 | 309.431 | 394.901 | 250.864 | 238.818 | 59.789 | 370.962 |

Continued…

**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$ft^3$ | 0.747 | 0.070 | 0.508 | 0.669 | 0.849 | 0.326 | 0.234 | 0.872 |
| Dissolved $CO_2$, moles/$ft^3$ | 4.057 | 0.360 | 2.742 | 3.635 | 5.141 | 0.915 | 0.287 | 1.649 |
| Solution $CO_2$, moles/$ft^3$ | 7.449 | 1.624 | 5.513 | 6.878 | 1.113 | 5.522 | 1.172 | 7.984 |
| Total $CO_2$, moles/$ft^3$ | 12.253 | 2.054 | 8.762 | 11.182 | 7.104 | 6.763 | 1.693 | 10.505 |
| Mineral $CO_2$, kg/$m^3$ | 1.160 | 0.109 | 0.789 | 1.040 | 1.320 | 0.506 | 0.363 | 1.356 |
| Dissolved $CO_2$, kg/$m^3$ | 6.305 | 0.559 | 4.261 | 5.650 | 7.991 | 1.422 | 0.446 | 2.562 |
| Solution $CO_2$, kg/$m^3$ | 11.578 | 2.525 | 8.568 | 10.690 | 1.730 | 8.582 | 1.822 | 12.408 |
| Total $CO_2$, kg/$m^3$ | 19.043 | 3.193 | 13.618 | 17.380 | 11.041 | 10.510 | 2.631 | 16.326 |
| Mineral $CO_2$, lb/$ft^3$ | 0.072 | 0.007 | 0.049 | 0.065 | 0.082 | 0.032 | 0.023 | 0.085 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.394 | 0.035 | 0.266 | 0.353 | 0.499 | 0.089 | 0.028 | 0.160 |
| Solution $CO_2$, lb/$ft^3$ | 0.723 | 0.158 | 0.535 | 0.667 | 0.108 | 0.536 | 0.114 | 0.775 |
| Total $CO_2$, lb/$ft^3$ | 1.189 | 0.199 | 0.850 | 1.085 | 0.689 | 0.656 | 0.164 | 1.019 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 221.9 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 0.755 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 3.805 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 6.499 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 11.059 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.047 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.238 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.406 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.690 | | | | | | | |

Continued…

**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | |
| pH | −1.007 | −0.678 | −0.977 | −0.997 | −1.865 | −0.605 | −0.766 | −0.688 |
| pE | 0.762 | −0.258 | 0.998 | 1.067 | 2.179 | 0.910 | 1.098 | 0.980 |
| Activity | −0.038 | −0.067 | −0.039 | −0.038 | −0.018 | −0.071 | −0.080 | −0.075 |
| Ionic Strength | 0.701 | 1.607 | 0.756 | 0.721 | 0.092 | 1.522 | 1.930 | 1.686 |
| Total Solution $CO_2$, moles | 2.273 | 4.183 | 2.398 | 2.318 | 1.084 | 4.445 | 4.102 | 4.111 |
| Solution, moles | | | | | | | | |
| Al | −6.693E-08 | −8.656E-08 | −6.660E-08 | −6.686E-08 | −3.786E-08 | −4.533E-08 | −1.835E-07 | −8.150E-08 |
| C | 2.270E+00 | 5.816E+00 | 2.394E+00 | 2.315E+00 | 1.084E+00 | 3.424E+00 | 1.085E+01 | 4.936E+00 |
| Ca | −7.373E-02 | −7.374E-02 | −7.373E-02 | −7.373E-02 | −7.354E-02 | −7.368E-02 | −7.374E-02 | −7.374E-02 |
| Cl | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Fe | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 4.822E-05 | 1.729E-04 | 7.927E-05 |
| K | 9.565E-02 | 2.205E-03 | 6.661E-02 | 8.490E-02 | 1.913E-02 | 4.911E-04 | 4.231E-03 | 2.180E-03 |
| Mg | 7.615E-01 | 2.463E+00 | 8.410E-01 | 7.894E-01 | 1.604E-01 | 1.637E+00 | 5.057E+00 | 2.389E+00 |
| Na | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| S | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.552E-01 | 1.020E+00 | 4.498E-01 |
| Si | −2.560E-05 | −3.870E-05 | −2.620E-05 | −2.590E-05 | −2.470E-05 | −2.090E-05 | −6.700E-05 | −3.420E-05 |
| Ti | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ Funston | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.152 | 1.260 | 0.308 | 0.241 | 0.000 | 0.000 | 2.560 | 0.762 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ Funston | 294.700 | 294.700 | 294.700 | 294.700 | 294.700 | 294.700 | 294.700 | 294.700 |
| Dolomite | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | –0.049 | –0.570 | 0.000 | –0.310 |
| Maximum Microcline | 0.033 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.048 | 0.000 | 0.033 | 0.043 | 0.059 | 0.570 | 0.000 | 0.310 |
| Phlogopite | –0.329 | –1.270 | –0.407 | –0.368 | –0.078 | –0.570 | –2.560 | –1.075 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.078 | –0.510 | –0.225 |
| Quartz | 0.100 | –1.000 | –0.100 | 0.100 | 0.200 | 1.100 | –3.000 | –0.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 0.510 | 0.225 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.152 | 1.260 | 0.308 | 0.241 | 0.000 | 0.000 | 2.600 | 0.762 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ Funston | 2.417 | 5.963 | 2.541 | 2.462 | 1.231 | 3.649 | 11.510 | 5.308 |
| Dolomite | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 |

Continued…

**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | −0.049 | −0.570 | 0.000 | −0.310 |
| Maximum Microcline | 0.033 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.048 | 0.000 | 0.033 | 0.043 | 0.059 | 0.570 | 0.000 | 0.310 |
| Phlogopite | −0.329 | −1.270 | −0.407 | −0.368 | −0.078 | −0.570 | −2.560 | −1.075 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −0.078 | −0.510 | −0.225 |
| Quartz | 0.135 | −1.300 | −0.107 | 0.015 | 0.156 | 1.150 | −2.600 | −0.140 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 0.510 | 0.225 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | −1.61E-04 | −2.15E-06 | −2.92E-06 | −2.92E-06 | −2.87E-06 | −2.92E-06 | −1.12E-06 | −2.91E-06 |
| $CaHCO_3^+$ | −1.11E-04 | −1.86E-05 | −2.79E-05 | −2.79E-05 | 6.37E-06 | −2.82E-05 | −7.95E-06 | −2.58E-05 |
| $CO_2$ | 8.01E-01 | 7.59E-01 | 7.96E-01 | 8.02E-01 | 8.91E-01 | 6.32E-01 | 8.07E-01 | 7.03E-01 |
| $CO_3^{2-}$ | 1.38E-04 | 9.32E-04 | 1.84E-04 | 1.67E-04 | 3.00E-06 | 8.60E-04 | 9.48E-04 | 8.01E-04 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.77E-07 | 3.77E-07 | 3.77E-07 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.23E-17 | 1.27E-17 | 1.30E-17 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.48E-05 | 7.18E-05 | 7.23E-05 |
| $HCO_3^-$ | 6.01E-01 | 1.41E+00 | 6.42E-01 | 6.15E-01 | 9.28E-02 | 1.22E+00 | 1.47E+00 | 1.25E+00 |
| $MgCO_3$ | 1.78E-03 | 1.30E-02 | 2.17E-03 | 1.91E-03 | 1.83E-05 | 1.57E-02 | 1.31E-02 | 1.30E-02 |
| $MgHCO_3^+$ | 4.91E-01 | 1.44E+00 | 5.55E-01 | 5.13E-01 | 3.66E-02 | 1.61E+00 | 1.49E+00 | 1.49E+00 |
| $NaCO_3^-$ | 3.82E-05 | 1.34E-04 | 4.36E-05 | 4.01E-05 | 8.54E-07 | 2.14E-04 | 8.01E-05 | 1.42E-04 |
| $NaHCO_3$ | 3.78E-01 | 5.54E-01 | 4.01E-01 | 3.86E-01 | 6.32E-02 | 9.67E-01 | 3.25E-01 | 6.49E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 0.510 | 0.225 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.147 | 0.147 | 0.147 | 0.147 | 0.147 | 0.225 | 0.657 | 0.372 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.801 | 0.759 | 0.796 | 0.802 | 0.891 | 0.632 | 0.807 | 0.703 |
| Solution $CO_2$, moles/kg $H_2O$ | 1.471 | 3.424 | 1.601 | 1.516 | 0.193 | 3.814 | 3.295 | 3.407 |
| Total $CO_2$, moles/kg $H_2O$ | 2.420 | 4.330 | 2.545 | 2.465 | 1.230 | 4.671 | 4.759 | 4.482 |
| Water, $g/cm^3$ | 0.179 | 0.017 | 0.122 | 0.160 | 0.204 | 0.051 | 0.013 | 0.083 |
| Water, $kg/m^3$ | 178.766 | 16.752 | 121.585 | 160.158 | 203.821 | 51.127 | 12.564 | 82.755 |

Continued…

**Table B-24. Summary of ND 6264 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, moles/$m^3$ | 26.360 | 2.471 | 17.928 | 23.616 | 29.977 | 11.498 | 8.257 | 30.808 |
| Dissolved $CO_2$, moles/$m^3$ | 143.258 | 12.708 | 96.815 | 128.379 | 181.560 | 32.301 | 10.135 | 58.217 |
| Solution $CO_2$, moles/$m^3$ | 263.015 | 57.364 | 194.643 | 242.848 | 39.254 | 194.997 | 41.395 | 281.911 |
| Total $CO_2$, moles/$m^3$ | 432.633 | 72.542 | 309.387 | 394.843 | 250.790 | 238.796 | 59.787 | 370.935 |
| Mineral $CO_2$, moles/$ft^3$ | 0.746 | 0.070 | 0.508 | 0.669 | 0.849 | 0.326 | 0.234 | 0.872 |
| Dissolved $CO_2$, moles/$ft^3$ | 4.057 | 0.360 | 2.742 | 3.635 | 5.141 | 0.915 | 0.287 | 1.649 |
| Solution $CO_2$, moles/$ft^3$ | 7.448 | 1.624 | 5.512 | 6.877 | 1.112 | 5.522 | 1.172 | 7.983 |
| Total $CO_2$, moles/$ft^3$ | 12.251 | 2.054 | 8.761 | 11.181 | 7.102 | 6.762 | 1.693 | 10.504 |
| Mineral $CO_2$, kg/$m^3$ | 1.160 | 0.109 | 0.789 | 1.039 | 1.319 | 0.506 | 0.363 | 1.356 |
| Dissolved $CO_2$, kg/$m^3$ | 6.305 | 0.559 | 4.261 | 5.650 | 7.990 | 1.422 | 0.446 | 2.562 |
| Solution $CO_2$, kg/$m^3$ | 11.575 | 2.525 | 8.566 | 10.688 | 1.728 | 8.582 | 1.822 | 12.407 |
| Total $CO_2$, kg/$m^3$ | 19.040 | 3.193 | 13.616 | 17.377 | 11.037 | 10.509 | 2.631 | 16.325 |
| Mineral $CO_2$, lb/$ft^3$ | 0.072 | 0.007 | 0.049 | 0.065 | 0.082 | 0.032 | 0.023 | 0.085 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.394 | 0.035 | 0.266 | 0.353 | 0.499 | 0.089 | 0.028 | 0.160 |
| Solution $CO_2$, lb/$ft^3$ | 0.723 | 0.158 | 0.535 | 0.667 | 0.108 | 0.536 | 0.114 | 0.775 |
| Total $CO_2$, lb/$ft^3$ | 1.189 | 0.199 | 0.850 | 1.085 | 0.689 | 0.656 | 0.164 | 1.019 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 221.9 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 0.755 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 3.805 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 6.498 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 11.058 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.047 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.238 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.406 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.690 | | | | | | | |

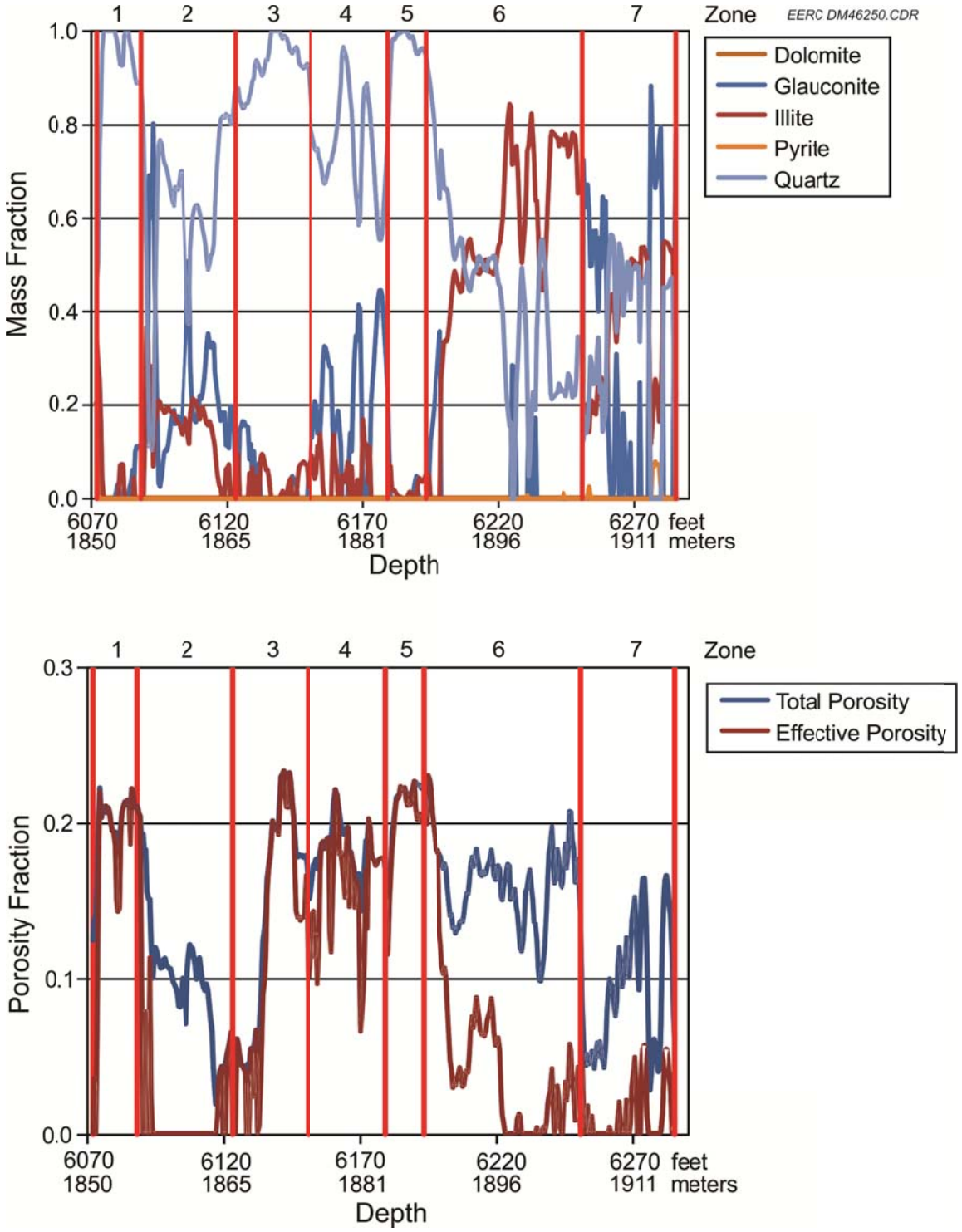



Figure B-5. ND 6264 mineral composition and porosity as a function of depth.

**ND 9622**

The water composition used for ND 9622 is from the ND 6436 well 64 miles (103 km) to the east. Mineral data were available for 70% of the COSS represented in this well. The total aquifer thickness is not known, as the well did not penetrate into the Precambrian.

Aquifer Zones 8 and 9 have very low porosities of 0.002 and 0.001, respectively. Other porosities range from 0.005 to 0.100. Zones 3 and 6 are dominated by quartz. Quartz and dolomite are the major minerals in Zones 1, 4, and 8. Glauconite is present in moderate amounts in Zones 2 and 7. The narrow Zone 5 contains ankerite, calcite, and dolomite in approximately equal amounts, and Zone 9 is dominated by quartz with some dolomite and illite. Little or no pyrite is present.

The PHREEQC calculations for Zone 9 did not converge. This thickness has been omitted from the calculation of the weighted average for $CO_2$ interactions. Zone 2 has the highest degree of reaction. Celadonite (glauconite) dissolves as does a significant portion of the calcite and illite, while a significant amount of dolomite forms. Muscovite and quartz also increase greatly. The increase in dolomite is small for the other zones. Zones 7 and 8 also show large decreases in celadonite and illite, with increases in muscovite and quartz. However, little dolomite is formed in these zones. Little more than half of the celadonite is predicted to dissolve in Zone 7.

The amount of $CO_2$ dissolved in the formation water ranges from 0.8 to 1.1 moles/kg (35.2 to 48.4 g/kg). Although Zone 2 has a very high amount of $CO_2$ reacting (106.8 kg/m$^3$, 6.67 lb/ft$^3$), the weighted average for the zone is 18.4 kg/m$^3$ (1.15 lb/ft$^3$).

## Table B-25. Average Mineral and Porosity Values for the ND 9622 Aquifer Zones

Well Name: ND 9622
API Identification: 33-023-00221-0000
State Identification: ND 9622

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 11,117.0 | 3388.5 | Average | 0.055 | 0.054 | 0.000 | 0.000 | 0.000 | 0.193 | 0.000 | 0.009 | 0.000 | 0.000 | 0.000 | 0.004 | 0.794 | 0.000 |
| End | 11,141.0 | 3395.8 | Minimum | 0.011 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.574 | 0.000 |
| Thickness | 24.0 | 7.3 | Maximum | 0.105 | 0.105 | 0.000 | 0.000 | 0.000 | 0.426 | 0.000 | 0.135 | 0.000 | 0.000 | 0.000 | 0.037 | 1.000 | 0.000 |
| Number of Values | 49 | | Standard deviation | 0.021 | 0.022 | 0.000 | 0.000 | 0.000 | 0.168 | 0.000 | 0.027 | 0.000 | 0.000 | 0.000 | 0.009 | 0.159 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 11,141.0 | 3395.8 | Average | 0.039 | 0.024 | 0.000 | 0.339 | 0.000 | 0.000 | 0.322 | 0.187 | 0.000 | 0.000 | 0.000 | 0.000 | 0.151 | 0.000 |
| End | 11,170.0 | 3404.6 | Minimum | 0.016 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.066 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 29.0 | 8.8 | Maximum | 0.078 | 0.063 | 0.000 | 0.934 | 0.000 | 0.000 | 0.929 | 0.325 | 0.000 | 0.000 | 0.000 | 0.007 | 0.730 | 0.000 |
| Number of Values | 57 | | Standard deviation | 0.016 | 0.015 | 0.000 | 0.327 | 0.000 | 0.000 | 0.317 | 0.059 | 0.000 | 0.000 | 0.000 | 0.001 | 0.243 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 11,170.0 | 3404.6 | Average | 0.086 | 0.086 | 0.000 | 0.010 | 0.000 | 0.060 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.053 | 0.874 | 0.000 |
| End | 11,218.0 | 3419.3 | Minimum | 0.041 | 0.041 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 48.0 | 14.6 | Maximum | 0.127 | 0.127 | 0.000 | 0.971 | 0.000 | 0.301 | 0.000 | 0.051 | 0.000 | 0.000 | 0.000 | 0.134 | 1.000 | 0.000 |
| Number of Values | 96 | | Standard deviation | 0.022 | 0.023 | 0.000 | 0.099 | 0.000 | 0.091 | 0.000 | 0.011 | 0.000 | 0.000 | 0.000 | 0.035 | 0.119 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 11,218.0 | 3419.3 | Average | 0.070 | 0.070 | 0.000 | 0.000 | 0.000 | 0.428 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.569 | 0.000 |
| End | 11,240.0 | 3426.0 | Minimum | 0.042 | 0.042 | 0.000 | 0.000 | 0.000 | 0.212 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.498 | 0.000 |
| Thickness | 22.0 | 6.7 | Maximum | 0.126 | 0.126 | 0.000 | 0.000 | 0.000 | 0.502 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.037 | 0.768 | 0.000 |
| Number of Values | 46 | | Standard deviation | 0.023 | 0.023 | 0.000 | 0.000 | 0.000 | 0.075 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.008 | 0.071 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 11,240.0 | 3426.0 | Average | 0.100 | 0.100 | 0.221 | 0.298 | 0.000 | 0.304 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.173 | 0.000 |
| End | 11,246.0 | 3427.8 | Minimum | 0.053 | 0.053 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 6.0 | 1.8 | Maximum | 0.160 | 0.160 | 1.000 | 1.000 | 0.000 | 1.000 | 0.047 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.996 | 0.000 |
| Number of Values | 10 | | Standard deviation | 0.035 | 0.035 | 0.351 | 0.369 | 0.000 | 0.470 | 0.015 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.327 | 0.000 |

Continued…

## Table B-25. Average Mineral and Porosity Values for the ND 9622 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 11,246.0 | 3427.8 | Average | 0.035 | 0.031 | 0.000 | 0.000 | 0.000 | 0.000 | 0.009 | 0.040 | 0.000 | 0.000 | 0.000 | 0.006 | 0.945 | 0.000 |
| End | 11,260.0 | 3432.1 | Minimum | 0.019 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.519 | 0.000 |
| Thickness | 14.0 | 4.3 | Maximum | 0.054 | 0.054 | 0.000 | 0.000 | 0.000 | 0.000 | 0.261 | 0.262 | 0.000 | 0.000 | 0.000 | 0.044 | 1.000 | 0.000 |
| Number of Values | 30 | | Standard deviation | 0.009 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.048 | 0.085 | 0.000 | 0.000 | 0.000 | 0.012 | 0.111 | 0.000 |
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 11,260.0 | 3432.1 | Average | 0.016 | 0.005 | 0.000 | 0.000 | 0.000 | 0.002 | 0.118 | 0.128 | 0.000 | 0.000 | 0.000 | 0.022 | 0.731 | 0.000 |
| End | 11,268.0 | 3434.5 | Minimum | 0.010 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.317 | 0.000 |
| Thickness | 8.0 | 2.4 | Maximum | 0.028 | 0.017 | 0.000 | 0.000 | 0.000 | 0.029 | 0.633 | 0.251 | 0.000 | 0.000 | 0.000 | 0.086 | 0.871 | 0.000 |
| Number of Values | 16 | | Standard deviation | 0.006 | 0.006 | 0.000 | 0.000 | 0.000 | 0.007 | 0.235 | 0.069 | 0.000 | 0.000 | 0.000 | 0.033 | 0.177 | 0.000 |
| Zone 8 | | | | | | | | | | | | | | | | | |
| Start | 11,268.0 | 3434.5 | Average | 0.011 | 0.002 | 0.000 | 0.000 | 0.000 | 0.359 | 0.039 | 0.104 | 0.000 | 0.000 | 0.000 | 0.007 | 0.491 | 0.000 |
| End | 11,304.0 | 3445.5 | Minimum | 0.008 | 0.001 | 0.000 | 0.000 | 0.000 | 0.123 | 0.000 | 0.035 | 0.000 | 0.000 | 0.000 | 0.000 | 0.273 | 0.000 |
| Thickness | 36.0 | 11.0 | Maximum | 0.021 | 0.014 | 0.000 | 0.000 | 0.000 | 0.582 | 0.274 | 0.160 | 0.000 | 0.000 | 0.000 | 0.082 | 0.640 | 0.000 |
| Number of Values | 72 | | Standard deviation | 0.002 | 0.002 | 0.000 | 0.000 | 0.000 | 0.097 | 0.068 | 0.030 | 0.000 | 0.000 | 0.000 | 0.017 | 0.081 | 0.000 |
| Zone 9 | | | | | | | | | | | | | | | | | |
| Start | 11,304.0 | 3445.5 | Average | 0.010 | 0.001 | 0.000 | 0.000 | 0.000 | 0.057 | 0.000 | 0.101 | 0.000 | 0.000 | 0.000 | 0.020 | 0.822 | 0.000 |
| End | 11,329.0 | 3453.1 | Minimum | 0.007 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.561 | 0.000 |
| Thickness | 25.0 | 7.6 | Maximum | 0.017 | 0.014 | 0.000 | 0.000 | 0.000 | 0.368 | 0.000 | 0.136 | 0.000 | 0.000 | 0.000 | 0.059 | 0.901 | 0.000 |
| Number of Values | 49 | | Standard deviation | 0.002 | 0.002 | 0.000 | 0.000 | 0.000 | 0.130 | 0.000 | 0.016 | 0.000 | 0.000 | 0.000 | 0.018 | 0.112 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 11,117.0 | 3388.5 | Average | 0.047 | 0.042 | 0.005 | 0.055 | 0.000 | 0.157 | 0.055 | 0.064 | 0.000 | 0.000 | 0.000 | 0.017 | 0.647 | 0.000 |
| End | 11,329.0 | 3453.1 | Minimum | 0.007 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 212.0 | 64.6 | Maximum | 0.160 | 0.160 | 1.000 | 1.000 | 0.000 | 1.000 | 0.929 | 0.325 | 0.000 | 0.000 | 0.000 | 0.134 | 1.000 | 0.000 |
| Number of Values | 425 | | Standard deviation | 0.035 | 0.038 | 0.061 | 0.184 | 0.000 | 0.197 | 0.167 | 0.076 | 0.000 | 0.000 | 0.000 | 0.029 | 0.297 | 0.000 |

**Table B-26. Summary of ND 9622 Aquifer Minerals and Conditions**

Well Name: ND 9622
API Identification: 33-023-00221-0000
State Identification: ND 9622

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Start, ft | 11,117 | 11,141 | 11,170 | 11,218 | 11,240 | 11,246 | 11,260 | 11,268 | 11,304 | 11,117 |
| End, ft | 11,141 | 11,170 | 11,218 | 11,240 | 11,246 | 11,260 | 11,268 | 11,304 | 11,329 | 11,329 |
| Thickness, ft | 24.0 | 29.0 | 48.0 | 22.0 | 6.0 | 14.0 | 8.0 | 36.0 | 25.0 | 212.0 |
| Start, m | 3388.5 | 3395.8 | 3404.6 | 3419.3 | 3426.0 | 3427.8 | 3432.1 | 3434.5 | 3445.5 | 3388.5 |
| End, m | 3395.8 | 3404.6 | 3419.3 | 3426.0 | 3427.8 | 3432.1 | 3434.5 | 3445.5 | 3453.1 | 3453.1 |
| Thickness, m | 7.3 | 8.8 | 14.6 | 6.7 | 1.8 | 4.3 | 2.4 | 11.0 | 7.6 | 64.6 |
| Temperature, °F | 252.0 | 252.0 | 252.0 | 252.0 | 252.0 | 252.0 | 252.0 | 252.0 | 252.0 | 252.0 |
| Temperature, °C | 122.2 | 122.2 | 122.2 | 122.2 | 122.2 | 122.2 | 122.2 | 122.2 | 122.2 | 122.2 |
| Pressure, psi | 6865 | 6870 | 6876 | 6883 | 6885 | 6887 | 6889 | 6893 | 6898 | 6882 |
| Pressure, kPa | 47,333 | 47,365 | 47,412 | 47,454 | 47,471 | 47,484 | 47,497 | 47,524 | 47,561 | 47,447 |
| Effective Porosity, fraction | 0.054 | 0.024 | 0.086 | 0.070 | 0.100 | 0.031 | 0.005 | 0.002 | 0.001 | 0.042 |
| Mass Fraction | | | | | | | | | | |
| Ankerite | 0.000 | 0.000 | 0.000 | 0.000 | 0.221 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 |
| Calcite | 0.000 | 0.339 | 0.010 | 0.000 | 0.298 | 0.000 | 0.000 | 0.000 | 0.000 | 0.055 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.193 | 0.000 | 0.060 | 0.428 | 0.304 | 0.000 | 0.002 | 0.359 | 0.057 | 0.157 |
| Glauconite | 0.000 | 0.322 | 0.000 | 0.000 | 0.005 | 0.009 | 0.118 | 0.039 | 0.000 | 0.055 |
| Illite | 0.009 | 0.187 | 0.004 | 0.000 | 0.000 | 0.040 | 0.128 | 0.104 | 0.101 | 0.064 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.004 | 0.000 | 0.053 | 0.003 | 0.000 | 0.006 | 0.022 | 0.007 | 0.020 | 0.017 |
| Quartz | 0.794 | 0.151 | 0.874 | 0.569 | 0.173 | 0.945 | 0.731 | 0.491 | 0.822 | 0.647 |
| Smectite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-27. Summary of ND 9622 Aquifer Calculation Results

Well Name: ND 9622
API Identification: 33-023-00221-0000
State Identification: ND 9622

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Start, m | 3388.5 | 3395.8 | 3404.6 | 3419.3 | 3426.0 | 3427.8 | 3432.1 | 3434.5 | 3445.5 | 3388.5 |
| End, m | 3395.8 | 3404.6 | 3419.3 | 3426.0 | 3427.8 | 3432.1 | 3434.5 | 3445.5 | 3453.1 | 3453.1 |
| Thickness, m | 7.3 | 8.8 | 14.6 | 6.7 | 1.8 | 4.3 | 2.4 | 11.0 | 7.6 | 64.6 |
| Start, ft | 11,117.0 | 11,141.0 | 11,170.0 | 11,218.0 | 11,240.0 | 11,246.0 | 11,260.0 | 11,268.0 | 11,304.0 | 11,117.0 |
| End, ft | 11,141.0 | 11,170.0 | 11,218.0 | 11,240.0 | 11,246.0 | 11,260.0 | 11,268.0 | 11,304.0 | 11,329.0 | 11,329.0 |
| Thickness, ft | 24.0 | 29.0 | 48.0 | 22.0 | 6.0 | 14.0 | 8.0 | 36.0 | 25.0 | 212.0 |
| **Minerals Without $CO_2$** | | | | | | | | | | |
| pH | 5.332 | 5.727 | 5.585 | 5.919 | 5.716 | 5.332 | 5.353 | 5.411 | NA | 5.697 |
| pE | –2.008 | –2.426 | –2.259 | –2.704 | –2.415 | –2.009 | –2.000 | –2.085 | NA | –2.395 |
| Activity | 0.850 | 0.887 | 0.849 | 0.848 | 0.848 | 0.851 | 0.924 | 0.919 | NA | 0.858 |
| Ionic Strength | 4.070 | 3.318 | 4.090 | 4.061 | 4.077 | 4.059 | 2.326 | 2.501 | NA | 3.934 |
| Total Solution $CO_2$, moles | 1.165E-03 | 9.680E-04 | 1.329E-03 | 2.016E-04 | 9.068E-04 | 1.167E-03 | 2.164E-03 | 1.393E-03 | NA | 9.256E-04 |
| Solution, moles | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 |
| C | 0.0012 | 0.0014 | 0.0014 | 0.0002 | 0.0009 | 0.0012 | 0.0049 | 0.0029 | NA | 0.0010 |
| Ca | 0.5325 | 0.7312 | 0.7063 | 0.5320 | 0.6563 | 0.5325 | 0.5344 | 0.5334 | NA | 0.7341 |
| Cl | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | NA | 5.9200 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | NA | 0.0000 |
| K | 0.0031 | 0.0395 | 0.0917 | 0.1948 | 0.1948 | 0.0031 | 0.1395 | 0.0058 | NA | 0.0341 |
| Mg | 0.2398 | 0.0231 | 0.0217 | 0.1442 | 0.0202 | 0.2398 | 0.1702 | 0.2378 | NA | 0.0228 |
| Na | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | NA | 4.3740 |
| S | 0.0009 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0009 | 0.0009 | 0.0009 | NA | 0.0008 |
| Si | 0.0013 | 0.0018 | 0.0013 | 0.0013 | 0.0013 | 0.0013 | 0.0029 | 0.0027 | NA | 0.0014 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | 387.100 | 2.967 | 0.000 | 74.100 | 0.000 | 0.000 | 0.000 | NA | 34.260 |
| Celadonite | 0.000 | 85.840 | 0.000 | 0.000 | 0.276 | 1.661 | 140.500 | 105.700 | NA | 8.029 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 6436 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Dolomite | 48.930 | 0.000 | 9.542 | 83.230 | 70.820 | 0.013 | 4.997 | 2258.000 | NA | 54.960 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | 1.126 | 55.820 | 0.298 | 0.000 | 0.000 | 8.472 | 170.100 | 314.600 | NA | 10.440 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Pyrite | 1.698 | 0.118 | 12.850 | 0.967 | 0.084 | 4.176 | 92.600 | 68.460 | NA | 9.106 |
| Quartz | 618.200 | 287.500 | 426.700 | 339.900 | 71.590 | 1288.000 | 6220.000 | 9473.000 | NA | 674.300 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Final Minerals, moles | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | 386.700 | 2.620 | 0.000 | 73.850 | 0.000 | 0.000 | 0.000 | NA | 33.860 |
| Celadonite | 0.000 | 58.320 | 0.024 | 0.000 | 0.275 | 0.000 | 55.580 | 0.000 | NA | 3.210 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 9622 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | |
| Dolomite | 48.930 | 0.198 | 9.715 | 83.230 | 70.940 | 0.012 | 4.995 | 2258.000 | NA | 55.160 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Kaolinite | 0.056 | 0.000 | 0.000 | 0.000 | 0.000 | 1.398 | 0.000 | 34.070 | NA | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.056 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Muscovite | 0.805 | 47.370 | 0.202 | 0.000 | 0.000 | 5.707 | 144.600 | 233.200 | NA | 8.794 |
| Phlogopite | 0.062 | 13.800 | 0.000 | 0.000 | 0.000 | 1.228 | 42.480 | 61.420 | NA | 2.450 |
| Pyrite | 1.698 | 0.118 | 12.850 | 0.967 | 0.084 | 4.176 | 92.600 | 68.460 | NA | 9.106 |
| Quartz | 619.400 | 409.400 | 426.900 | 339.900 | 71.590 | 1301.000 | 6594.000 | 10,040.000 | NA | 696.400 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Change (initial – final), moles | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | –0.397 | –0.347 | 0.000 | –0.248 | 0.000 | 0.000 | 0.000 | NA | –0.403 |
| Celadonite | 0.000 | –27.520 | 0.024 | 0.000 | 0.000 | –1.661 | –84.930 | –105.700 | NA | –4.819 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 9622 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | |
| Dolomite | –0.001 | 0.198 | 0.173 | 0.000 | 0.124 | 0.000 | -0.002 | -0.001 | NA | 0.201 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | –1.126 | –55.820 | –0.298 | 0.000 | 0.000 | –8.472 | –170.100 | –314.600 | NA | –10.440 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Kaolinite | 0.056 | 0.000 | 0.000 | 0.000 | 0.000 | 1.398 | 0.000 | 34.070 | NA | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.056 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Muscovite | 0.805 | 47.370 | 0.202 | 0.000 | 0.000 | 5.707 | 144.600 | 233.200 | NA | 8.794 |
| Phlogopite | 0.062 | 13.800 | 0.000 | 0.000 | 0.000 | 1.228 | 42.480 | 61.420 | NA | 2.450 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Quartz | 1.226 | 121.900 | 0.172 | –0.001 | –0.001 | 12.690 | 374.000 | 571.800 | NA | 22.080 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Final Solution, moles | | | | | | | | | | |
| $CaCO_3$ | 1.423E-06 | 5.447E-06 | 5.447E-06 | 1.834E-06 | 5.447E-06 | 1.423E-06 | 1.704E-06 | 1.443E-06 | NA | 5.447E-06 |
| $CaHCO_3^+$ | 2.014E-04 | 3.290E-04 | 4.293E-04 | 6.718E-05 | 3.182E-04 | 2.014E-04 | 2.603E-04 | 1.908E-04 | NA | 3.364E-04 |
| $CO_2$ | 7.109E-04 | 4.174E-04 | 6.368E-04 | 6.173E-05 | 3.778E-04 | 7.121E-04 | 1.526E-03 | 9.098E-04 | NA | 3.849E-04 |
| $CO_3^{2-}$ | 1.542E-08 | 5.330E-08 | 4.446E-08 | 1.994E-08 | 4.795E-08 | 1.547E-08 | 3.084E-08 | 2.470E-08 | NA | 4.460E-08 |
| $FeCO_3$ | 8.681E-12 | 3.789E-11 | 1.847E-11 | 3.207E-12 | 1.576E-11 | 8.800E-12 | 1.103E-10 | 6.613E-11 | NA | 1.706E-11 |
| $FeCO_3^+$ | 2.836E-22 | 5.013E-22 | 3.378E-22 | 2.115E-23 | 2.018E-22 | 2.874E-22 | 4.161E-21 | 2.032E-21 | NA | 2.312E-22 |
| $FeHCO_3^+$ | 1.189E-08 | 2.215E-08 | 1.408E-08 | 1.137E-09 | 8.911E-09 | 1.205E-08 | 1.632E-07 | 8.465E-08 | NA | 1.020E-08 |
| $HCO_3^-$ | 1.119E-04 | 1.637E-04 | 1.797E-04 | 3.745E-05 | 1.437E-04 | 1.122E-04 | 2.464E-04 | 1.692E-04 | NA | 1.408E-04 |
| $MgCO_3$ | 1.480E-07 | 3.865E-08 | 3.865E-08 | 1.148E-07 | 3.865E-08 | 1.479E-07 | 1.235E-07 | 1.459E-07 | NA | 3.865E-08 |
| $MgHCO_3^+$ | 1.000E-04 | 1.115E-05 | 1.455E-05 | 2.009E-05 | 1.078E-05 | 9.999E-05 | 9.016E-05 | 9.216E-05 | NA | 1.140E-05 |
| $NaCO_3^-$ | 4.175E-10 | 1.150E-09 | 1.205E-09 | 5.400E-10 | 1.299E-09 | 4.176E-10 | 4.875E-10 | 4.145E-10 | NA | 1.154E-09 |
| $NaHCO_3$ | 3.942E-05 | 4.120E-05 | 6.353E-05 | 1.318E-05 | 5.069E-05 | 3.935E-05 | 3.866E-05 | 2.905E-05 | NA | 4.651E-05 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | –3.970E-01 | –3.474E-01 | 0.000E+00 | –2.477E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | NA | –4.033E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | –1.041E-03 | 3.958E-01 | 3.462E-01 | –2.448E-05 | 2.470E-01 | –9.814E-04 | –4.740E-03 | –2.740E-03 | NA | 4.024E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | NA | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | –1.041E-03 | –1.200E-03 | –1.200E-03 | –2.448E-05 | –7.000E-04 | –9.814E-04 | –4.740E-03 | –2.740E-03 | NA | –9.000E-04 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 7.109E-04 | 4.174E-04 | 6.368E-04 | 6.173E-05 | 3.778E-04 | 7.121E-04 | 1.526E-03 | 9.098E-04 | NA | 3.849E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 4.543E-04 | 5.506E-04 | 6.926E-04 | 1.399E-04 | 5.289E-04 | 4.545E-04 | 6.375E-04 | 4.829E-04 | NA | 5.407E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 1.240E-04 | –2.320E-04 | 1.294E-04 | 1.771E-04 | 2.067E-04 | 1.852E-04 | –2.576E-03 | –1.347E-03 | NA | 2.555E-05 |
| Water, g/cm$^3$ | 0.054 | 0.024 | 0.086 | 0.070 | 0.100 | 0.031 | 0.005 | 0.002 | 0.001 | 0.042 |
| Water, kg/m$^3$ | 54.047 | 23.894 | 85.955 | 70.495 | 99.922 | 31.276 | 5.317 | 2.361 | 1.333 | 41.794 |
| Mineral $CO_2$, moles/m$^3$ | –5.627E-02 | –2.867E-02 | –1.031E-01 | –1.726E-03 | –6.995E-02 | –3.069E-02 | –2.520E-02 | –6.468E-03 | NA | –3.761E-02 |
| Dissolved $CO_2$, moles/m$^3$ | 3.842E-02 | 9.973E-03 | 5.474E-02 | 4.352E-03 | 3.775E-02 | 2.227E-02 | 8.114E-03 | 2.148E-03 | NA | 1.609E-02 |
| Solution $CO_2$, moles/m$^3$ | 2.455E-02 | 1.316E-02 | 5.953E-02 | 9.860E-03 | 5.285E-02 | 1.422E-02 | 3.390E-03 | 1.140E-03 | NA | 2.260E-02 |
| Total $CO_2$, moles/m$^3$ | 6.703E-03 | –5.543E-03 | 1.112E-02 | 1.249E-02 | 2.066E-02 | 5.794E-03 | –1.370E-02 | –3.180E-03 | NA | 1.068E-03 |
| Mineral $CO_2$, moles/ft$^3$ | –1.594E-03 | –8.119E-04 | –2.921E-03 | –4.887E-05 | –1.981E-03 | –8.692E-04 | –7.137E-04 | –1.832E-04 | NA | –1.065E-03 |
| Dissolved $CO_2$, moles/ft$^3$ | 1.088E-03 | 2.824E-04 | 1.550E-03 | 1.232E-04 | 1.069E-03 | 6.307E-04 | 2.298E-04 | 6.081E-05 | NA | 4.555E-04 |
| Solution $CO_2$, moles/ft$^3$ | 6.953E-04 | 3.725E-04 | 1.686E-03 | 2.792E-04 | 1.497E-03 | 4.026E-04 | 9.600E-05 | 3.228E-05 | NA | 6.399E-04 |
| Total $CO_2$, moles/ft$^3$ | 1.898E-04 | –1.570E-04 | 3.150E-04 | 3.536E-04 | 5.849E-04 | 1.641E-04 | –3.879E-04 | –9.006E-05 | NA | 3.024E-05 |
| Mineral $CO_2$, kg/m$^3$ | –2.477E-03 | –1.262E-03 | –4.539E-03 | –7.595E-05 | –3.078E-03 | –1.351E-03 | –1.109E-03 | –2.847E-04 | NA | –1.655E-03 |
| Dissolved $CO_2$, kg/m$^3$ | 1.691E-03 | 4.389E-04 | 2.409E-03 | 1.915E-04 | 1.661E-03 | 9.802E-04 | 3.571E-04 | 9.452E-05 | NA | 7.080E-04 |
| Solution $CO_2$, kg/m$^3$ | 1.081E-03 | 5.790E-04 | 2.620E-03 | 4.339E-04 | 2.326E-03 | 6.257E-04 | 1.492E-04 | 5.017E-05 | NA | 9.945E-04 |
| Total $CO_2$, kg/m$^3$ | 2.950E-04 | –2.440E-04 | 4.896E-04 | 5.495E-04 | 9.090E-04 | 2.550E-04 | –6.029E-04 | –1.400E-04 | NA | 4.700E-05 |
| Mineral $CO_2$, lb/ft$^3$ | –1.546E-04 | –7.878E-05 | –2.834E-04 | –4.741E-06 | –1.922E-04 | –8.433E-05 | –6.925E-05 | –1.777E-05 | NA | –1.033E-04 |
| Dissolved $CO_2$, lb/ft$^3$ | 1.056E-04 | 2.740E-05 | 1.504E-04 | 1.196E-05 | 1.037E-04 | 6.119E-05 | 2.229E-05 | 5.900E-06 | NA | 4.420E-05 |
| Solution $CO_2$, lb/ft$^3$ | 6.746E-05 | 3.615E-05 | 1.636E-04 | 2.709E-05 | 1.452E-04 | 3.906E-05 | 9.314E-06 | 3.132E-06 | NA | 6.208E-05 |
| Total $CO_2$, lb/ft$^3$ | 1.842E-05 | –1.523E-05 | 3.056E-05 | 3.430E-05 | 5.675E-05 | 1.592E-05 | –3.764E-05 | –8.738E-06 | NA | 2.934E-06 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Zone 9* | Total |
| Weighted Average of Zones | | | | | | | | | | |
| Total Thickness, m | 57.0 | | | | | | | | | |
| Mineral $CO_2$, $kg/m^3$ | –1.990E-03 | | | | | | | | | |
| Dissolved $CO_2$, $kg/m^3$ | 1.086E-03 | | | | | | | | | |
| Solution $CO_2$, $kg/m^3$ | 1.090E-03 | | | | | | | | | |
| Total $CO_2$, $kg/m^3$ | 1.859E-04 | | | | | | | | | |
| Mineral $CO_2$, $lb/ft^3$ | –1.242E-04 | | | | | | | | | |
| Dissolved $CO_2$, $lb/ft^3$ | 6.780E-05 | | | | | | | | | |
| Solution $CO_2$, $lb/ft^3$ | 6.802E-05 | | | | | | | | | |
| Total $CO_2$, $lb/ft^3$ | 1.160E-05 | | | | | | | | | |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | | | | |
| pH | 3.808 | 4.773 | 4.046 | 3.862 | 4.087 | 5.103 | 5.075 | 5.178 | NA | 4.484 |
| pE | –0.134 | –1.121 | –0.364 | –0.182 | –0.406 | –1.517 | –1.488 | –1.604 | NA | –0.816 |
| Activity | 0.835 | 0.911 | 0.834 | 0.834 | 0.832 | 0.833 | 0.903 | 0.897 | NA | 0.840 |
| Ionic Strength | 4.053 | 1.893 | 4.089 | 4.065 | 4.051 | 4.036 | 2.318 | 2.506 | NA | 3.566 |
| Total Solution $CO_2$, moles | 8.28E-01 | 1.14E+00 | 8.36E-01 | 8.31E-01 | 8.41E-01 | 1.12E+00 | 1.25E+00 | 1.31E+00 | NA | 9.00E-01 |
| Solution, moles | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 |
| C | 0.8300 | 3.0730 | 0.8375 | 0.8317 | 0.8444 | 1.1580 | 2.7990 | 2.7190 | NA | 1.0470 |
| Ca | 0.4189 | 0.0516 | 0.6920 | 0.5361 | 0.5786 | 0.0000 | 0.0000 | 0.0000 | NA | 0.1066 |
| Cl | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | NA | 5.9200 |
| Fe | 0.0006 | 0.0010 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0003 | 0.0002 | NA | 0.0008 |
| K | 0.0994 | 1.5900 | 0.1451 | 0.1948 | 0.3785 | 0.0051 | 0.2740 | 0.0096 | NA | 1.3640 |
| Mg | 0.3127 | 0.0017 | 0.0214 | 0.1483 | 0.0180 | 0.9426 | 0.9059 | 1.1220 | NA | 0.0034 |
| Na | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | NA | 4.3740 |
| S | 0.0020 | 0.0051 | 0.0017 | 0.0018 | 0.0017 | 0.0212 | 0.0319 | 0.0447 | NA | 0.0024 |
| Si | 0.0013 | 0.0035 | 0.0013 | 0.0013 | 0.0013 | 0.0013 | 0.0029 | 0.0027 | NA | 0.0015 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | 387.100 | 2.967 | 0.000 | 74.100 | 0.000 | 0.000 | 0.000 | NA | 34.260 |
| Celadonite | 0.000 | 85.840 | 0.000 | 0.000 | 0.276 | 1.661 | 140.500 | 105.700 | NA | 8.029 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 9622 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | NA | 300.000 |
| Dolomite | 48.930 | 0.000 | 9.542 | 83.230 | 70.820 | 0.013 | 4.997 | 2258.000 | NA | 54.960 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | 1.126 | 55.820 | 0.298 | 0.000 | 0.000 | 8.472 | 170.100 | 314.600 | NA | 10.440 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Pyrite | 1.698 | 0.118 | 12.850 | 0.967 | 0.084 | 4.176 | 92.600 | 68.460 | NA | 9.106 |
| Quartz | 618.200 | 287.500 | 426.700 | 339.900 | 71.590 | 1288.000 | 6220.000 | 9473.000 | NA | 674.300 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Final Minerals, moles | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | 287.700 | 2.610 | 0.000 | 73.650 | 0.000 | 0.000 | 0.000 | NA | 23.910 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 55.910 | 0.000 | NA | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 9622 | 298.900 | 196.500 | 299.100 | 299.200 | 298.800 | 297.800 | 296.100 | 296.200 | NA | 287.700 |
| Dolomite | 49.040 | 99.940 | 9.739 | 83.230 | 71.220 | 0.545 | 5.529 | 2258.000 | NA | 65.740 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Kaolinite | 0.139 | 0.000 | 0.000 | 0.000 | 0.000 | 0.989 | 0.000 | 33.600 | NA | 0.000 |
| Maximum Microcline | 0.000 | 69.790 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 3.665 |
| Muscovite | 0.771 | 48.140 | 0.228 | 0.000 | 0.092 | 6.117 | 144.700 | 233.700 | NA | 9.459 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.816 | 41.950 | 60.950 | NA | 0.000 |
| Pyrite | 1.698 | 0.115 | 12.850 | 0.967 | 0.084 | 4.166 | 92.590 | 68.440 | NA | 9.105 |
| Quartz | 619.500 | 472.400 | 427.100 | 339.900 | 72.420 | 1302.000 | 6594.000 | 10050.000 | NA | 703.600 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.010 | 0.015 | 0.022 | NA | 0.000 |
| Change (initial – final), moles | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | –99.460 | –0.357 | 0.000 | –0.449 | 0.000 | 0.000 | 0.000 | NA | –10.350 |
| Celadonite | 0.000 | –85.840 | 0.000 | 0.000 | –0.276 | –1.661 | –84.600 | –105.700 | NA | –8.029 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 9622 | –1.056 | –103.500 | –0.875 | –0.823 | –1.199 | –2.232 | –3.878 | –3.805 | NA | –12.250 |
| Dolomite | 0.113 | 99.940 | 0.197 | -0.004 | 0.402 | 0.532 | 0.532 | 0.532 | NA | 10.780 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | –1.126 | –55.820 | –0.298 | 0.000 | 0.000 | –8.472 | –170.100 | –314.600 | NA | –10.440 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Kaolinite | 0.139 | 0.000 | 0.000 | 0.000 | 0.000 | 0.989 | 0.000 | 33.600 | NA | 0.000 |
| Maximum Microcline | 0.000 | 69.790 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 3.665 |
| Muscovite | 0.771 | 48.140 | 0.228 | 0.000 | 0.092 | 6.117 | 144.700 | 233.700 | NA | 9.459 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.816 | 41.950 | 60.950 | NA | 0.000 |
| Pyrite | –0.001 | –0.002 | 0.000 | 0.000 | 0.000 | –0.010 | –0.016 | –0.022 | NA | –0.001 |
| Quartz | 1.350 | 184.900 | 0.356 | –0.001 | 0.826 | 13.510 | 374.100 | 572.700 | NA | 29.280 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.010 | 0.015 | 0.022 | NA | 0.000 |
| Final Solution, moles | | | | | | | | | | |
| $CaCO_3$ | 1.107E-06 | 5.447E-06 | 5.447E-06 | 1.820E-06 | 5.447E-06 | 1.224E-09 | 2.525E-09 | 1.284E-09 | NA | 5.447E-06 |
| $CaHCO_3^+$ | 5.242E-03 | 3.232E-03 | 1.486E-02 | 7.600E-03 | 1.357E-02 | 2.939E-07 | 7.323E-07 | 2.903E-07 | NA | 5.652E-03 |
| $CO_2$ | 8.131E-01 | 1.091E+00 | 8.115E-01 | 8.152E-01 | 8.172E-01 | 8.191E-01 | 1.031E+00 | 1.005E+00 | NA | 8.699E-01 |
| $CO_3^{2-}$ | 1.548E-08 | 1.365E-06 | 4.643E-08 | 1.992E-08 | 5.609E-08 | 6.058E-06 | 5.643E-06 | 9.130E-06 | NA | 3.546E-07 |
| $FeCO_3$ | 1.393E-10 | 3.783E-08 | 3.214E-10 | 1.469E-10 | 3.945E-10 | 3.783E-08 | 3.783E-08 | 3.783E-08 | NA | 4.767E-09 |
| $FeCO_3^+$ | 3.411E-19 | 1.105E-17 | 4.618E-19 | 3.218E-19 | 5.165E-19 | 3.838E-18 | 4.647E-18 | 3.519E-18 | NA | 2.526E-18 |
| $FeHCO_3^+$ | 6.388E-06 | 2.173E-04 | 8.488E-06 | 5.940E-06 | 9.510E-06 | 8.794E-05 | 1.062E-04 | 8.277E-05 | NA | 4.787E-05 |
| $HCO_3^-$ | 3.758E-03 | 4.392E-02 | 6.499E-03 | 4.265E-03 | 7.160E-03 | 7.454E-02 | 8.562E-02 | 1.069E-01 | NA | 1.872E-02 |
| $MgCO_3$ | 1.902E-07 | 3.865E-08 | 3.865E-08 | 1.157E-07 | 3.865E-08 | 1.720E-04 | 8.337E-05 | 1.639E-04 | NA | 3.865E-08 |
| $MgHCO_3^+$ | 4.302E-03 | 1.095E-04 | 5.037E-04 | 2.308E-03 | 4.597E-04 | 1.974E-01 | 1.155E-01 | 1.770E-01 | NA | 1.915E-04 |
| $NaCO_3^-$ | 4.190E-10 | 1.916E-08 | 1.256E-09 | 5.391E-10 | 1.512E-09 | 1.604E-07 | 8.889E-08 | 1.515E-07 | NA | 8.610E-09 |
| $NaHCO_3$ | 1.320E-03 | 5.647E-03 | 2.295E-03 | 1.501E-03 | 2.505E-03 | 2.556E-02 | 1.337E-02 | 1.816E-02 | NA | 5.500E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | –99.460 | –0.357 | 0.000 | –0.449 | 0.000 | 0.000 | 0.000 | NA | –10.350 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.226 | 199.880 | 0.395 | –0.008 | 0.804 | 1.064 | 1.064 | 1.064 | NA | 21.560 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.010 | 0.015 | 0.022 | NA | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.226 | 100.421 | 0.037 | –0.008 | 0.355 | 1.074 | 1.079 | 1.086 | NA | 11.210 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.813 | 1.091 | 0.812 | 0.815 | 0.817 | 0.819 | 1.031 | 1.005 | NA | 0.870 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.015 | 0.053 | 0.024 | 0.016 | 0.024 | 0.298 | 0.215 | 0.302 | NA | 0.030 |
| Total $CO_2$, moles/kg $H_2O$ | 1.054 | 101.565 | 0.873 | 0.823 | 1.196 | 2.191 | 2.325 | 2.393 | NA | 12.110 |
| Water, g/cm$^3$ | 0.054 | 0.024 | 0.086 | 0.070 | 0.100 | 0.031 | 0.005 | 0.002 | 0.001 | 0.042 |
| Water, kg/m$^3$ | 54.047 | 23.894 | 85.955 | 70.495 | 99.922 | 31.276 | 5.317 | 2.361 | 1.333 | 41.794 |
| Mineral $CO_2$, moles/m$^3$ | 12.226 | 2399.444 | 3.206 | –0.574 | 35.502 | 33.581 | 5.739 | 2.563 | NA | 468.515 |
| Dissolved $CO_2$, moles/m$^3$ | 43.946 | 26.068 | 69.753 | 57.468 | 81.656 | 25.618 | 5.482 | 2.372 | NA | 36.357 |
| Solution $CO_2$, moles/m$^3$ | 0.791 | 1.270 | 2.078 | 1.105 | 2.369 | 9.313 | 1.142 | 0.714 | NA | 1.259 |
| Total $CO_2$, moles/m$^3$ | 56.962 | 2426.782 | 75.036 | 57.999 | 119.527 | 68.512 | 12.362 | 5.649 | NA | 506.131 |
| Mineral $CO_2$, moles/ft$^3$ | 0.346 | 67.945 | 0.091 | –0.016 | 1.005 | 0.951 | 0.162 | 0.073 | NA | 13.267 |
| Dissolved $CO_2$, moles/ft$^3$ | 1.244 | 0.738 | 1.975 | 1.627 | 2.312 | 0.725 | 0.155 | 0.067 | NA | 1.030 |
| Solution $CO_2$, moles/ft$^3$ | 0.022 | 0.036 | 0.059 | 0.031 | 0.067 | 0.264 | 0.032 | 0.020 | NA | 0.036 |
| Total $CO_2$, moles/ft$^3$ | 1.613 | 68.719 | 2.125 | 1.642 | 3.385 | 1.940 | 0.350 | 0.160 | NA | 14.332 |
| Mineral $CO_2$, kg/m$^3$ | 0.538 | 105.600 | 0.141 | –0.025 | 1.562 | 1.478 | 0.253 | 0.113 | NA | 20.619 |
| Dissolved $CO_2$, kg/m$^3$ | 1.934 | 1.147 | 3.070 | 2.529 | 3.594 | 1.127 | 0.241 | 0.104 | NA | 1.600 |
| Solution $CO_2$, kg/m$^3$ | 0.035 | 0.056 | 0.091 | 0.049 | 0.104 | 0.410 | 0.050 | 0.031 | NA | 0.055 |
| Total $CO_2$, kg/m$^3$ | 2.507 | 106.803 | 3.302 | 2.553 | 5.260 | 3.015 | 0.544 | 0.249 | NA | 22.275 |
| Mineral $CO_2$, lb/ft$^3$ | 0.034 | 6.592 | 0.009 | –0.002 | 0.098 | 0.092 | 0.016 | 0.007 | NA | 1.287 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.121 | 0.072 | 0.192 | 0.158 | 0.224 | 0.070 | 0.015 | 0.007 | NA | 0.100 |
| Solution $CO_2$, lb/ft$^3$ | 0.002 | 0.003 | 0.006 | 0.003 | 0.007 | 0.026 | 0.003 | 0.002 | NA | 0.003 |
| Total $CO_2$, lb/ft$^3$ | 0.156 | 6.667 | 0.206 | 0.159 | 0.328 | 0.188 | 0.034 | 0.016 | NA | 1.391 |
| Weighted Average of Zones | | | | | | | | | | |
| Total Thickness, m | 57.0 | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 16.672 | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 1.742 | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 0.085 | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 18.498 | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 1.041 | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.109 | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.005 | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 1.155 | | | | | | | | | |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | | | |
| pH | –1.524 | –0.954 | –1.539 | –2.057 | –1.629 | –0.229 | –0.278 | –0.233 | NA | –1.213 |
| pE | 1.874 | 1.305 | 1.895 | 2.522 | 2.009 | 0.492 | 0.512 | 0.481 | NA | 1.579 |
| Activity | –0.015 | 0.024 | –0.015 | –0.014 | –0.016 | –0.018 | –0.021 | –0.022 | NA | –0.018 |
| Ionic Strength | –0.017 | –1.425 | –0.001 | 0.004 | –0.026 | –0.023 | –0.008 | 0.005 | NA | –0.368 |
| Total Solution $CO_2$, moles | 0.827 | 1.143 | 0.834 | 0.831 | 0.840 | 1.116 | 1.244 | 1.307 | NA | 0.899 |
| Solution, moles | | | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| C | 0.829 | 3.072 | 0.836 | 0.831 | 0.843 | 1.157 | 2.794 | 2.716 | NA | 1.046 |
| Ca | –0.114 | –0.680 | –0.014 | 0.004 | –0.078 | –0.532 | –0.534 | –0.533 | NA | –0.628 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Fe | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.001 |
| K | 0.096 | 1.550 | 0.053 | 0.000 | 0.184 | 0.002 | 0.135 | 0.004 | NA | 1.330 |
| Mg | 0.073 | –0.021 | 0.000 | 0.004 | –0.002 | 0.703 | 0.736 | 0.884 | NA | –0.019 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| S | 0.001 | 0.004 | 0.001 | 0.001 | 0.001 | 0.020 | 0.031 | 0.044 | NA | 0.002 |
| Si | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Initial Minerals, moles | | | | | | | | | NA | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 9622 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | NA | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Final Minerals, moles | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | –99.000 | –0.010 | 0.000 | –0.200 | 0.000 | 0.000 | 0.000 | NA | –9.950 |
| Celadonite | 0.000 | –58.320 | –0.024 | 0.000 | –0.275 | 0.000 | 0.330 | 0.000 | NA | –3.210 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 9622 | 298.900 | 196.500 | 299.100 | 299.200 | 298.800 | 297.800 | 296.100 | 296.200 | NA | 287.700 |
| Dolomite | 0.110 | 99.742 | 0.024 | 0.000 | 0.280 | 0.533 | 0.534 | 0.000 | NA | 10.580 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Kaolinite | 0.082 | 0.000 | 0.000 | 0.000 | 0.000 | -0.409 | 0.000 | –0.470 | NA | 0.000 |
| Maximum Microcline | 0.000 | 69.790 | –0.056 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 3.665 |
| Muscovite | –0.034 | 0.770 | 0.027 | 0.000 | 0.092 | 0.410 | 0.100 | 0.500 | NA | 0.665 |
| Phlogopite | –0.062 | –13.800 | 0.000 | 0.000 | 0.000 | –0.412 | –0.530 | –0.470 | NA | –2.450 |
| Pyrite | 0.000 | –0.002 | 0.000 | –0.001 | 0.000 | –0.010 | –0.010 | –0.020 | NA | –0.001 |
| Quartz | 0.100 | 63.000 | 0.200 | 0.000 | 0.830 | 1.000 | 0.000 | 10.000 | NA | 7.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.010 | 0.015 | 0.022 | NA | 0.000 |
| Change (initial –final), moles | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Calcite | 0.000 | –99.063 | –0.010 | 0.000 | –0.201 | 0.000 | 0.000 | 0.000 | NA | –9.947 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Celadonite | 0.000 | –58.320 | –0.024 | 0.000 | –0.275 | 0.000 | 0.330 | 0.000 | NA | –3.210 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| $CO_2$ ND 9622 | 1.056 | 103.500 | 0.875 | 0.823 | 1.199 | 2.232 | 3.878 | 3.805 | NA | 12.250 |
| Dolomite | 0.114 | 99.742 | 0.024 | –0.004 | 0.278 | 0.532 | 0.534 | 0.533 | NA | 10.579 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Kaolinite | 0.082 | 0.000 | 0.000 | 0.000 | 0.000 | -0.409 | 0.000 | –0.470 | NA | 0.000 |
| Maximum Microcline | 0.000 | 69.790 | –0.056 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 3.665 |
| Muscovite | –0.034 | 0.770 | 0.027 | 0.000 | 0.092 | 0.410 | 0.100 | 0.500 | NA | 0.665 |
| Phlogopite | –0.062 | –13.800 | 0.000 | 0.000 | 0.000 | –0.412 | –0.530 | –0.470 | NA | –2.450 |
| Pyrite | –0.001 | –0.002 | 0.000 | 0.000 | 0.000 | –0.010 | –0.015 | –0.022 | NA | –0.001 |
| Quartz | 0.124 | 63.000 | 0.184 | 0.000 | 0.827 | 0.820 | 0.100 | 0.900 | NA | 7.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 |
| Siderite | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.010 | 0.015 | 0.022 | NA | 0.000 |
| Final Solution, moles | | | | | | | | | | |
| $CaCO_3$ | –3.160E-07 | 0.000E+00 | 0.000E+00 | –1.400E-08 | 0.000E+00 | –1.422E-06 | –1.701E-06 | –1.442E-06 | NA | 0.000E+00 |
| $CaHCO_3^+$ | 5.041E-03 | 2.903E-03 | 1.443E-02 | 7.533E-03 | 1.325E-02 | –2.011E-04 | –2.596E-04 | –1.905E-04 | NA | 5.316E-03 |
| $CO_2$ | 8.124E-01 | 1.091E+00 | 8.109E-01 | 8.151E-01 | 8.168E-01 | 8.184E-01 | 1.029E+00 | 1.004E+00 | NA | 8.695E-01 |
| $CO_3^{2-}$ | 6.000E-11 | 1.312E-06 | 1.970E-09 | –2.000E-11 | 8.140E-09 | 6.043E-06 | 5.612E-06 | 9.105E-06 | NA | 3.100E-07 |
| $FeCO_3$ | 1.306E-10 | 3.779E-08 | 3.029E-10 | 1.437E-10 | 3.787E-10 | 3.782E-08 | 3.772E-08 | 3.776E-08 | NA | 4.750E-09 |
| $FeCO_3^+$ | 3.408E-19 | 1.105E-17 | 4.615E-19 | 3.218E-19 | 5.163E-19 | 3.838E-18 | 4.643E-18 | 3.517E-18 | NA | 2.526E-18 |
| $FeHCO_3^+$ | 6.376E-06 | 2.173E-04 | 8.474E-06 | 5.939E-06 | 9.501E-06 | 8.793E-05 | 1.060E-04 | 8.269E-05 | NA | 4.786E-05 |
| $HCO_3^-$ | 3.646E-03 | 4.376E-02 | 6.319E-03 | 4.228E-03 | 7.016E-03 | 7.443E-02 | 8.537E-02 | 1.067E-01 | NA | 1.858E-02 |
| $MgCO_3$ | 4.220E-08 | 0.000E+00 | 0.000E+00 | 9.000E-10 | 0.000E+00 | 1.719E-04 | 8.325E-05 | 1.638E-04 | NA | 0.000E+00 |
| $MgHCO_3^+$ | 4.202E-03 | 9.835E-05 | 4.892E-04 | 2.288E-03 | 4.489E-04 | 1.973E-01 | 1.154E-01 | 1.769E-01 | NA | 1.801E-04 |
| $NaCO_3^-$ | 1.500E-12 | 1.801E-08 | 5.100E-11 | –9.000E-13 | 2.130E-10 | 1.600E-07 | 8.840E-08 | 1.511E-07 | NA | 7.456E-09 |
| $NaHCO_3$ | 1.281E-03 | 5.606E-03 | 2.231E-03 | 1.488E-03 | 2.454E-03 | 2.552E-02 | 1.333E-02 | 1.813E-02 | NA | 5.453E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | –99.063 | –0.010 | 0.000 | –0.201 | 0.000 | 0.000 | 0.000 | NA | –9.947 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.227 | 199.484 | 0.048 | –0.008 | 0.557 | 1.065 | 1.069 | 1.067 | NA | 21.158 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.010 | 0.015 | 0.022 | NA | 0.000 |

* Calculation did not converge to a solution.

Continued…

**Table B-27. Summary of ND 9622 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9* | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/kg $H_2O$ | 0.227 | 100.422 | 0.039 | −0.008 | 0.356 | 1.075 | 1.084 | 1.088 | NA | 11.211 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.812 | 1.091 | 0.811 | 0.815 | 0.817 | 0.818 | 1.029 | 1.004 | NA | 0.870 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.014 | 0.053 | 0.023 | 0.016 | 0.023 | 0.297 | 0.214 | 0.302 | NA | 0.030 |
| Total $CO_2$, moles/kg $H_2O$ | 1.054 | 101.566 | 0.873 | 0.823 | 1.196 | 2.190 | 2.327 | 2.394 | NA | 12.110 |
| Water, g/cm$^3$ | 0.054 | 0.024 | 0.086 | 0.070 | 0.100 | 0.031 | 0.005 | 0.002 | 0.001 | 0.042 |
| Water, kg/m$^3$ | 54.047 | 23.894 | 85.955 | 70.495 | 99.922 | 31.276 | 5.317 | 2.361 | 1.333 | 41.794 |
| Mineral $CO_2$, moles/m$^3$ | 12.282 | 2399.473 | 3.309 | –0.572 | 35.572 | 33.611 | 5.764 | 2.569 | NA | 468.552 |
| Dissolved $CO_2$, moles/m$^3$ | 43.907 | 26.058 | 69.698 | 57.463 | 81.618 | 25.596 | 5.474 | 2.370 | NA | 36.341 |
| Solution $CO_2$, moles/m$^3$ | 0.766 | 1.256 | 2.018 | 1.096 | 2.316 | 9.299 | 1.138 | 0.712 | NA | 1.236 |
| Total $CO_2$, moles/m$^3$ | 56.955 | 2426.788 | 75.025 | 57.987 | 119.507 | 68.506 | 12.376 | 5.652 | NA | 506.129 |
| Mineral $CO_2$, moles/ft$^3$ | 0.348 | 67.946 | 0.094 | –0.016 | 1.007 | 0.952 | 0.163 | 0.073 | NA | 13.268 |
| Dissolved $CO_2$, moles/ft$^3$ | 1.243 | 0.738 | 1.974 | 1.627 | 2.311 | 0.725 | 0.155 | 0.067 | NA | 1.029 |
| Solution $CO_2$, moles/ft$^3$ | 0.022 | 0.036 | 0.057 | 0.031 | 0.066 | 0.263 | 0.032 | 0.020 | NA | 0.035 |
| Total $CO_2$, moles/ft$^3$ | 1.613 | 68.719 | 2.124 | 1.642 | 3.384 | 1.940 | 0.350 | 0.160 | NA | 14.332 |
| Mineral $CO_2$, kg/m$^3$ | 0.541 | 105.601 | 0.146 | −0.025 | 1.566 | 1.479 | 0.254 | 0.113 | NA | 20.621 |
| Dissolved $CO_2$, kg/m$^3$ | 1.932 | 1.147 | 3.067 | 2.529 | 3.592 | 1.126 | 0.241 | 0.104 | NA | 1.599 |
| Solution $CO_2$, kg/m$^3$ | 0.034 | 0.055 | 0.089 | 0.048 | 0.102 | 0.409 | 0.050 | 0.031 | NA | 0.054 |
| Total $CO_2$, kg/m$^3$ | 2.507 | 106.803 | 3.302 | 2.552 | 5.259 | 3.015 | 0.545 | 0.249 | NA | 22.275 |
| Mineral $CO_2$, lb/ft$^3$ | 0.034 | 6.592 | 0.009 | –0.002 | 0.098 | 0.092 | 0.016 | 0.007 | NA | 1.287 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.121 | 0.072 | 0.191 | 0.158 | 0.224 | 0.070 | 0.015 | 0.007 | NA | 0.100 |
| Solution $CO_2$, lb/ft$^3$ | 0.002 | 0.003 | 0.006 | 0.003 | 0.006 | 0.026 | 0.003 | 0.002 | NA | 0.003 |
| Total $CO_2$, lb/ft$^3$ | 0.156 | 6.667 | 0.206 | 0.159 | 0.328 | 0.188 | 0.034 | 0.016 | NA | 1.391 |
| Weighted Average of Zones | | | | | | | | | | |
| Total Thickness, m | 57.0 | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 16.674 | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 1.741 | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 0.083 | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 18.498 | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 1.041 | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.109 | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.005 | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 1.155 | | | | | | | | | |

* Calculation did not converge to a solution.

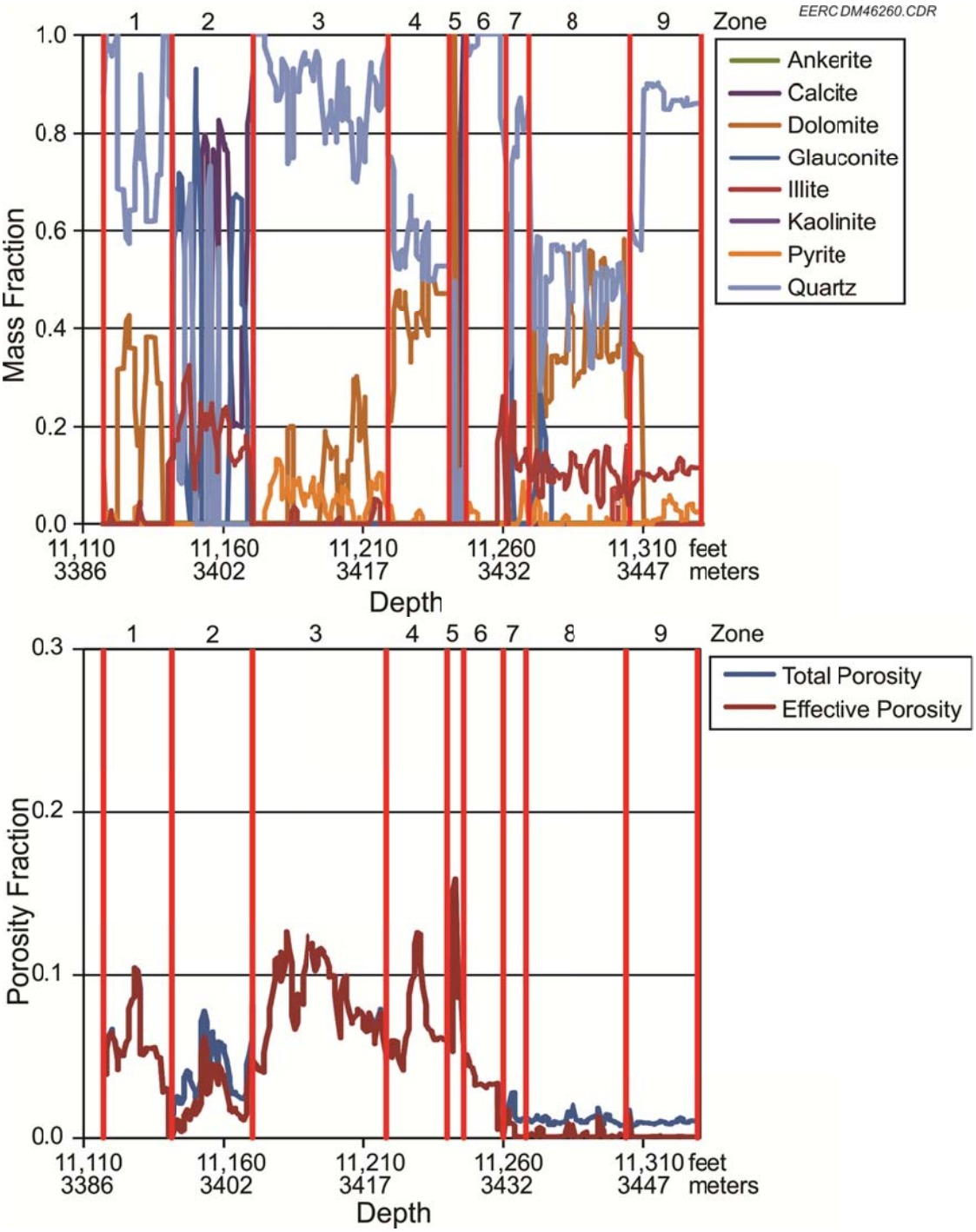



Figure B-6. ND 9622 mineral composition and porosity as a function of depth.

**MT API 21127**

The water composition used for MT API 21127 is from the ND 9622 well 41 miles (66 km) to the east southeast. Mineral data were available for 25% of the COSS represented in this well. The total aquifer thickness is not known, as the well did not penetrate into the Precambrian.

Aquifer Zones 1, 3, 6, and 8 are predominantly quartz, ranging from 92% to 94%. Zone 4 is mainly quartz and dolomite, with quartz predominating. Zone 7 is the opposite, with the ratio of quartz to dolomite reversed. Zone 5 is similar to Zone 7, but with calcite instead of quartz predominating. The thin Zone 2 is exclusively calcite. There are small amounts of pyrite and other minerals. Porosity ranges from 0.014 to 0.080.

The zones are similar in the interaction with $CO_2$. Small additional amounts of calcite, celadonite (glauconite), and illite dissolve, with corresponding small increases in dolomite, kaolinite, and muscovite. Little or no siderite is formed.

The amount of $CO_2$ dissolved in the formation water is approximately 0.65 moles/kg (28.6 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 2.8 kg/m$^3$ (0.2 lb/ft$^3$) of formation rock.

## Table B-28. Average Mineral and Porosity for the MT API 21127 Aquifer Zones

Well Name: MT API 21127
API Identification: 25-019-21127-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 9063.0 | 2762.4 | Average | 0.073 | 0.072 | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 | 0.007 | 0.000 | 0.000 | 0.000 | 0.070 | 0.919 | 0.000 |
| End | 9074.0 | 2765.8 | Minimum | 0.044 | 0.036 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.021 | 0.819 | 0.000 |
| Thickness | 11.0 | 3.4 | Maximum | 0.120 | 0.119 | 0.000 | 0.000 | 0.000 | 0.064 | 0.000 | 0.056 | 0.000 | 0.000 | 0.000 | 0.173 | 0.973 | 0.000 |
| Number of Values | 23 | | Standard deviation | 0.023 | 0.023 | 0.000 | 0.000 | 0.000 | 0.013 | 0.000 | 0.016 | 0.000 | 0.000 | 0.000 | 0.051 | 0.053 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 9074.0 | 2765.8 | Average | 0.040 | 0.040 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| End | 9077.0 | 2766.7 | Minimum | 0.036 | 0.036 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 3.0 | 0.9 | Maximum | 0.045 | 0.045 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Number of Values | 6 | | Standard deviation | 0.003 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 9077.0 | 2766.7 | Average | 0.053 | 0.049 | 0.000 | 0.009 | 0.000 | 0.002 | 0.000 | 0.022 | 0.000 | 0.000 | 0.000 | 0.027 | 0.940 | 0.000 |
| End | 9094.0 | 2771.9 | Minimum | 0.041 | 0.028 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.795 | 0.000 |
| Thickness | 17.0 | 5.2 | Maximum | 0.064 | 0.064 | 0.000 | 0.164 | 0.000 | 0.068 | 0.000 | 0.087 | 0.000 | 0.000 | 0.000 | 0.044 | 0.980 | 0.000 |
| Number of Values | 34 | | Standard deviation | 0.008 | 0.011 | 0.000 | 0.038 | 0.000 | 0.012 | 0.000 | 0.032 | 0.000 | 0.000 | 0.000 | 0.009 | 0.047 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 9094.0 | 2771.9 | Average | 0.023 | 0.023 | 0.000 | 0.000 | 0.000 | 0.383 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.040 | 0.576 | 0.000 |
| End | 9112.5 | 2777.5 | Minimum | 0.006 | 0.006 | 0.000 | 0.000 | 0.000 | 0.117 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.394 | 0.000 |
| Thickness | 18.5 | 5.6 | Maximum | 0.041 | 0.041 | 0.000 | 0.000 | 0.000 | 0.540 | 0.000 | 0.005 | 0.000 | 0.000 | 0.000 | 0.091 | 0.875 | 0.000 |
| Number of Values | 37 | | Standard deviation | 0.011 | 0.010 | 0.000 | 0.000 | 0.000 | 0.119 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.026 | 0.135 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 9112.5 | 2777.5 | Average | 0.019 | 0.019 | 0.000 | 0.562 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.066 | 0.372 | 0.000 |
| End | 9124.0 | 2781.0 | Minimum | 0.008 | 0.008 | 0.000 | 0.215 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 11.5 | 3.5 | Maximum | 0.036 | 0.034 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.120 | 0.746 | 0.000 |
| Number of Values | 23 | | Standard deviation | 0.009 | 0.009 | 0.000 | 0.173 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.039 | 0.187 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 9124.0 | 2781.0 | Average | 0.082 | 0.080 | 0.000 | 0.006 | 0.000 | 0.003 | 0.000 | 0.009 | 0.000 | 0.000 | 0.000 | 0.044 | 0.938 | 0.000 |
| End | 9314.5 | 2839.1 | Minimum | 0.005 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.653 | 0.000 |
| Thickness | 190.5 | 58.1 | Maximum | 0.146 | 0.146 | 0.000 | 0.329 | 0.000 | 0.158 | 0.000 | 0.126 | 0.000 | 0.000 | 0.000 | 0.188 | 1.000 | 0.000 |
| Number of Values | 381 | | Standard deviation | 0.030 | 0.030 | 0.000 | 0.030 | 0.000 | 0.018 | 0.000 | 0.019 | 0.000 | 0.000 | 0.000 | 0.031 | 0.041 | 0.000 |

Continued…

## Table B-28. Average Mineral and Porosity for the MT API 21127 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 9314.5 | 2839.1 | Average | 0.017 | 0.014 | 0.000 | 0.000 | 0.000 | 0.683 | 0.003 | 0.016 | 0.000 | 0.000 | 0.000 | 0.028 | 0.270 | 0.000 |
| End | 9326.0 | 2842.6 | Minimum | 0.005 | 0.005 | 0.000 | 0.000 | 0.000 | 0.188 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 11.5 | 3.5 | Maximum | 0.052 | 0.038 | 0.000 | 0.000 | 0.000 | 1.000 | 0.015 | 0.089 | 0.000 | 0.000 | 0.000 | 0.068 | 0.671 | 0.000 |
| Number of Values | 23 | | Standard deviation | 0.017 | 0.012 | 0.000 | 0.000 | 0.000 | 0.240 | 0.004 | 0.031 | 0.000 | 0.000 | 0.000 | 0.021 | 0.209 | 0.000 |
| Zone 8 | | | | | | | | | | | | | | | | | |
| Start | 9326.0 | 2842.6 | Average | 0.039 | 0.033 | 0.000 | 0.014 | 0.000 | 0.007 | 0.001 | 0.030 | 0.000 | 0.000 | 0.000 | 0.016 | 0.932 | 0.000 |
| End | 9369.5 | 2855.8 | Minimum | 0.019 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.767 | 0.000 |
| Thickness | 43.5 | 13.3 | Maximum | 0.054 | 0.049 | 0.000 | 0.191 | 0.000 | 0.150 | 0.018 | 0.097 | 0.000 | 0.000 | 0.000 | 0.069 | 1.000 | 0.000 |
| Number of Values | 87 | | Standard deviation | 0.007 | 0.009 | 0.000 | 0.039 | 0.000 | 0.027 | 0.003 | 0.028 | 0.000 | 0.000 | 0.000 | 0.017 | 0.048 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 9063.0 | 2762.4 | Average | 0.065 | 0.063 | 0.000 | 0.037 | 0.000 | 0.052 | 0.000 | 0.012 | 0.000 | 0.000 | 0.000 | 0.039 | 0.860 | 0.000 |
| End | 9369.5 | 2855.8 | Minimum | 0.005 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 306.5 | 93.4 | Maximum | 0.146 | 0.146 | 0.000 | 1.000 | 0.000 | 1.000 | 0.018 | 0.126 | 0.000 | 0.000 | 0.000 | 0.188 | 1.000 | 0.000 |
| Number of Values | 614 | | Standard deviation | 0.034 | 0.035 | 0.000 | 0.149 | 0.000 | 0.164 | 0.001 | 0.022 | 0.000 | 0.000 | 0.000 | 0.032 | 0.211 | 0.000 |

**Table B-29. Summary of MT API 21127 Aquifer Minerals and Conditions**

Well Name: MT API 21127
API Identification: 25-019-21127-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Start, ft | 9063 | 9074 | 9077 | 9094 | 9112.5 | 9124 | 9314.5 | 9326 | 9063 |
| End, ft | 9074 | 9077 | 9094 | 9112.5 | 9124 | 9314.5 | 9326 | 9369.5 | 9369.5 |
| Thickness, ft | 11.0 | 3.0 | 17.0 | 18.5 | 11.5 | 190.5 | 11.5 | 43.5 | 306.5 |
| Start, m | 2762.4 | 2765.8 | 2766.7 | 2771.9 | 2777.5 | 2781.0 | 2839.1 | 2842.6 | 2762.4 |
| End, m | 2765.8 | 2766.7 | 2771.9 | 2777.5 | 2781.0 | 2839.1 | 2842.6 | 2855.8 | 2855.8 |
| Thickness, m | 3.4 | 0.9 | 5.2 | 5.6 | 3.5 | 58.1 | 3.5 | 13.3 | 93.4 |
| Temperature, °F | 222.0 | 222.0 | 222.0 | 222.0 | 222.0 | 222.0 | 222.0 | 222.0 | 222.0 |
| Temperature, °C | 105.6 | 105.6 | 105.6 | 105.6 | 105.6 | 105.6 | 105.6 | 105.6 | 105.6 |
| Pressure, psi | 5613 | 5614 | 5616 | 5619 | 5621 | 5639 | 5657 | 5662 | 5639 |
| Pressure, kPa | 38,697 | 38,706 | 38,718 | 38,740 | 38,758 | 38,881 | 39,004 | 39,038 | 38,877 |
| Effective Porosity, fraction | 0.072 | 0.040 | 0.049 | 0.023 | 0.019 | 0.080 | 0.014 | 0.033 | 0.063 |
| Mass Fraction | | | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1.000 | 0.009 | 0.000 | 0.562 | 0.006 | 0.000 | 0.014 | 0.037 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.003 | 0.000 | 0.002 | 0.383 | 0.000 | 0.003 | 0.683 | 0.007 | 0.052 |
| Glauconite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.001 | 0.000 |
| Illite | 0.007 | 0.000 | 0.022 | 0.000 | 0.000 | 0.009 | 0.016 | 0.030 | 0.012 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.070 | 0.000 | 0.027 | 0.040 | 0.066 | 0.044 | 0.028 | 0.016 | 0.039 |
| Quartz | 0.919 | 0.000 | 0.940 | 0.576 | 0.372 | 0.938 | 0.270 | 0.932 | 0.860 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-30. Summary of MT API 21127 Aquifer Calculations Results

Well Name: MT API 21127
API Identification: 25-019-21127-0000

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Start, m | 2762.4 | 2765.8 | 2766.7 | 2771.9 | 2777.5 | 2781.0 | 2839.1 | 2842.6 | 2762.4 |
| End, m | 2765.8 | 2766.7 | 2771.9 | 2777.5 | 2781.0 | 2839.1 | 2842.6 | 2855.8 | 2855.8 |
| Thickness, m | 3.4 | 0.9 | 5.2 | 5.6 | 3.5 | 58.1 | 3.5 | 13.3 | 93.4 |
| Start, ft | 9063.0 | 9074.0 | 9077.0 | 9094.0 | 9112.5 | 9124.0 | 9314.5 | 9326.0 | 9063.0 |
| End, ft | 9074.0 | 9077.0 | 9094.0 | 9112.5 | 9124.0 | 9314.5 | 9326.0 | 9369.5 | 9369.5 |
| Thickness, ft | 11.0 | 3.0 | 17.0 | 18.5 | 11.5 | 190.5 | 11.5 | 43.5 | 306.5 |
| **Minerals Without $CO_2$** | | | | | | | | | |
| pH | 5.925 | 5.625 | 6.337 | 5.925 | 6.337 | 6.337 | 5.924 | 6.336 | 6.337 |
| pE | –2.481 | 0.313 | –2.948 | –2.481 | –2.949 | –2.949 | –2.480 | –2.947 | –2.949 |
| Activity | 0.826 | 0.826 | 0.824 | 0.826 | 0.826 | 0.826 | 0.825 | 0.822 | 0.825 |
| Ionic Strength | 4.134 | 4.132 | 4.166 | 4.126 | 4.133 | 4.140 | 4.148 | 4.200 | 4.145 |
| Total Solution $CO_2$, moles | 6.050E-04 | 3.817E-03 | 4.249E-04 | 6.054E-04 | 4.262E-04 | 4.259E-04 | 6.041E-04 | 4.236E-04 | 4.257E-04 |
| Solution, moles | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0006 | 0.0038 | 0.0004 | 0.0006 | 0.0004 | 0.0004 | 0.0006 | 0.0004 | 0.0004 |
| Ca | 0.1800 | 0.2220 | 0.2211 | 0.1800 | 0.2211 | 0.2211 | 0.1800 | 0.2212 | 0.2211 |
| Cl | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0009 | 0.0000 | 0.0004 | 0.0009 | 0.0004 | 0.0004 | 0.0009 | 0.0003 | 0.0004 |
| Mg | 0.0481 | 0.0073 | 0.0072 | 0.0481 | 0.0072 | 0.0072 | 0.0481 | 0.0072 | 0.0072 |
| Na | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 |
| S | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 |
| Si | 0.0010 | 0.0000 | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 650.600 | 4.833 | 0.000 | 838.900 | 1.893 | 0.000 | 10.720 | 15.060 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.298 | 0.090 | 0.017 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.544 | 0.000 | 0.562 | 246.900 | 0.000 | 0.506 | 730.300 | 2.716 | 11.390 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.702 | 0.000 | 2.920 | 0.086 | 0.171 | 0.734 | 8.360 | 6.104 | 1.274 |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 21.090 | 0.000 | 11.790 | 39.970 | 82.120 | 11.370 | 45.600 | 10.570 | 13.380 |
| Quartz | 549.600 | 0.000 | 807.700 | 1140.000 | 926.000 | 488.800 | 886.600 | 1194.000 | 581.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 650.500 | 4.750 | 0.000 | 838.800 | 1.811 | 0.000 | 10.640 | 14.980 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.547 | 0.039 | 0.606 | 246.900 | 0.041 | 0.550 | 730.300 | 2.761 | 11.440 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.233 | 0.000 | 0.972 | 0.028 | 0.057 | 0.243 | 1.921 | 1.973 | 0.412 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.364 | 0.000 | 1.510 | 0.045 | 0.089 | 0.381 | 5.185 | 3.216 | 0.671 |
| Phlogopite | 0.057 | 0.000 | 0.241 | 0.005 | 0.013 | 0.059 | 1.127 | 0.537 | 0.110 |
| Pyrite | 21.090 | 0.000 | 11.790 | 39.970 | 82.120 | 11.370 | 45.600 | 10.570 | 13.380 |
| Quartz | 550.400 | 0.000 | 810.700 | 1140.000 | 926.100 | 489.500 | 898.200 | 1201.000 | 583.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | –0.077 | –0.083 | 0.000 | –0.079 | –0.082 | 0.000 | –0.083 | –0.082 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –1.298 | –0.090 | –0.017 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Dolomite | 0.003 | 0.039 | 0.045 | 0.003 | 0.041 | 0.045 | 0.003 | 0.045 | 0.045 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –0.702 | 0.000 | –2.920 | –0.086 | –0.171 | –0.734 | –8.360 | –6.104 | –1.274 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.233 | 0.000 | 0.972 | 0.028 | 0.057 | 0.243 | 1.921 | 1.973 | 0.412 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.364 | 0.000 | 1.510 | 0.045 | 0.089 | 0.381 | 5.185 | 3.216 | 0.671 |
| Phlogopite | 0.057 | 0.000 | 0.241 | 0.005 | 0.013 | 0.059 | 1.127 | 0.537 | 0.110 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.728 | 0.000 | 3.020 | 0.091 | 0.177 | 0.762 | 11.670 | 6.521 | 1.359 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | |
| $CaCO_3$ | 2.16E-06 | 6.18E-06 | 6.18E-06 | 2.16E-06 | 6.18E-06 | 6.18E-06 | 2.16E-06 | 6.18E-06 | 6.18E-06 |
| $CaHCO_3^+$ | 8.11E-05 | 4.63E-04 | 8.98E-05 | 8.11E-05 | 8.98E-05 | 8.98E-05 | 8.10E-05 | 8.97E-05 | 8.98E-05 |
| $CO_2$ | 2.21E-04 | 2.05E-03 | 7.66E-05 | 2.21E-04 | 7.71E-05 | 7.70E-05 | 2.20E-04 | 7.62E-05 | 7.69E-05 |
| $CO_3^{2-}$ | 8.60E-08 | 2.00E-07 | 1.99E-07 | 8.61E-08 | 2.01E-07 | 2.00E-07 | 8.56E-08 | 1.97E-07 | 2.00E-07 |
| $FeCO_3$ | 9.80E-12 | 0.00E+00 | 1.65E-11 | 9.89E-12 | 1.71E-11 | 1.70E-11 | 9.63E-12 | 1.58E-11 | 1.69E-11 |
| $FeCO_3^+$ | 1.03E-22 | 0.00E+00 | 5.88E-23 | 1.04E-22 | 6.13E-23 | 6.08E-23 | 1.01E-22 | 5.64E-23 | 6.03E-23 |
| $FeHCO_3^+$ | 3.32E-09 | 0.00E+00 | 2.15E-09 | 3.35E-09 | 2.24E-09 | 2.23E-09 | 3.26E-09 | 2.07E-09 | 2.21E-09 |
| $HCO_3^-$ | 1.63E-04 | 7.56E-04 | 1.46E-04 | 1.63E-04 | 1.47E-04 | 1.47E-04 | 1.62E-04 | 1.44E-04 | 1.46E-04 |
| $MgCO_3$ | 1.52E-07 | 5.30E-08 | 5.30E-08 | 1.52E-07 | 5.30E-08 | 5.30E-08 | 1.52E-07 | 5.30E-08 | 5.30E-08 |
| $MgHCO_3^+$ | 2.43E-05 | 1.69E-05 | 3.28E-06 | 2.43E-05 | 3.28E-06 | 3.28E-06 | 2.43E-05 | 3.28E-06 | 3.28E-06 |
| $NaCO_3^-$ | 6.79E-09 | 1.58E-08 | 1.59E-08 | 6.80E-09 | 1.58E-08 | 1.58E-08 | 6.79E-09 | 1.59E-08 | 1.58E-08 |
| $NaHCO_3$ | 1.14E-04 | 5.28E-04 | 1.03E-04 | 1.14E-04 | 1.03E-04 | 1.03E-04 | 1.14E-04 | 1.04E-04 | 1.03E-04 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | –7.714E-02 | –8.251E-02 | 0.000E+00 | –7.889E-02 | –8.248E-02 | 0.000E+00 | –8.255E-02 | –8.249E-02 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 6.872E-03 | 7.722E-02 | 8.956E-02 | 6.870E-03 | 8.236E-02 | 8.954E-02 | 6.876E-03 | 8.960E-02 | 8.954E-02 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 6.872E-03 | 8.000E-05 | 7.050E-03 | 6.870E-03 | 3.470E-03 | 7.060E-03 | 6.876E-03 | 7.050E-03 | 7.050E-03 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 2.208E-04 | 2.046E-03 | 7.664E-05 | 2.210E-04 | 7.711E-05 | 7.702E-05 | 2.203E-04 | 7.617E-05 | 7.694E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 3.842E-04 | 1.770E-03 | 3.483E-04 | 3.844E-04 | 3.491E-04 | 3.490E-04 | 3.837E-04 | 3.475E-04 | 3.487E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 7.477E-03 | 3.896E-03 | 7.475E-03 | 7.475E-03 | 3.896E-03 | 7.486E-03 | 7.480E-03 | 7.474E-03 | 7.476E-03 |
| Water, g/cm$^3$ | 0.072 | 0.040 | 0.049 | 0.023 | 0.019 | 0.080 | 0.014 | 0.033 | 0.063 |
| Water, kg/m$^3$ | 72.064 | 39.953 | 49.495 | 23.019 | 18.564 | 80.137 | 14.197 | 33.480 | 62.916 |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Total |
| Mineral $CO_2$, moles/$m^3$ | 4.952E-01 | 3.196E-03 | 3.489E-01 | 1.581E-01 | 6.442E-02 | 5.658E-01 | 9.762E-02 | 2.360E-01 | 4.436E-01 |
| Dissolved $CO_2$, moles/$m^3$ | 1.591E-02 | 8.174E-02 | 3.793E-03 | 5.087E-03 | 1.431E-03 | 6.172E-03 | 3.128E-03 | 2.550E-03 | 4.841E-03 |
| Solution $CO_2$, moles/$m^3$ | 2.768E-02 | 7.073E-02 | 1.724E-02 | 8.848E-03 | 6.480E-03 | 2.796E-02 | 5.448E-03 | 1.163E-02 | 2.194E-02 |
| Total $CO_2$, moles/$m^3$ | 5.388E-01 | 1.557E-01 | 3.700E-01 | 1.721E-01 | 7.233E-02 | 5.999E-01 | 1.062E-01 | 2.502E-01 | 4.703E-01 |
| Mineral $CO_2$, moles/$ft^3$ | 1.402E-02 | 9.051E-05 | 9.881E-03 | 4.478E-03 | 1.824E-03 | 1.602E-02 | 2.764E-03 | 6.684E-03 | 1.256E-02 |
| Dissolved $CO_2$, moles/$ft^3$ | 4.506E-04 | 2.315E-03 | 1.074E-04 | 1.441E-04 | 4.054E-05 | 1.748E-04 | 8.857E-05 | 7.221E-05 | 1.371E-04 |
| Solution $CO_2$, moles/$ft^3$ | 7.839E-04 | 2.003E-03 | 4.881E-04 | 2.506E-04 | 1.835E-04 | 7.919E-04 | 1.543E-04 | 3.295E-04 | 6.213E-04 |
| Total $CO_2$, moles/$ft^3$ | 1.526E-02 | 4.408E-03 | 1.048E-02 | 4.873E-03 | 2.048E-03 | 1.699E-02 | 3.007E-03 | 7.085E-03 | 1.332E-02 |
| Mineral $CO_2$, kg/$m^3$ | 2.179E-02 | 1.407E-04 | 1.536E-02 | 6.960E-03 | 2.835E-03 | 2.490E-02 | 4.296E-03 | 1.039E-02 | 1.952E-02 |
| Dissolved $CO_2$, kg/$m^3$ | 7.003E-04 | 3.598E-03 | 1.669E-04 | 2.239E-04 | 6.300E-05 | 2.716E-04 | 1.376E-04 | 1.122E-04 | 2.130E-04 |
| Solution $CO_2$, kg/$m^3$ | 1.218E-03 | 3.113E-03 | 7.587E-04 | 3.894E-04 | 2.852E-04 | 1.231E-03 | 2.398E-04 | 5.120E-04 | 9.656E-04 |
| Total $CO_2$, kg/$m^3$ | 2.371E-02 | 6.851E-03 | 1.628E-02 | 7.573E-03 | 3.183E-03 | 2.640E-02 | 4.674E-03 | 1.101E-02 | 2.070E-02 |
| Mineral $CO_2$, lb/$ft^3$ | 1.361E-03 | 8.781E-06 | 9.587E-04 | 4.345E-04 | 1.770E-04 | 1.554E-03 | 2.682E-04 | 6.485E-04 | 1.219E-03 |
| Dissolved $CO_2$, lb/$ft^3$ | 4.372E-05 | 2.246E-04 | 1.042E-05 | 1.398E-05 | 3.933E-06 | 1.696E-05 | 8.593E-06 | 7.006E-06 | 1.330E-05 |
| Solution $CO_2$, lb/$ft^3$ | 7.606E-05 | 1.943E-04 | 4.736E-05 | 2.431E-05 | 1.780E-05 | 7.683E-05 | 1.497E-05 | 3.196E-05 | 6.028E-05 |
| Total $CO_2$, lb/$ft^3$ | 1.480E-03 | 4.277E-04 | 1.016E-03 | 4.728E-04 | 1.987E-04 | 1.648E-03 | 2.918E-04 | 6.875E-04 | 1.292E-03 |
| Weighted Average of Zones | | | | | | | | | |
| Total Thickness, m | 93.4 | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 1.927E-02 | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.754E-04 | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 9.971E-04 | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 2.055E-02 | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 1.203E-03 | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 1.719E-05 | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 6.225E-05 | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 1.283E-03 | | | | | | | | |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | | | |
| pH | 4.173 | 4.371 | 4.385 | 4.205 | 4.385 | 4.384 | 5.526 | 4.382 | 4.384 |
| pE | –0.364 | 1.593 | –0.577 | –0.390 | –0.577 | –0.576 | –1.853 | –0.574 | –0.576 |
| Activity | 0.814 | 0.815 | 0.813 | 0.814 | 0.814 | 0.814 | 0.806 | 0.813 | 0.814 |
| Ionic Strength | 4.127 | 4.145 | 4.158 | 4.134 | 4.146 | 4.148 | 4.328 | 4.164 | 4.149 |
| Total Solution $CO_2$, moles | 6.71E-01 | 6.81E-01 | 6.80E-01 | 6.72E-01 | 6.82E-01 | 6.85E-01 | 1.14E+00 | 6.87E-01 | 6.85E-01 |
| Solution, moles | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.6688 | 0.6805 | 0.6763 | 0.6712 | 0.6816 | 0.6834 | 1.1690 | 0.6810 | 0.6830 |
| Ca | 0.0875 | 0.2361 | 0.2214 | 0.1657 | 0.2214 | 0.2214 | 0.0000 | 0.2214 | 0.2214 |
| Cl | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 |
| Fe | 0.0002 | 0.0000 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0002 | 0.0002 |
| K | 0.0507 | 0.0000 | 0.0310 | 0.0471 | 0.0312 | 0.0312 | 0.0022 | 0.0310 | 0.0312 |
| Mg | 0.1254 | 0.0078 | 0.0073 | 0.0495 | 0.0073 | 0.0073 | 0.5131 | 0.0073 | 0.0073 |
| Na | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 |
| S | 0.0058 | 0.0053 | 0.0058 | 0.0057 | 0.0058 | 0.0058 | 0.0439 | 0.0058 | 0.0058 |
| Si | 0.0010 | 0.0000 | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 | 0.0010 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 650.600 | 4.833 | 0.000 | 838.900 | 1.893 | 0.000 | 10.720 | 15.060 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.298 | 0.090 | 0.017 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.544 | 0.000 | 0.562 | 246.900 | 0.000 | 0.506 | 730.300 | 2.716 | 11.390 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.702 | 0.000 | 2.920 | 0.086 | 0.171 | 0.734 | 8.360 | 6.104 | 1.274 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 21.090 | 0.000 | 11.790 | 39.970 | 82.120 | 11.370 | 45.600 | 10.570 | 13.380 |
| Quartz | 549.600 | 0.000 | 807.700 | 1140.000 | 926.000 | 488.800 | 886.600 | 1194.000 | 581.900 |

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**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 650.500 | 4.026 | 0.000 | 838.700 | 1.633 | 0.000 | 9.025 | 14.650 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | 299.100 | 299.300 | 298.600 | 299.300 | 299.300 | 299.100 | 298.500 | 297.700 | 299.000 |
| Dolomite | 0.639 | 0.038 | 1.330 | 246.900 | 0.081 | 0.728 | 730.500 | 4.371 | 11.770 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.252 | 0.000 | 0.777 | 0.092 | 0.089 | 0.230 | 1.708 | 1.482 | 0.349 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.370 | 0.000 | 1.721 | 0.004 | 0.071 | 0.409 | 5.399 | 3.722 | 0.750 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.912 | 0.000 | 0.000 |
| Pyrite | 21.090 | 0.000 | 11.790 | 39.970 | 82.120 | 11.370 | 45.590 | 10.570 | 13.380 |
| Quartz | 550.500 | 0.000 | 811.200 | 1140.000 | 926.200 | 489.700 | 898.700 | 1202.000 | 583.500 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.019 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | –0.091 | –0.807 | 0.000 | –0.119 | –0.260 | 0.000 | –1.693 | –0.412 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –1.298 | –0.090 | –0.017 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | –0.853 | –0.662 | –1.399 | –0.699 | –0.721 | –0.860 | –1.547 | –2.290 | –1.011 |
| Dolomite | 0.096 | 0.038 | 0.769 | 0.018 | 0.081 | 0.222 | 0.183 | 1.655 | 0.374 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –0.702 | 0.000 | –2.920 | –0.086 | –0.171 | –0.734 | –8.360 | –6.104 | –1.274 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.252 | 0.000 | 0.777 | 0.092 | 0.089 | 0.230 | 1.708 | 1.482 | 0.349 |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.370 | 0.000 | 1.721 | 0.004 | 0.071 | 0.409 | 5.399 | 3.722 | 0.750 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.912 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.019 | 0.000 | 0.000 |
| Quartz | 0.841 | 0.000 | 3.503 | 0.102 | 0.204 | 0.880 | 12.100 | 7.595 | 1.578 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.019 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | |
| $CaCO_3$ | 9.31E-07 | 6.18E-06 | 6.18E-06 | 2.05E-06 | 6.18E-06 | 6.18E-06 | 7.14E-10 | 6.18E-06 | 6.18E-06 |
| $CaHCO_3^+$ | 1.98E-03 | 8.31E-03 | 8.04E-03 | 4.03E-03 | 8.05E-03 | 8.07E-03 | 6.60E-08 | 8.09E-03 | 8.06E-03 |
| $CO_2$ | 6.51E-01 | 6.50E-01 | 6.49E-01 | 6.51E-01 | 6.51E-01 | 6.53E-01 | 6.40E-01 | 6.55E-01 | 6.53E-01 |
| $CO_3^{2-}$ | 7.82E-08 | 1.95E-07 | 2.07E-07 | 9.08E-08 | 2.08E-07 | 2.08E-07 | 3.97E-05 | 2.07E-07 | 2.08E-07 |
| $FeCO_3$ | 4.67E-10 | 0.00E+00 | 1.23E-09 | 4.49E-10 | 1.25E-09 | 1.25E-09 | 6.81E-08 | 1.22E-09 | 1.24E-09 |
| $FeCO_3^+$ | 6.42E-19 | 0.00E+00 | 1.03E-18 | 5.82E-19 | 1.05E-18 | 1.05E-18 | 2.99E-18 | 1.04E-18 | 1.05E-18 |
| $FeHCO_3^+$ | 8.94E-06 | 0.00E+00 | 1.44E-05 | 7.99E-06 | 1.46E-05 | 1.46E-05 | 5.68E-05 | 1.44E-05 | 1.46E-05 |
| $HCO_3^-$ | 8.36E-03 | 1.32E-02 | 1.36E-02 | 9.01E-03 | 1.36E-02 | 1.37E-02 | 1.86E-01 | 1.36E-02 | 1.37E-02 |
| $MgCO_3$ | 3.52E-07 | 5.30E-08 | 5.30E-08 | 1.60E-07 | 5.30E-08 | 5.30E-08 | 4.59E-04 | 5.30E-08 | 5.30E-08 |
| $MgHCO_3^+$ | 3.18E-03 | 3.04E-04 | 2.94E-04 | 1.35E-03 | 2.94E-04 | 2.95E-04 | 1.81E-01 | 2.95E-04 | 2.95E-04 |
| $NaCO_3^-$ | 6.17E-09 | 1.53E-08 | 1.64E-08 | 7.16E-09 | 1.64E-08 | 1.64E-08 | 3.06E-06 | 1.64E-08 | 1.64E-08 |
| $NaHCO_3$ | 5.83E-03 | 9.21E-03 | 9.54E-03 | 6.29E-03 | 9.53E-03 | 9.55E-03 | 1.30E-01 | 9.60E-03 | 9.55E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | –0.091 | –0.807 | 0.000 | –0.119 | –0.260 | 0.000 | –1.693 | –0.412 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.192 | 0.076 | 1.537 | 0.035 | 0.162 | 0.444 | 0.367 | 3.310 | 0.748 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.019 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.192 | –0.015 | 0.731 | 0.035 | 0.043 | 0.184 | 0.386 | 1.617 | 0.336 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.651 | 0.650 | 0.649 | 0.651 | 0.651 | 0.653 | 0.640 | 0.655 | 0.653 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.019 | 0.031 | 0.031 | 0.021 | 0.032 | 0.032 | 0.498 | 0.032 | 0.032 |
| Total $CO_2$, moles/kg $H_2O$ | 0.862 | 0.666 | 1.411 | 0.708 | 0.726 | 0.869 | 1.524 | 2.304 | 1.020 |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Water, $g/cm^3$ | 0.072 | 0.040 | 0.049 | 0.023 | 0.019 | 0.080 | 0.014 | 0.033 | 0.063 |
| Water, $kg/m^3$ | 72.064 | 39.953 | 49.495 | 23.019 | 18.564 | 80.137 | 14.197 | 33.480 | 62.916 |
| Mineral $CO_2$, $moles/m^3$ | 13.831 | -0.580 | 36.161 | 0.816 | 0.803 | 14.753 | 5.480 | 54.137 | 21.133 |
| Dissolved $CO_2$, $moles/m^3$ | 46.928 | 25.957 | 32.113 | 14.995 | 12.081 | 52.345 | 9.088 | 21.933 | 41.084 |
| Solution $CO_2$, $moles/m^3$ | 1.396 | 1.239 | 1.558 | 0.476 | 0.585 | 2.531 | 7.064 | 1.059 | 1.987 |
| Total $CO_2$, $moles/m^3$ | 62.155 | 26.617 | 69.832 | 16.287 | 13.469 | 69.629 | 21.632 | 77.129 | 64.204 |
| Mineral $CO_2$, $moles/ft^3$ | 0.392 | –0.016 | 1.024 | 0.023 | 0.023 | 0.418 | 0.155 | 1.533 | 0.598 |
| Dissolved $CO_2$, $moles/ft^3$ | 1.329 | 0.735 | 0.909 | 0.425 | 0.342 | 1.482 | 0.257 | 0.621 | 1.163 |
| Solution $CO_2$, $moles/ft^3$ | 0.040 | 0.035 | 0.044 | 0.013 | 0.017 | 0.072 | 0.200 | 0.030 | 0.056 |
| Total $CO_2$, $moles/ft^3$ | 1.760 | 0.754 | 1.977 | 0.461 | 0.381 | 1.972 | 0.613 | 2.184 | 1.818 |
| Mineral $CO_2$, $kg/m^3$ | 0.609 | –0.026 | 1.591 | 0.036 | 0.035 | 0.649 | 0.241 | 2.383 | 0.930 |
| Dissolved $CO_2$, $kg/m^3$ | 2.065 | 1.142 | 1.413 | 0.660 | 0.532 | 2.304 | 0.400 | 0.965 | 1.808 |
| Solution $CO_2$, $kg/m^3$ | 0.061 | 0.055 | 0.069 | 0.021 | 0.026 | 0.111 | 0.311 | 0.047 | 0.087 |
| Total $CO_2$, $kg/m^3$ | 2.735 | 1.171 | 3.073 | 0.717 | 0.593 | 3.064 | 0.952 | 3.394 | 2.826 |
| Mineral $CO_2$, $lb/ft^3$ | 0.038 | –0.002 | 0.099 | 0.002 | 0.002 | 0.041 | 0.015 | 0.149 | 0.058 |
| Dissolved $CO_2$, $lb/ft^3$ | 0.129 | 0.071 | 0.088 | 0.041 | 0.033 | 0.144 | 0.025 | 0.060 | 0.113 |
| Solution $CO_2$, $lb/ft^3$ | 0.004 | 0.003 | 0.004 | 0.001 | 0.002 | 0.007 | 0.019 | 0.003 | 0.005 |
| Total $CO_2$, $lb/ft^3$ | 0.171 | 0.073 | 0.192 | 0.045 | 0.037 | 0.191 | 0.059 | 0.212 | 0.176 |
| Weighted Average of Zones | | | | | | | | | |
| Total Thickness, m | 93.4 | | | | | | | | |
| Mineral $CO_2$, $kg/m^3$ | 0.864 | | | | | | | | |
| Dissolved $CO_2$, $kg/m^3$ | 1.807 | | | | | | | | |
| Solution $CO_2$, $kg/m^3$ | 0.096 | | | | | | | | |
| Total $CO_2$, $kg/m^3$ | 2.768 | | | | | | | | |
| Mineral $CO_2$, $lb/ft^3$ | 0.054 | | | | | | | | |
| Dissolved $CO_2$, $lb/ft^3$ | 0.113 | | | | | | | | |
| Solution $CO_2$, $lb/ft^3$ | 0.006 | | | | | | | | |
| Total $CO_2$, $lb/ft^3$ | 0.173 | | | | | | | | |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | | |
| pH | –1.752 | –1.254 | –1.952 | –1.720 | –1.952 | –1.953 | –0.398 | –1.954 | –1.953 |
| pE | 2.117 | 1.280 | 2.371 | 2.091 | 2.372 | 2.373 | 0.627 | 2.373 | 2.373 |
| Activity | –0.012 | –0.011 | –0.011 | –0.012 | –0.012 | –0.012 | –0.019 | –0.009 | –0.011 |
| Ionic Strength | –0.007 | 0.013 | –0.008 | 0.008 | 0.013 | 0.008 | 0.180 | –0.036 | 0.004 |
| Total Solution $CO_2$, moles | 0.670 | 0.677 | 0.680 | 0.671 | 0.682 | 0.684 | 1.137 | 0.686 | 0.684 |
| Solution, moles | | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 0.668 | 0.677 | 0.676 | 0.671 | 0.681 | 0.683 | 1.168 | 0.681 | 0.683 |
| Ca | –0.093 | 0.014 | 0.000 | –0.014 | 0.000 | 0.000 | –0.180 | 0.000 | 0.000 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.050 | 0.000 | 0.031 | 0.046 | 0.031 | 0.031 | 0.001 | 0.031 | 0.031 |
| Mg | 0.077 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.465 | 0.000 | 0.000 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.039 | 0.000 | 0.000 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | –0.724 | 0.000 | –0.100 | –0.178 | 0.000 | –1.615 | –0.330 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | 299.100 | 299.300 | 298.600 | 299.300 | 299.300 | 299.100 | 298.500 | 297.700 | 299.000 |
| Dolomite | 0.092 | 0.000 | 0.724 | 0.000 | 0.040 | 0.177 | 0.200 | 1.610 | 0.330 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.018 | 0.000 | –0.195 | 0.064 | 0.033 | –0.013 | –0.213 | –0.491 | –0.064 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.007 | 0.000 | 0.211 | –0.041 | –0.017 | 0.028 | 0.214 | 0.506 | 0.079 |
| Phlogopite | –0.057 | 0.000 | –0.241 | –0.005 | –0.013 | –0.059 | –0.215 | –0.537 | –0.110 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.010 | 0.000 | 0.000 |
| Quartz | 0.100 | 0.000 | 0.500 | 0.000 | 0.100 | 0.200 | 0.500 | 1.000 | 0.300 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.019 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | –0.014 | –0.724 | 0.000 | –0.040 | –0.178 | 0.000 | –1.610 | –0.329 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21127 | 0.853 | 0.662 | 1.399 | 0.699 | 0.721 | 0.860 | 1.547 | 2.290 | 1.011 |
| Dolomite | 0.093 | 0.000 | 0.724 | 0.014 | 0.040 | 0.177 | 0.180 | 1.610 | 0.329 |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.018 | 0.000 | –0.195 | 0.064 | 0.033 | –0.013 | –0.213 | –0.491 | –0.064 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.007 | 0.000 | 0.211 | –0.041 | –0.017 | 0.028 | 0.214 | 0.506 | 0.079 |
| Phlogopite | –0.057 | 0.000 | –0.241 | –0.005 | –0.013 | –0.059 | –0.215 | –0.537 | –0.110 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.019 | 0.000 | 0.000 |
| Quartz | 0.113 | 0.000 | 0.483 | 0.011 | 0.027 | 0.118 | 0.430 | 1.074 | 0.219 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.019 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | |
| $CaCO_3$ | –1.23E-06 | 0.00E+00 | 0.00E+00 | –1.14E-07 | 0.00E+00 | 0.00E+00 | –2.16E-06 | 0.00E+00 | 0.00E+00 |
| $CaHCO_3^+$ | 1.90E-03 | 7.85E-03 | 7.95E-03 | 3.95E-03 | 7.96E-03 | 7.98E-03 | –8.10E-05 | 8.00E-03 | 7.97E-03 |
| $CO_2$ | 6.51E-01 | 6.48E-01 | 6.49E-01 | 6.51E-01 | 6.51E-01 | 6.53E-01 | 6.40E-01 | 6.55E-01 | 6.53E-01 |
| $CO_3^{2-}$ | –7.79E-09 | –5.70E-09 | 8.10E-09 | 4.64E-09 | 7.20E-09 | 7.30E-09 | 3.96E-05 | 9.50E-09 | 7.60E-09 |
| $FeCO_3$ | 4.57E-10 | 0.00E+00 | 1.21E-09 | 4.40E-10 | 1.23E-09 | 1.23E-09 | 6.81E-08 | 1.21E-09 | 1.23E-09 |
| $FeCO_3^+$ | 6.42E-19 | 0.00E+00 | 1.03E-18 | 5.82E-19 | 1.05E-18 | 1.05E-18 | 2.99E-18 | 1.04E-18 | 1.05E-18 |
| $FeHCO_3^+$ | 8.94E-06 | 0.00E+00 | 1.44E-05 | 7.99E-06 | 1.46E-05 | 1.46E-05 | 5.68E-05 | 1.44E-05 | 1.46E-05 |
| $HCO_3^-$ | 8.20E-03 | 1.24E-02 | 1.34E-02 | 8.85E-03 | 1.35E-02 | 1.35E-02 | 1.86E-01 | 1.35E-02 | 1.35E-02 |
| $MgCO_3$ | 2.00E-07 | 0.00E+00 | 0.00E+00 | 8.40E-09 | 0.00E+00 | 0.00E+00 | 4.59E-04 | 0.00E+00 | 0.00E+00 |
| $MgHCO_3^+$ | 3.16E-03 | 2.87E-04 | 2.90E-04 | 1.32E-03 | 2.91E-04 | 2.91E-04 | 1.81E-01 | 2.92E-04 | 2.91E-04 |
| $NaCO_3^-$ | –6.26E-10 | –4.80E-10 | 5.30E-10 | 3.64E-10 | 5.40E-10 | 5.40E-10 | 3.05E-06 | 5.30E-10 | 5.40E-10 |
| $NaHCO_3$ | 5.72E-03 | 8.68E-03 | 9.44E-03 | 6.18E-03 | 9.42E-03 | 9.45E-03 | 1.30E-01 | 9.50E-03 | 9.45E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | –0.014 | –0.724 | 0.000 | –0.040 | –0.178 | 0.000 | –1.610 | –0.329 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.185 | –0.001 | 1.448 | 0.029 | 0.080 | 0.355 | 0.360 | 3.220 | 0.658 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.019 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.185 | –0.015 | 0.724 | 0.029 | 0.040 | 0.177 | 0.379 | 1.610 | 0.329 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.651 | 0.648 | 0.649 | 0.651 | 0.651 | 0.653 | 0.640 | 0.655 | 0.653 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.019 | 0.029 | 0.031 | 0.020 | 0.031 | 0.031 | 0.497 | 0.031 | 0.031 |
| Total $CO_2$, moles/kg $H_2O$ | 0.855 | 0.662 | 1.403 | 0.700 | 0.722 | 0.861 | 1.516 | 2.296 | 1.013 |
| Water, $g/cm^3$ | 0.072 | 0.040 | 0.049 | 0.023 | 0.019 | 0.080 | 0.014 | 0.033 | 0.063 |
| Water, $kg/m^3$ | 72.064 | 39.953 | 49.495 | 23.019 | 18.564 | 80.137 | 14.197 | 33.480 | 62.916 |

Continued…

**Table B-30. Summary of MT API 21127 Aquifer Calculations Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$m^3$ | 13.335 | –0.583 | 35.812 | 0.658 | 0.738 | 14.187 | 5.382 | 53.901 | 20.690 |
| Dissolved $CO_2$, moles/$m^3$ | 46.912 | 25.876 | 32.109 | 14.990 | 12.080 | 52.339 | 9.084 | 21.930 | 41.079 |
| Solution $CO_2$, moles/$m^3$ | 1.368 | 1.169 | 1.541 | 0.467 | 0.579 | 2.503 | 7.058 | 1.048 | 1.965 |
| Total $CO_2$, moles/$m^3$ | 61.616 | 26.461 | 69.462 | 16.115 | 13.397 | 69.029 | 21.525 | 76.878 | 63.734 |
| Mineral $CO_2$, moles/$ft^3$ | 0.378 | –0.017 | 1.014 | 0.019 | 0.021 | 0.402 | 0.152 | 1.526 | 0.586 |
| Dissolved $CO_2$, moles/$ft^3$ | 1.328 | 0.733 | 0.909 | 0.424 | 0.342 | 1.482 | 0.257 | 0.621 | 1.163 |
| Solution $CO_2$, moles/$ft^3$ | 0.039 | 0.033 | 0.044 | 0.013 | 0.016 | 0.071 | 0.200 | 0.030 | 0.056 |
| Total $CO_2$, moles/$ft^3$ | 1.745 | 0.749 | 1.967 | 0.456 | 0.379 | 1.955 | 0.610 | 2.177 | 1.805 |
| Mineral $CO_2$, kg/$m^3$ | 0.587 | –0.026 | 1.576 | 0.029 | 0.032 | 0.624 | 0.237 | 2.372 | 0.911 |
| Dissolved $CO_2$, kg/$m^3$ | 2.065 | 1.139 | 1.413 | 0.660 | 0.532 | 2.303 | 0.400 | 0.965 | 1.808 |
| Solution $CO_2$, kg/$m^3$ | 0.060 | 0.051 | 0.068 | 0.021 | 0.025 | 0.110 | 0.311 | 0.046 | 0.086 |
| Total $CO_2$, kg/$m^3$ | 2.712 | 1.165 | 3.057 | 0.709 | 0.590 | 3.038 | 0.947 | 3.383 | 2.805 |
| Mineral $CO_2$, lb/$ft^3$ | 0.037 | –0.002 | 0.098 | 0.002 | 0.002 | 0.039 | 0.015 | 0.148 | 0.057 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.129 | 0.071 | 0.088 | 0.041 | 0.033 | 0.144 | 0.025 | 0.060 | 0.113 |
| Solution $CO_2$, lb/$ft^3$ | 0.004 | 0.003 | 0.004 | 0.001 | 0.002 | 0.007 | 0.019 | 0.003 | 0.005 |
| Total $CO_2$, lb/$ft^3$ | 0.169 | 0.073 | 0.191 | 0.044 | 0.037 | 0.190 | 0.059 | 0.211 | 0.175 |
| Weighted Average of Zones | | | | | | | | | |
| Total Thickness, m | 93.4 | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 0.845 | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.807 | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.095 | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 2.747 | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.053 | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.113 | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.006 | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.171 | | | | | | | | |

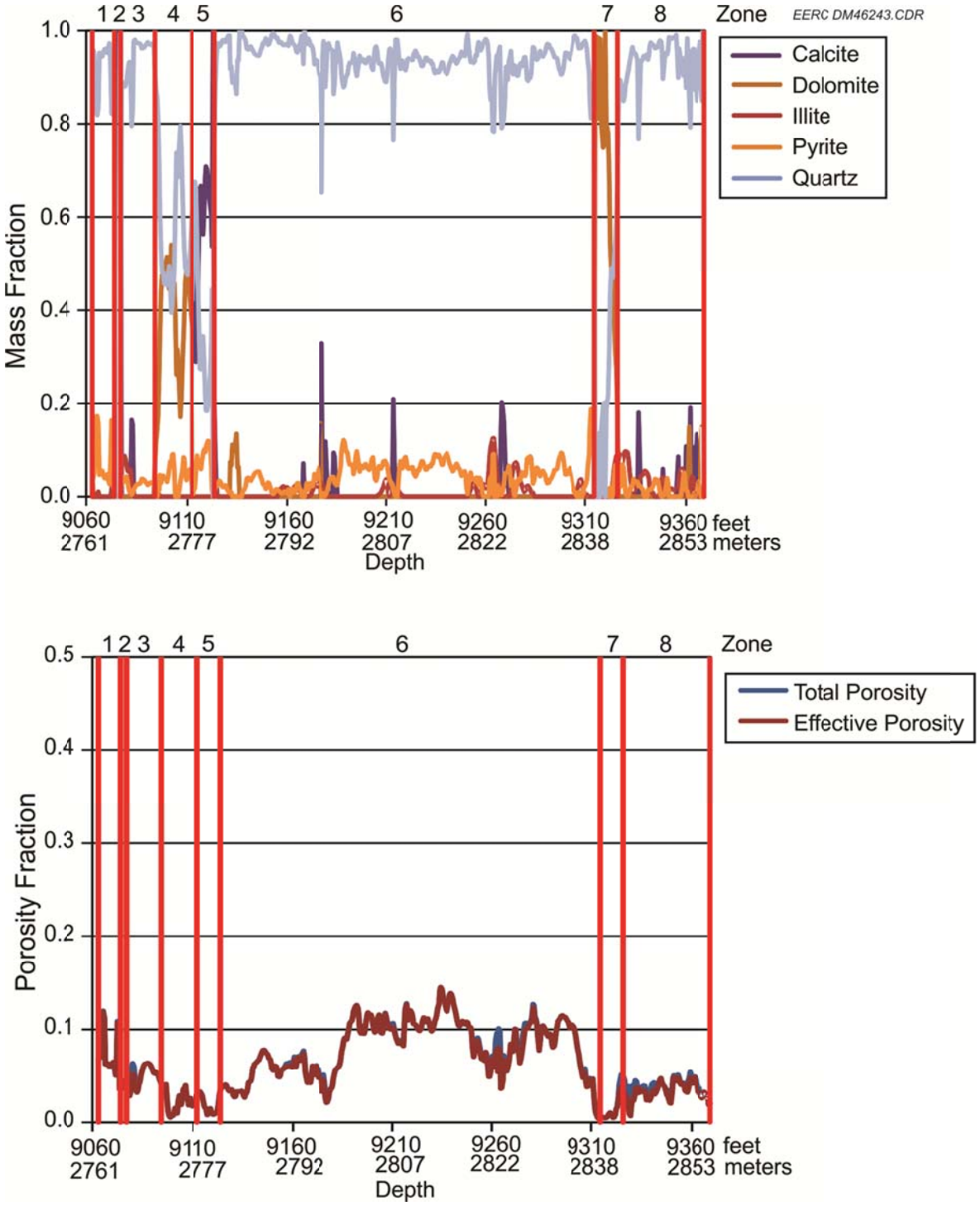



Figure B-7. MT API 21127 mineral composition and porosity as a function of depth.

**MT API 21500**

The water composition was available along with the mineral composition for the MT API 21500 well. Mineral data were available for 90% of the COSS represented in this well. The total aquifer thickness is not known, as the well did not penetrate into the Precambrian.

Aquifer Zone 7 is nearly all quartz, while Zones 1, 2, 3, and 5 are quartz and calcite, with the quartz predominating (56% to 75% quartz). Zones 4 and 6 have similar amounts of illite and quartz. The porosity ranges from 0.034 to 1.100, with the illite–quartz Zones 4 and 6 having the lowest porosity.

Small additional amounts of calcite and kaolinite dissolve, and less phlogopite (biotite) forms. There are commensurate increases in dolomite, quartz, and muscovite. Zone 6 shows the greatest interaction with $CO_2$.

The amount of $CO_2$ dissolved in the formation water is approximately 1.0 moles/kg (44 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 6.8 kg/m$^3$ (0.4 lb/ft$^3$) of formation rock.

## Table B-31. Average Mineral and Porosity for the MT API 21500 Aquifer Zones

Well Name: MT API 21500
API Identification: 25-091-21500-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 10,931.0 | 3331.8 | Average | 0.110 | 0.110 | 0.000 | 0.443 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.557 | 0.000 |
| End | 10,947.0 | 3336.7 | Minimum | 0.085 | 0.085 | 0.000 | 0.271 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.329 | 0.000 |
| Thickness | 16.0 | 4.9 | Maximum | 0.122 | 0.122 | 0.000 | 0.671 | 0.000 | 0.000 | 0.000 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.729 | 0.000 |
| Number of Values | 33 | | Standard deviation | 0.011 | 0.011 | 0.000 | 0.100 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.100 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 10,947.0 | 3336.7 | Average | 0.082 | 0.081 | 0.000 | 0.243 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.747 | 0.000 |
| End | 10,954.0 | 3338.8 | Minimum | 0.055 | 0.050 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.330 | 0.000 |
| Thickness | 7.0 | 2.1 | Maximum | 0.111 | 0.111 | 0.000 | 0.670 | 0.000 | 0.000 | 0.000 | 0.045 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 15 | | Standard deviation | 0.019 | 0.020 | 0.000 | 0.190 | 0.000 | 0.000 | 0.000 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.180 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 10,954.0 | 3338.8 | Average | 0.101 | 0.099 | 0.000 | 0.394 | 0.000 | 0.000 | 0.000 | 0.022 | 0.000 | 0.000 | 0.000 | 0.000 | 0.583 | 0.000 |
| End | 10,958.0 | 3340.0 | Minimum | 0.075 | 0.061 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.453 | 0.000 |
| Thickness | 4.0 | 1.2 | Maximum | 0.114 | 0.114 | 0.000 | 0.547 | 0.000 | 0.000 | 0.000 | 0.136 | 0.000 | 0.000 | 0.000 | 0.000 | 0.864 | 0.000 |
| Number of Values | 8 | | Standard deviation | 0.015 | 0.019 | 0.000 | 0.180 | 0.000 | 0.000 | 0.000 | 0.048 | 0.000 | 0.000 | 0.000 | 0.000 | 0.134 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 10,958.0 | 3340.0 | Average | 0.065 | 0.034 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.298 | 0.000 | 0.000 | 0.000 | 0.000 | 0.702 | 0.000 |
| End | 10,974.0 | 3344.9 | Minimum | 0.053 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.059 | 0.000 | 0.000 | 0.000 | 0.000 | 0.593 | 0.000 |
| Thickness | 16.0 | 4.9 | Maximum | 0.084 | 0.060 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.407 | 0.000 | 0.000 | 0.000 | 0.000 | 0.941 | 0.000 |
| Number of Values | 32 | | Standard deviation | 0.008 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.103 | 0.000 | 0.000 | 0.000 | 0.000 | 0.103 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 10,974.0 | 3344.9 | Average | 0.065 | 0.061 | 0.000 | 0.258 | 0.000 | 0.000 | 0.000 | 0.041 | 0.000 | 0.000 | 0.000 | 0.000 | 0.700 | 0.000 |
| End | 10,986.0 | 3348.5 | Minimum | 0.058 | 0.050 | 0.000 | 0.043 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.508 | 0.000 |
| Thickness | 12.0 | 3.7 | Maximum | 0.077 | 0.077 | 0.000 | 0.479 | 0.000 | 0.000 | 0.000 | 0.111 | 0.000 | 0.000 | 0.000 | 0.000 | 0.877 | 0.000 |
| Number of Values | 24 | | Standard deviation | 0.006 | 0.008 | 0.000 | 0.119 | 0.000 | 0.000 | 0.000 | 0.028 | 0.000 | 0.000 | 0.000 | 0.000 | 0.105 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 10,986.0 | 3348.5 | Average | 0.060 | 0.039 | 0.000 | 0.057 | 0.000 | 0.000 | 0.000 | 0.195 | 0.000 | 0.000 | 0.000 | 0.000 | 0.748 | 0.000 |
| End | 11,000.0 | 3352.8 | Minimum | 0.036 | 0.009 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.387 | 0.000 |
| Thickness | 14.0 | 4.3 | Maximum | 0.103 | 0.103 | 0.000 | 0.387 | 0.000 | 0.000 | 0.000 | 0.269 | 0.000 | 0.000 | 0.000 | 0.000 | 0.879 | 0.000 |
| Number of Values | 28 | | Standard deviation | 0.017 | 0.023 | 0.000 | 0.110 | 0.000 | 0.000 | 0.000 | 0.067 | 0.000 | 0.000 | 0.000 | 0.000 | 0.104 | 0.000 |

Continued. . .

## Table B-31. Average Mineral and Porosity for the MT API 21500 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 11,000.0 | 3352.8 | Average | 0.110 | 0.108 | 0.000 | 0.027 | 0.000 | 0.000 | 0.000 | 0.026 | 0.000 | 0.000 | 0.000 | 0.020 | 0.928 | 0.000 |
| End | 11,031.0 | 3362.3 | Minimum | 0.084 | 0.080 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.715 | 0.000 |
| Thickness | 31.0 | 9.4 | Maximum | 0.141 | 0.141 | 0.000 | 0.231 | 0.000 | 0.000 | 0.000 | 0.094 | 0.000 | 0.000 | 0.000 | 0.090 | 1.000 | 0.000 |
| Number of Values | 61 | | Standard deviation | 0.012 | 0.014 | 0.000 | 0.057 | 0.000 | 0.000 | 0.000 | 0.029 | 0.000 | 0.000 | 0.000 | 0.023 | 0.070 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 10,931.0 | 3331.8 | Average | 0.088 | 0.079 | 0.000 | 0.154 | 0.000 | 0.000 | 0.000 | 0.089 | 0.000 | 0.000 | 0.000 | 0.006 | 0.751 | 0.000 |
| End | 11,031.0 | 3362.3 | Minimum | 0.036 | 0.009 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.329 | 0.000 |
| Thickness | 100.0 | 30.5 | Maximum | 0.141 | 0.141 | 0.000 | 0.671 | 0.000 | 0.000 | 0.000 | 0.407 | 0.000 | 0.000 | 0.000 | 0.090 | 1.000 | 0.000 |
| Number of Values | 201 | | Standard deviation | 0.025 | 0.035 | 0.000 | 0.194 | 0.000 | 0.000 | 0.000 | 0.121 | 0.000 | 0.000 | 0.000 | 0.015 | 0.167 | 0.000 |

**Table B-32. Summary of MT API 21500 Aquifer Minerals and Conditions**

Well Name: MT API 21500
API Identification: 25-091-21500-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Start, ft | 10,931 | 10,947 | 10,954 | 10,958 | 10,974 | 10,986 | 11,000 | 10,931 |
| End, ft | 10,947 | 10,954 | 10,958 | 10,974 | 10,986 | 11,000 | 11,031 | 11,031 |
| Thickness, ft | 16.0 | 7.0 | 4.0 | 16.0 | 12.0 | 14.0 | 31.0 | 100.0 |
| Start, m | 3331.8 | 3336.7 | 3338.8 | 3340.0 | 3344.9 | 3348.5 | 3352.8 | 3331.8 |
| End, m | 3336.7 | 3338.8 | 3340.0 | 3344.9 | 3348.5 | 3352.8 | 3362.3 | 3362.3 |
| Thickness, m | 4.9 | 2.1 | 1.2 | 4.9 | 3.7 | 4.3 | 9.4 | 30.5 |
| Temperature, °F | 211.0 | 211.0 | 211.0 | 211.0 | 211.0 | 211.0 | 211.0 | 211.0 |
| Temperature, °C | 99.4 | 99.4 | 99.4 | 99.4 | 99.4 | 99.4 | 99.4 | 99.4 |
| Pressure, psi | 7127 | 7129 | 7130 | 7132 | 7135 | 7137 | 7141 | 7135 |
| Pressure, kPa | 49,141 | 49,155 | 49,162 | 49,174 | 49,191 | 49,207 | 49,235 | 49,193 |
| Effective Porosity, fraction | 0.110 | 0.081 | 0.099 | 0.034 | 0.061 | 0.039 | 0.108 | 0.079 |
| Mass Fraction | | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.443 | 0.243 | 0.394 | 0.000 | 0.258 | 0.057 | 0.027 | 0.154 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Glauconite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.010 | 0.022 | 0.298 | 0.041 | 0.195 | 0.026 | 0.089 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.006 |
| Quartz | 0.557 | 0.747 | 0.583 | 0.702 | 0.700 | 0.748 | 0.928 | 0.751 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-33. Summary of MT API 21500 Aquifer Calculation Results

Well Name: MT API 21500
API Identification: 25-091-21500-0000

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Start, m | 3331.8 | 3336.7 | 3338.8 | 3340.0 | 3344.9 | 3348.5 | 3352.8 | 3331.8 |
| End, m | 3336.7 | 3338.8 | 3340.0 | 3344.9 | 3348.5 | 3352.8 | 3362.3 | 3362.3 |
| Thickness, m | 4.9 | 2.1 | 1.2 | 4.9 | 3.7 | 4.3 | 9.4 | 30.5 |
| Start, ft | 10,931.0 | 10,947.0 | 10,954.0 | 10,958.0 | 10,974.0 | 10,986.0 | 11,000.0 | 10,931.0 |
| End, ft | 10,947.0 | 10,954.0 | 10,958.0 | 10,974.0 | 10,986.0 | 11,000.0 | 11,031.0 | 11,031.0 |
| Thickness, ft | 16.0 | 7.0 | 4.0 | 16.0 | 12.0 | 14.0 | 31.0 | 100.0 |
| **Minerals Without $CO_2$** | | | | | | | | |
| pH | 5.482 | 6.271 | 6.271 | 5.769 | 6.269 | 6.257 | 6.271 | 6.268 |
| pE | 8.666 | 7.843 | 7.842 | 7.880 | 7.845 | 7.828 | –2.891 | –2.888 |
| Activity | 0.859 | 0.861 | 0.861 | 0.817 | 0.859 | 0.840 | 0.861 | 0.858 |
| Ionic Strength | 3.700 | 3.721 | 3.729 | 4.528 | 3.764 | 4.135 | 3.730 | 3.798 |
| Total Solution $CO_2$, moles | 0.005 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| Solution, moles | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0048 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0003 | 0.0004 | 0.0004 |
| Ca | 0.3146 | 0.3795 | 0.3795 | 0.2820 | 0.3795 | 0.3797 | 0.3795 | 0.3795 |
| Cl | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.1363 | 0.0005 | 0.0005 | 0.0010 | 0.0005 | 0.0004 | 0.0005 | 0.0005 |
| Mg | 0.0105 | 0.0127 | 0.0127 | 0.1098 | 0.0126 | 0.0125 | 0.0127 | 0.0126 |
| Na | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 |
| S | 0.0013 | 0.0013 | 0.0013 | 0.0013 | 0.0013 | 0.0013 | 0.0014 | 0.0014 |
| Si | 0.0009 | 0.0009 | 0.0009 | 0.0006 | 0.0009 | 0.0008 | 0.0009 | 0.0009 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 95.140 | 72.560 | 95.520 | 0.000 | 105.500 | 36.750 | 5.957 | 47.600 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.012 | 0.772 | 1.401 | 58.460 | 4.420 | 32.790 | 1.492 | 7.206 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.628 | 1.542 |
| Quartz | 199.000 | 371.700 | 235.300 | 878.300 | 476.600 | 802.500 | 342.100 | 388.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 95.080 | 72.360 | 95.330 | 0.000 | 105.300 | 36.560 | 5.762 | 47.400 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.028 | 0.097 | 0.097 | 0.000 | 0.097 | 0.098 | 0.097 | 0.097 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.009 | 0.218 | 19.240 | 1.225 | 10.680 | 0.249 | 2.153 |
| Maximum Microcline | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.004 | 0.573 | 0.898 | 30.380 | 2.458 | 17.110 | 0.945 | 3.897 |
| Phlogopite | 0.000 | 0.039 | 0.092 | 4.847 | 0.344 | 2.707 | 0.100 | 0.576 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.628 | 1.542 |
| Quartz | 199.000 | 372.500 | 236.800 | 938.800 | 481.300 | 836.400 | 343.700 | 395.500 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –0.060 | –0.195 | –0.195 | 0.000 | –0.195 | –0.195 | –0.195 | −0.195 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Dolomite | 0.028 | 0.097 | 0.097 | 0.000 | 0.097 | 0.098 | 0.097 | 0.097 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –0.012 | –0.772 | –1.401 | –58.460 | –4.420 | –32.790 | –1.492 | –7.206 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.009 | 0.218 | 19.240 | 1.225 | 10.680 | 0.249 | 2.153 |
| Maximum Microcline | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.004 | 0.573 | 0.898 | 30.380 | 2.458 | 17.110 | 0.945 | 3.897 |
| Phlogopite | 0.000 | 0.039 | 0.092 | 4.847 | 0.344 | 2.707 | 0.100 | 0.576 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | –0.020 | 0.846 | 1.496 | 60.460 | 4.616 | 33.930 | 1.591 | 7.495 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 6.44E-06 | 6.44E-06 | 6.44E-06 | 1.84E-06 | 6.44E-06 | 6.44E-06 | 6.44E-06 | 6.44E-06 |
| $CaHCO_3^+$ | 7.17E-04 | 1.16E-04 | 1.16E-04 | 9.92E-05 | 1.16E-04 | 1.16E-04 | 1.16E-04 | 1.17E-04 |
| $CO_2$ | 2.78E-03 | 6.06E-05 | 6.05E-05 | 1.83E-04 | 6.01E-05 | 5.62E-05 | 6.05E-05 | 5.97E-05 |
| $CO_3^{2-}$ | 1.45E-07 | 1.20E-07 | 1.20E-07 | 3.72E-08 | 1.19E-07 | 1.07E-07 | 1.20E-07 | 1.18E-07 |
| $FeCO_3$ | | | | | | | 5.02E-11 | 4.62E-11 |
| $FeCO_3^+$ | | | | | | | 2.15E-22 | 1.97E-22 |
| $FeHCO_3^+$ | | | | | | | 7.86E-09 | 7.22E-09 |
| $HCO_3^-$ | 8.01E-04 | 1.07E-04 | 1.07E-04 | 1.01E-04 | 1.06E-04 | 9.64E-05 | 1.07E-04 | 1.05E-04 |
| $MgCO_3$ | 5.94E-08 | 5.94E-08 | 5.94E-08 | 2.07E-07 | 5.94E-08 | 5.94E-08 | 5.94E-08 | 5.94E-08 |
| $MgHCO_3^+$ | 2.70E-05 | 4.38E-06 | 4.38E-06 | 4.55E-05 | 4.38E-06 | 4.38E-06 | 4.38E-06 | 4.38E-06 |
| $NaCO_3^-$ | 1.17E-08 | 9.62E-09 | 9.62E-09 | 3.73E-09 | 9.62E-09 | 9.62E-09 | 9.62E-09 | 9.62E-09 |
| $NaHCO_3$ | 4.62E-04 | 6.21E-05 | 6.22E-05 | 8.19E-05 | 6.26E-05 | 6.64E-05 | 6.22E-05 | 6.29E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | –6.030E-02 | –1.946E-01 | –1.946E-01 | 0.000E+00 | –1.946E-01 | –1.950E-01 | –1.946E-01 | –1.946E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 5.580E-02 | 1.945E-01 | 1.945E-01 | 2.462E-04 | 1.946E-01 | 1.951E-01 | 1.945E-01 | 1.946E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | –4.500E-03 | –1.000E-04 | –8.000E-05 | 2.462E-04 | –4.000E-05 | 6.000E-05 | –1.000E-04 | –2.000E-05 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 2.784E-03 | 6.056E-05 | 6.048E-05 | 1.826E-04 | 6.010E-05 | 5.624E-05 | 6.047E-05 | 5.974E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 2.013E-03 | 2.969E-04 | 2.968E-04 | 3.299E-04 | 2.962E-04 | 2.902E-04 | 2.968E-04 | 2.957E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 2.967E-04 | 2.575E-04 | 2.773E-04 | 7.587E-04 | 3.163E-04 | 4.065E-04 | 2.573E-04 | 3.355E-04 |
| Water, $g/cm^3$ | 0.110 | 0.081 | 0.099 | 0.034 | 0.061 | 0.039 | 0.108 | 0.079 |
| Water, $kg/m^3$ | 110.169 | 81.246 | 98.842 | 34.142 | 60.833 | 39.482 | 107.628 | 78.947 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$m^3$ | –4.958E-01 | –8.125E-03 | –7.907E-03 | 8.406E-03 | –2.433E-03 | 2.369E-03 | –1.076E-02 | –1.579E-03 |
| Dissolved $CO_2$, moles/$m^3$ | 3.067E-01 | 4.920E-03 | 5.978E-03 | 6.234E-03 | 3.656E-03 | 2.220E-03 | 6.508E-03 | 4.716E-03 |
| Solution $CO_2$, moles/$m^3$ | 2.217E-01 | 2.412E-02 | 2.933E-02 | 1.126E-02 | 1.802E-02 | 1.146E-02 | 3.194E-02 | 2.335E-02 |
| Total $CO_2$, moles/$m^3$ | 3.269E-02 | 2.092E-02 | 2.741E-02 | 2.590E-02 | 1.924E-02 | 1.605E-02 | 2.769E-02 | 2.648E-02 |
| Mineral $CO_2$, moles/$ft^3$ | –1.404E-02 | –2.301E-04 | –2.239E-04 | 2.380E-04 | –6.890E-05 | 6.708E-05 | –3.048E-04 | –4.471E-05 |
| Dissolved $CO_2$, moles/$ft^3$ | 8.685E-03 | 1.393E-04 | 1.693E-04 | 1.765E-04 | 1.035E-04 | 6.288E-05 | 1.843E-04 | 1.336E-04 |
| Solution $CO_2$, moles/$ft^3$ | 6.279E-03 | 6.831E-04 | 8.307E-04 | 3.190E-04 | 5.102E-04 | 3.245E-04 | 9.046E-04 | 6.611E-04 |
| Total $CO_2$, moles/$ft^3$ | 9.257E-04 | 5.923E-04 | 7.760E-04 | 7.335E-04 | 5.448E-04 | 4.544E-04 | 7.841E-04 | 7.499E-04 |
| Mineral $CO_2$, kg/$m^3$ | –2.182E-02 | –3.576E-04 | –3.480E-04 | 3.699E-04 | –1.071E-04 | 1.043E-04 | –4.737E-04 | –6.949E-05 |
| Dissolved $CO_2$, kg/$m^3$ | 1.350E-02 | 2.165E-04 | 2.631E-04 | 2.744E-04 | 1.609E-04 | 9.772E-05 | 2.864E-04 | 2.076E-04 |
| Solution $CO_2$, kg/$m^3$ | 9.759E-03 | 1.062E-03 | 1.291E-03 | 4.957E-04 | 7.929E-04 | 5.043E-04 | 1.406E-03 | 1.027E-03 |
| Total $CO_2$, kg/$m^3$ | 1.439E-03 | 9.206E-04 | 1.206E-03 | 1.140E-03 | 8.467E-04 | 7.063E-04 | 1.219E-03 | 1.166E-03 |
| Mineral $CO_2$, lb/$ft^3$ | –1.362E-03 | –2.232E-05 | –2.172E-05 | 2.309E-05 | –6.685E-06 | 6.508E-06 | –2.957E-05 | –4.338E-06 |
| Dissolved $CO_2$, lb/$ft^3$ | 8.427E-04 | 1.352E-05 | 1.642E-05 | 1.713E-05 | 1.004E-05 | 6.100E-06 | 1.788E-05 | 1.296E-05 |
| Solution $CO_2$, lb/$ft^3$ | 6.092E-04 | 6.627E-05 | 8.060E-05 | 3.095E-05 | 4.950E-05 | 3.148E-05 | 8.777E-05 | 6.414E-05 |
| Total $CO_2$, lb/$ft^3$ | 8.981E-05 | 5.747E-05 | 7.529E-05 | 7.117E-05 | 5.286E-05 | 4.409E-05 | 7.608E-05 | 7.276E-05 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 30.5 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | –3.616E-03 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.351E-03 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 2.368E-03 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 1.104E-03 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | –2.257E-04 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 1.468E-04 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 1.478E-04 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 6.889E-05 | | | | | | | |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| **Minerals with $CO_2$** | | | | | | | | |
| pH | 4.208 | 4.180 | 4.179 | 5.497 | 4.179 | 4.172 | 4.179 | 4.178 |
| pE | 9.889 | 9.953 | 9.990 | 8.465 | 9.833 | 9.964 | –0.329 | –0.328 |
| Activity | 0.842 | 0.843 | 0.843 | 0.791 | 0.842 | 0.836 | 0.843 | 0.842 |
| Ionic Strength | 3.715 | 3.727 | 3.730 | 4.752 | 3.743 | 3.872 | 3.732 | 3.757 |
| Total Solution $CO_2$, moles | 1.04E+00 | 1.04E+00 | 1.04E+00 | 1.75E+00 | 1.04E+00 | 1.02E+00 | 1.05E+00 | 1.04E+00 |
| Solution, moles | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.0440 | 1.0440 | 1.0430 | 1.2770 | 1.0360 | 0.9666 | 1.0460 | 1.0300 |
| Ca | 0.3263 | 0.3699 | 0.3699 | 0.0000 | 0.3699 | 0.3703 | 0.3703 | 0.3704 |
| Cl | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0005 | 0.0005 |
| K | 0.1477 | 0.0570 | 0.0570 | 0.0018 | 0.0567 | 0.0540 | 0.0571 | 0.0565 |
| Mg | 0.0109 | 0.0124 | 0.0124 | 0.7116 | 0.0124 | 0.0124 | 0.0125 | 0.0125 |
| Na | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 |
| S | 0.0013 | 0.0013 | 0.0013 | 0.0013 | 0.0013 | 0.0013 | 0.0024 | 0.0024 |
| Si | 0.0009 | 0.0009 | 0.0009 | 0.0006 | 0.0009 | 0.0008 | 0.0009 | 0.0009 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 95.140 | 72.560 | 95.520 | 0.000 | 105.500 | 36.750 | 5.957 | 47.600 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.012 | 0.772 | 1.401 | 58.460 | 4.420 | 32.790 | 1.492 | 7.206 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.628 | 1.542 |
| Quartz | 199.000 | 371.700 | 235.300 | 878.300 | 476.600 | 802.500 | 342.100 | 388.000 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 95.070 | 72.260 | 95.060 | 0.000 | 104.200 | 28.440 | 5.472 | 45.690 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | 299.000 | 298.800 | 298.700 | 298.200 | 297.900 | 290.900 | 298.600 | 297.200 |
| Dolomite | 0.027 | 0.216 | 0.373 | 0.282 | 1.128 | 8.219 | 0.396 | 1.824 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.054 | 0.211 | 18.940 | 0.966 | 8.053 | 0.234 | 1.662 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.009 | 0.556 | 0.933 | 30.670 | 2.745 | 19.770 | 0.988 | 4.417 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 4.552 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.628 | 1.541 |
| Quartz | 199.000 | 372.600 | 237.000 | 939.400 | 481.900 | 841.800 | 343.900 | 396.700 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –0.072 | –0.304 | –0.461 | 0.000 | –1.216 | –8.308 | –0.484 | –1.913 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | –1.027 | –1.172 | –1.328 | –1.841 | –2.076 | –9.098 | –1.353 | –2.766 |
| Dolomite | 0.027 | 0.216 | 0.373 | 0.282 | 1.128 | 8.219 | 0.396 | 1.824 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –0.012 | –0.772 | –1.401 | –58.460 | –4.420 | –32.790 | –1.492 | –7.206 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.054 | 0.211 | 18.940 | 0.966 | 8.053 | 0.234 | 1.662 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Muscovite | 0.009 | 0.556 | 0.933 | 30.670 | 2.745 | 19.770 | 0.988 | 4.417 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 4.552 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.001 | –0.001 |
| Quartz | 0.014 | 0.925 | 1.680 | 61.050 | 5.303 | 39.340 | 1.790 | 8.646 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 6.44E-06 | 6.44E-06 | 6.44E-06 | 3.66E-10 | 6.44E-06 | 6.44E-06 | 6.44E-06 | 6.44E-06 |
| $CaHCO_3^+$ | 1.35E-02 | 1.44E-02 | 1.44E-02 | 3.61E-08 | 1.44E-02 | 1.45E-02 | 1.44E-02 | 1.44E-02 |
| $CO_2$ | 1.01E+00 | 1.01E+00 | 1.01E+00 | 8.73E-01 | 1.00E+00 | 9.87E-01 | 1.01E+00 | 1.00E+00 |
| $CO_3^{2-}$ | 1.46E-07 | 1.28E-07 | 1.28E-07 | 5.05E-05 | 1.28E-07 | 1.23E-07 | 1.28E-07 | 1.27E-07 |
| $FeCO_3$ | | | | | | | 3.56E-09 | 3.47E-09 |
| $FeCO_3^+$ | | | | | | | 5.54E-18 | 5.39E-18 |
| $FeHCO_3^+$ | | | | | | | 6.89E-05 | 6.70E-05 |
| $HCO_3^-$ | 1.51E-02 | 1.41E-02 | 1.41E-02 | 2.54E-01 | 1.41E-02 | 1.37E-02 | 1.41E-02 | 1.40E-02 |
| $MgCO_3$ | 5.94E-08 | 5.94E-08 | 5.94E-08 | 1.05E-03 | 5.94E-08 | 5.94E-08 | 5.94E-08 | 5.94E-08 |
| $MgHCO_3^+$ | 5.07E-04 | 5.40E-04 | 5.40E-04 | 4.20E-01 | 5.41E-04 | 5.44E-04 | 5.41E-04 | 5.41E-04 |
| $NaCO_3^-$ | 1.17E-08 | 1.02E-08 | 1.02E-08 | 4.81E-06 | 1.02E-08 | 1.02E-08 | 1.02E-08 | 1.02E-08 |
| $NaHCO_3$ | 8.70E-03 | 8.17E-03 | 8.17E-03 | 2.01E-01 | 8.20E-03 | 8.39E-03 | 8.18E-03 | 8.21E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | –0.072 | –0.304 | –0.461 | 0.000 | –1.216 | –8.308 | –0.484 | –1.913 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.055 | 0.432 | 0.746 | 0.564 | 2.256 | 16.438 | 0.792 | 3.648 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | –0.017 | 0.128 | 0.285 | 0.564 | 1.040 | 8.130 | 0.308 | 1.735 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.007 | 1.005 | 1.005 | 0.873 | 1.004 | 0.987 | 1.007 | 1.002 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.038 | 0.037 | 0.037 | 0.876 | 0.037 | 0.037 | 0.037 | 0.037 |
| Total $CO_2$, moles/kg $H_2O$ | 1.028 | 1.170 | 1.328 | 2.313 | 2.081 | 9.154 | 1.352 | 2.774 |
| Water, g/cm$^3$ | 0.110 | 0.081 | 0.099 | 0.034 | 0.061 | 0.039 | 0.108 | 0.079 |
| Water, kg/m$^3$ | 110.169 | 81.246 | 98.842 | 34.142 | 60.833 | 39.482 | 107.628 | 78.947 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, moles/$m^3$ | –1.833 | 10.416 | 28.200 | 19.270 | 63.266 | 320.985 | 33.139 | 136.973 |
| Dissolved $CO_2$, moles/$m^3$ | 110.941 | 81.652 | 99.336 | 29.802 | 61.076 | 38.960 | 108.381 | 79.105 |
| Solution $CO_2$, moles/$m^3$ | 4.160 | 3.024 | 3.679 | 29.905 | 2.263 | 1.462 | 4.017 | 2.941 |
| Total $CO_2$, moles/$m^3$ | 113.267 | 95.091 | 131.214 | 78.977 | 126.606 | 361.407 | 145.536 | 219.019 |
| Mineral $CO_2$, moles/$ft^3$ | –0.052 | 0.295 | 0.799 | 0.546 | 1.792 | 9.089 | 0.938 | 3.879 |
| Dissolved $CO_2$, moles/$ft^3$ | 3.142 | 2.312 | 2.813 | 0.844 | 1.729 | 1.103 | 3.069 | 2.240 |
| Solution $CO_2$, moles/$ft^3$ | 0.118 | 0.086 | 0.104 | 0.847 | 0.064 | 0.041 | 0.114 | 0.083 |
| Total $CO_2$, moles/$ft^3$ | 3.207 | 2.693 | 3.716 | 2.236 | 3.585 | 10.234 | 4.121 | 6.202 |
| Mineral $CO_2$, kg/$m^3$ | –0.081 | 0.458 | 1.241 | 0.848 | 2.784 | 14.127 | 1.458 | 6.028 |
| Dissolved $CO_2$, kg/$m^3$ | 4.882 | 3.593 | 4.372 | 1.312 | 2.688 | 1.715 | 4.770 | 3.481 |
| Solution $CO_2$, kg/$m^3$ | 0.183 | 0.133 | 0.162 | 1.316 | 0.100 | 0.064 | 0.177 | 0.129 |
| Total $CO_2$, kg/$m^3$ | 4.985 | 4.185 | 5.775 | 3.476 | 5.572 | 15.906 | 6.405 | 9.639 |
| Mineral $CO_2$, lb/$ft^3$ | –0.005 | 0.029 | 0.077 | 0.053 | 0.174 | 0.882 | 0.091 | 0.376 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.305 | 0.224 | 0.273 | 0.082 | 0.168 | 0.107 | 0.298 | 0.217 |
| Solution $CO_2$, lb/$ft^3$ | 0.011 | 0.008 | 0.010 | 0.082 | 0.006 | 0.004 | 0.011 | 0.008 |
| Total $CO_2$, lb/$ft^3$ | 0.311 | 0.261 | 0.361 | 0.217 | 0.348 | 0.993 | 0.400 | 0.602 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 30.5 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 2.968 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 3.459 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.331 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 6.759 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.185 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.216 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.021 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.422 | | | | | | | |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | |
| pH | –1.274 | –2.091 | –2.092 | –0.272 | –2.090 | –2.085 | –2.092 | –2.090 |
| pE | 1.223 | 2.110 | 2.148 | 0.585 | 1.988 | 2.136 | 2.562 | 2.560 |
| Activity | –0.017 | –0.018 | –0.018 | –0.026 | –0.017 | –0.004 | –0.018 | –0.016 |
| Ionic Strength | 0.015 | 0.006 | 0.001 | 0.224 | –0.021 | –0.263 | 0.002 | –0.041 |
| Total Solution $CO_2$, moles | 1.039 | 1.042 | 1.042 | 1.748 | 1.041 | 1.024 | 1.045 | 1.040 |
| Solution, moles | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.039 | 1.044 | 1.043 | 1.277 | 1.036 | 0.966 | 1.046 | 1.030 |
| Ca | 0.012 | –0.010 | –0.010 | –0.282 | –0.010 | –0.009 | –0.009 | –0.009 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| K | 0.011 | 0.057 | 0.056 | 0.001 | 0.056 | 0.054 | 0.057 | 0.056 |
| Mg | 0.000 | 0.000 | 0.000 | 0.602 | 0.000 | 0.000 | 0.000 | 0.000 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –0.010 | –0.100 | –0.270 | 0.000 | –1.100 | –8.120 | –0.290 | –1.710 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | 299.000 | 298.800 | 298.700 | 298.200 | 297.900 | 290.900 | 298.600 | 297.200 |
| Dolomite | 0.000 | 0.119 | 0.276 | 0.282 | 1.031 | 8.121 | 0.299 | 1.727 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.045 | –0.007 | –0.300 | –0.260 | –2.627 | –0.015 | –0.491 |
| Maximum Microcline | –0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.006 | –0.017 | 0.035 | 0.290 | 0.287 | 2.660 | 0.043 | 0.520 |
| Phlogopite | 0.000 | –0.039 | –0.092 | –0.295 | –0.344 | –2.707 | –0.100 | –0.576 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.001 |
| Quartz | 0.000 | 0.100 | 0.200 | 0.600 | 0.600 | 5.400 | 0.200 | 1.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –0.011 | –0.109 | –0.266 | 0.000 | –1.021 | –8.113 | –0.290 | –1.718 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21500 | 1.027 | 1.172 | 1.328 | 1.841 | 2.076 | 9.098 | 1.353 | 2.766 |
| Dolomite | 0.000 | 0.119 | 0.276 | 0.282 | 1.031 | 8.121 | 0.299 | 1.727 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.045 | –0.007 | –0.300 | –0.260 | –2.627 | –0.015 | –0.491 |
| Maximum Microcline | –0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Muscovite | 0.006 | –0.017 | 0.035 | 0.290 | 0.287 | 2.660 | 0.043 | 0.520 |
| Phlogopite | 0.000 | –0.039 | –0.092 | –0.295 | –0.344 | –2.707 | –0.100 | –0.576 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | –0.001 | –0.001 |
| Quartz | 0.034 | 0.079 | 0.184 | 0.590 | 0.687 | 5.410 | 0.199 | 1.151 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | –1.84E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $CaHCO_3^+$ | 1.27E-02 | 1.42E-02 | 1.42E-02 | –9.92E-05 | 1.43E-02 | 1.43E-02 | 1.43E-02 | 1.43E-02 |
| $CO_2$ | 1.00E+00 | 1.00E+00 | 1.00E+00 | 8.73E-01 | 1.00E+00 | 9.87E-01 | 1.01E+00 | 1.00E+00 |
| $CO_3^{2-}$ | 4.00E-10 | 8.10E-09 | 8.20E-09 | 5.05E-05 | 9.00E-09 | 1.57E-08 | 8.20E-09 | 9.50E-09 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.51E-09 | 3.42E-09 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.54E-18 | 5.39E-18 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.88E-05 | 6.70E-05 |
| $HCO_3^-$ | 1.43E-02 | 1.40E-02 | 1.40E-02 | 2.53E-01 | 1.40E-02 | 1.36E-02 | 1.40E-02 | 1.39E-02 |
| $MgCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.04E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $MgHCO_3^+$ | 4.80E-04 | 5.36E-04 | 5.36E-04 | 4.20E-01 | 5.37E-04 | 5.39E-04 | 5.37E-04 | 5.37E-04 |
| $NaCO_3^-$ | 1.00E-11 | 6.24E-10 | 6.24E-10 | 4.81E-06 | 6.25E-10 | 5.89E-10 | 6.24E-10 | 6.15E-10 |
| $NaHCO_3$ | 8.24E-03 | 8.11E-03 | 8.11E-03 | 2.01E-01 | 8.13E-03 | 8.32E-03 | 8.12E-03 | 8.15E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | –0.011 | –0.109 | –0.266 | 0.000 | –1.021 | –8.113 | –0.290 | –1.718 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | –0.001 | 0.237 | 0.552 | 0.564 | 2.061 | 16.243 | 0.598 | 3.453 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | –0.012 | 0.128 | 0.285 | 0.564 | 1.040 | 8.130 | 0.308 | 1.735 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.004 | 1.005 | 1.005 | 0.873 | 1.004 | 0.987 | 1.007 | 1.002 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.036 | 0.037 | 0.037 | 0.876 | 0.037 | 0.037 | 0.037 | 0.037 |
| Total $CO_2$, moles/kg $H_2O$ | 1.028 | 1.170 | 1.327 | 2.312 | 2.081 | 9.153 | 1.352 | 2.774 |
| Water, g/cm$^3$ | 0.110 | 0.081 | 0.099 | 0.034 | 0.061 | 0.039 | 0.108 | 0.079 |
| Water, kg/m$^3$ | 110.169 | 81.246 | 98.842 | 34.142 | 60.833 | 39.482 | 107.628 | 78.947 |

Continued…

**Table B-33. Summary of MT API 21500 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, moles/$m^3$ | –1.337 | 10.424 | 28.207 | 19.261 | 63.269 | 320.982 | 33.149 | 136.974 |
| Dissolved $CO_2$, moles/$m^3$ | 110.634 | 81.647 | 99.330 | 29.796 | 61.073 | 38.958 | 108.375 | 79.100 |
| Solution $CO_2$, moles/$m^3$ | 3.938 | 3.000 | 3.650 | 29.894 | 2.245 | 1.451 | 3.985 | 2.918 |
| Total $CO_2$, moles/$m^3$ | 113.234 | 95.070 | 131.187 | 78.951 | 126.587 | 361.391 | 145.509 | 218.992 |
| Mineral $CO_2$, moles/$ft^3$ | –0.038 | 0.295 | 0.799 | 0.545 | 1.792 | 9.089 | 0.939 | 3.879 |
| Dissolved $CO_2$, moles/$ft^3$ | 3.133 | 2.312 | 2.813 | 0.844 | 1.729 | 1.103 | 3.069 | 2.240 |
| Solution $CO_2$, moles/$ft^3$ | 0.112 | 0.085 | 0.103 | 0.846 | 0.064 | 0.041 | 0.113 | 0.083 |
| Total $CO_2$, moles/$ft^3$ | 3.206 | 2.692 | 3.715 | 2.236 | 3.585 | 10.234 | 4.120 | 6.201 |
| Mineral $CO_2$, kg/$m^3$ | −0.059 | 0.459 | 1.241 | 0.848 | 2.784 | 14.126 | 1.459 | 6.028 |
| Dissolved $CO_2$, kg/$m^3$ | 4.869 | 3.593 | 4.372 | 1.311 | 2.688 | 1.715 | 4.770 | 3.481 |
| Solution $CO_2$, kg/$m^3$ | 0.173 | 0.132 | 0.161 | 1.316 | 0.099 | 0.064 | 0.175 | 0.128 |
| Total $CO_2$, kg/$m^3$ | 4.983 | 4.184 | 5.774 | 3.475 | 5.571 | 15.905 | 6.404 | 9.638 |
| Mineral $CO_2$, lb/$ft^3$ | –0.004 | 0.029 | 0.077 | 0.053 | 0.174 | 0.882 | 0.091 | 0.376 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.304 | 0.224 | 0.273 | 0.082 | 0.168 | 0.107 | 0.298 | 0.217 |
| Solution $CO_2$, lb/$ft^3$ | 0.011 | 0.008 | 0.010 | 0.082 | 0.006 | 0.004 | 0.011 | 0.008 |
| Total $CO_2$, lb/$ft^3$ | 0.311 | 0.261 | 0.360 | 0.217 | 0.348 | 0.993 | 0.400 | 0.602 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 30.5 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 2.972 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 3.456 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.329 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 6.758 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.186 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.216 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.021 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.422 | | | | | | | |

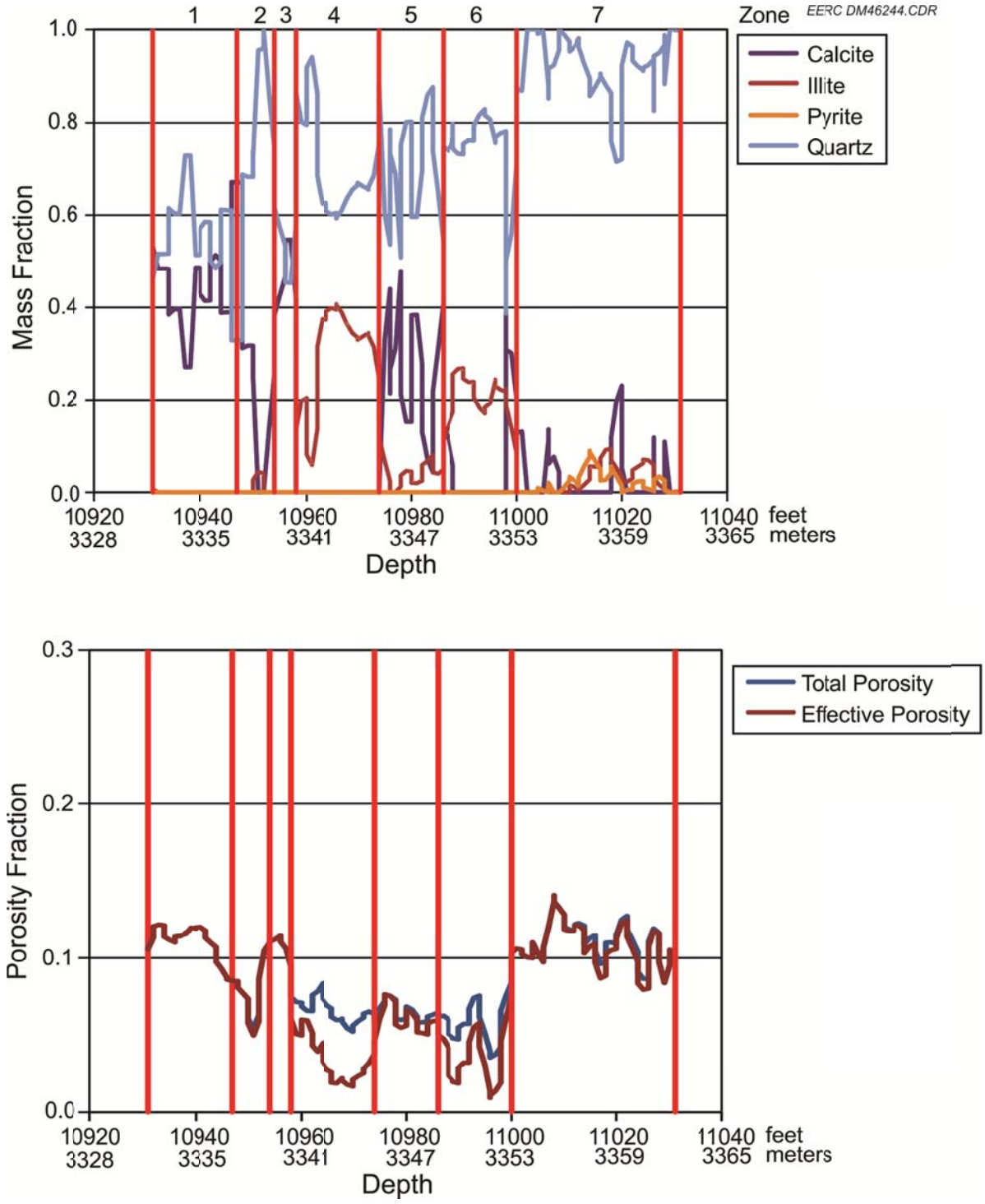



Figure B-8. MT API 21500 mineral composition and porosity as a function of depth.

**ND 12596**

The water composition was available along with the mineral composition for the ND 12596 well. Mineral data were available for 92% of the COSS represented in this well. The total aquifer thickness is not known, as the well did not penetrate into the Precambrian.

Zone 1 is dominated by quartz, while Zones 2 and 3 also contain moderate amounts of glauconite. Zone 4 is approximately 66% quartz and 31% calcite, and Zone 5 is predominantly calcite. The porosity of Zone 5 is very low (0.006), and Zone 1 is higher than the others (0.075).

A low degree of reaction occurs in Zone 2. Zones 1, 3, 4, and 5 show large decreases in calcite along with almost identical increases in dolomite. Zone 5 shows decreases in kaolinite and phlogopite with $CO_2$ and increases in muscovite and quartz.

The amount of $CO_2$ dissolved in the formation water ranges from 1.1 to 1.4 moles/kg (48.4 to 61.6 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 18.6 kg/m$^3$ (1.2 lb/ft$^3$) of formation rock. Although the amount of $CO_2$ per kg formation water is high for Zone 5, the low porosity strongly decreases the amount on the basis of rock volume.

## Table B-34. Average Mineral and Porosity for the ND 12596 Aquifer Zones

Well Name: ND 12596
API Identification: 33-053-02268-0000
State Identification: ND 12596

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Mica | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 14,801.0 | 4511.4 | Average | 0.125 | 0.075 | 0.000 | 0.046 | 0.107 | 0.000 | 0.039 | 0.011 | 0.000 | 0.025 | 0.000 | 0.000 | 0.773 | 0.000 |
| End | 14,868.0 | 4531.8 | Minimum | 0.077 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.313 | 0.000 |
| Thickness | 67.0 | 20.4 | Maximum | 0.316 | 0.284 | 0.000 | 0.574 | 0.221 | 0.000 | 0.531 | 0.125 | 0.000 | 0.178 | 0.000 | 0.000 | 0.932 | 0.000 |
| Number of Values | 136 | | Standard deviation | 0.043 | 0.052 | 0.000 | 0.114 | 0.061 | 0.000 | 0.100 | 0.023 | 0.000 | 0.046 | 0.000 | 0.000 | 0.137 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 14,868.0 | 4531.8 | Average | 0.078 | 0.027 | 0.000 | 0.000 | 0.063 | 0.000 | 0.354 | 0.060 | 0.000 | 0.013 | 0.000 | 0.000 | 0.509 | 0.000 |
| End | 14,888.0 | 4537.9 | Minimum | 0.049 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 20.0 | 6.1 | Maximum | 0.175 | 0.135 | 0.000 | 0.000 | 0.209 | 0.000 | 0.882 | 0.119 | 0.000 | 0.156 | 0.000 | 0.000 | 0.816 | 0.000 |
| Number of Values | 40 | | Standard deviation | 0.031 | 0.032 | 0.000 | 0.000 | 0.062 | 0.000 | 0.244 | 0.040 | 0.000 | 0.040 | 0.000 | 0.000 | 0.229 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 14,888.0 | 4537.9 | Average | 0.054 | 0.029 | 0.000 | 0.017 | 0.039 | 0.000 | 0.176 | 0.027 | 0.000 | 0.000 | 0.000 | 0.000 | 0.660 | 0.000 |
| End | 15,000.0 | 4572.0 | Minimum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 112.0 | 34.1 | Maximum | 0.144 | 0.128 | 0.000 | 0.264 | 0.142 | 0.000 | 0.574 | 0.203 | 0.000 | 0.000 | 0.000 | 0.000 | 0.964 | 0.000 |
| Number of Values | 224 | | Standard deviation | 0.028 | 0.026 | 0.000 | 0.055 | 0.041 | 0.000 | 0.182 | 0.045 | 0.000 | 0.000 | 0.000 | 0.000 | 0.261 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 15,000.0 | 4572.0 | Average | 0.045 | 0.039 | 0.000 | 0.309 | 0.000 | 0.000 | 0.000 | 0.034 | 0.000 | 0.000 | 0.000 | 0.000 | 0.657 | 0.000 |
| End | 15,046.0 | 4586.0 | Minimum | 0.011 | 0.001 | 0.000 | 0.139 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.060 | 0.000 |
| Thickness | 46.0 | 14.0 | Maximum | 0.083 | 0.080 | 0.000 | 0.893 | 0.000 | 0.000 | 0.000 | 0.170 | 0.000 | 0.000 | 0.000 | 0.000 | 0.843 | 0.000 |
| Number of Values | 92 | | Standard deviation | 0.017 | 0.023 | 0.000 | 0.126 | 0.000 | 0.000 | 0.000 | 0.044 | 0.000 | 0.000 | 0.000 | 0.000 | 0.146 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 15,046.0 | 4586.0 | Average | 0.027 | 0.006 | 0.000 | 0.706 | 0.000 | 0.000 | 0.000 | 0.123 | 0.000 | 0.000 | 0.000 | 0.000 | 0.171 | 0.000 |
| End | 15,260.0 | 4651.3 | Minimum | 0.005 | 0.001 | 0.000 | 0.356 | 0.000 | 0.000 | 0.000 | 0.016 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 214.0 | 65.2 | Maximum | 0.060 | 0.034 | 0.000 | 0.976 | 0.000 | 0.000 | 0.000 | 0.263 | 0.000 | 0.000 | 0.000 | 0.000 | 0.520 | 0.000 |
| Number of Values | 427 | | Standard deviation | 0.011 | 0.007 | 0.000 | 0.176 | 0.000 | 0.000 | 0.000 | 0.059 | 0.000 | 0.000 | 0.000 | 0.000 | 0.163 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 14,801.0 | 4511.4 | Average | 0.052 | 0.026 | 0.000 | 0.369 | 0.028 | 0.000 | 0.064 | 0.071 | 0.000 | 0.004 | 0.000 | 0.000 | 0.443 | 0.000 |
| End | 15,260.0 | 4651.3 | Minimum | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 459.0 | 139.9 | Maximum | 0.316 | 0.284 | 0.000 | 0.976 | 0.221 | 0.000 | 0.882 | 0.263 | 0.000 | 0.178 | 0.000 | 0.000 | 0.964 | 0.000 |
| Number of Values | 919 | | Standard deviation | 0.041 | 0.035 | 0.000 | 0.351 | 0.051 | 0.000 | 0.146 | 0.070 | 0.000 | 0.021 | 0.000 | 0.000 | 0.320 | 0.000 |

**Table B-35. Summary of ND 12596 Aquifer and Cap Rock Minerals and Conditions**

Well Name: ND 12596
API Identification: 33-053-02268-0000
State Identification: ND 12596

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Total | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Start, ft | 14,801 | 14,868 | 14,888 | 15,000 | 15,046 | 14,801 | 14,652 | 14,673 | 14,698 | 14,788 | 14,652 |
| End, ft | 14,868 | 14,888 | 15,000 | 15,046 | 15,260 | 15,260 | 14,673 | 14,698 | 14,788 | 14,800 | 14,800 |
| Thickness, ft | 67.0 | 20.0 | 112.0 | 46.0 | 214.0 | 459.0 | 21.0 | 25.0 | 90.0 | 12.0 | 148.0 |
| Start, m | 4511.4 | 4531.8 | 4537.9 | 4572.0 | 4586.0 | 4511.4 | 4465.9 | 4472.3 | 4480.0 | 4507.4 | 4465.9 |
| End, m | 4531.8 | 4537.9 | 4572.0 | 4586.0 | 4651.3 | 4651.3 | 4472.3 | 4480.0 | 4507.4 | 4511.0 | 4511.0 |
| Thickness, m | 20.4 | 6.1 | 34.1 | 14.0 | 65.2 | 139.9 | 6.4 | 7.6 | 27.4 | 3.7 | 45.1 |
| Temperature, °F | 268.0 | 268.0 | 268.0 | 268.0 | 268.0 | 268.0 | 268.0 | 268.0 | 268.0 | 268.0 | 268.0 |
| Temperature, °C | 131.1 | 131.1 | 131.1 | 131.1 | 131.1 | 131.1 | 131.1 | 131.1 | 131.1 | 131.1 | 131.1 |
| Pressure, psi | 8404 | 8412 | 8424 | 8438 | 8461 | 8439 | 8374 | 8378 | 8388 | 8397 | 8385 |
| Pressure, kPa | 57,945 | 57,998 | 58,078 | 58,175 | 58,333 | 58,184 | 57,735 | 57,763 | 57,833 | 57,895 | 57,813 |
| Effective Porosity, fraction | 0.075 | 0.027 | 0.029 | 0.039 | 0.006 | 0.026 | 0.193 | 0.111 | 0.055 | 0.353 | 0.109 |
| Mass Fraction | | | | | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.046 | 0.000 | 0.018 | 0.309 | 0.706 | 0.377 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Chlorite | 0.107 | 0.063 | 0.043 | 0.000 | 0.000 | 0.029 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Glauconite | 0.039 | 0.354 | 0.192 | 0.000 | 0.000 | 0.065 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.011 | 0.060 | 0.029 | 0.034 | 0.123 | 0.073 | 0.030 | 0.211 | 0.224 | 0.000 | 0.176 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.025 | 0.013 | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mica | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.437 | 0.678 | 0.749 | 0.129 | 0.642 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.773 | 0.509 | 0.718 | 0.657 | 0.171 | 0.452 | 0.212 | 0.023 | 0.017 | 0.584 | 0.092 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.321 | 0.087 | 0.010 | 0.287 | 0.090 |

## Table B-36. Summary of ND 12596 Aquifer Calculation Results

Well Name: ND 12596
API Identification: 33-053-02268-0000
State Identification: ND 12596

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Total |
|---|---|---|---|---|---|---|
| Start, m | 4511.4 | 4531.8 | 4537.9 | 4572.0 | 4586.0 | 4511.4 |
| End, m | 4531.8 | 4537.9 | 4572.0 | 4586.0 | 4651.3 | 4651.3 |
| Thickness, m | 20.4 | 6.1 | 34.1 | 14.0 | 65.2 | 139.9 |
| Start, ft | 14801.0 | 14868.0 | 14888.0 | 15000.0 | 15046.0 | 14801.0 |
| End, ft | 14868.0 | 14888.0 | 15000.0 | 15046.0 | 15260.0 | 15260.0 |
| Thickness, ft | 67.0 | 20.0 | 112.0 | 46.0 | 214.0 | 459.0 |
| **Minerals Without $CO_2$** | | | | | | |
| pH | 6.090 | 5.585 | 5.811 | 5.918 | 5.959 | 5.932 |
| pE | –1.594 | –0.633 | –1.096 | –1.023 | 0.128 | –1.233 |
| Activity | 0.861 | 0.924 | 0.900 | 0.854 | 0.572 | 0.875 |
| Ionic Strength | 3.489 | 2.108 | 2.687 | 3.615 | 6.813 | 3.226 |
| Total Solution $CO_2$, moles | 4.277E-04 | 2.365E-03 | 1.399E-03 | 7.170E-04 | 4.377E-04 | 7.509E-04 |
| Solution, moles | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0004 | 0.0049 | 0.0021 | 0.0007 | 0.0001 | 0.0009 |
| Ca | 0.3054 | 0.2366 | 0.2845 | 0.3052 | 0.3085 | 0.3051 |
| Cl | 5.3350 | 5.3350 | 5.3350 | 5.3350 | 5.3350 | 5.3350 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0000 | 0.0959 | 0.0438 | 0.0007 | 0.0001 | 0.0008 |
| Mg | 0.0101 | 0.0316 | 0.0094 | 0.0100 | 0.0068 | 0.0101 |
| Na | 4.7190 | 4.7190 | 4.7190 | 4.7190 | 4.7190 | 4.7190 |
| S | 0.0072 | 0.0072 | 0.0072 | 0.0072 | 0.0072 | 0.0072 |
| Si | 0.0016 | 0.0031 | 0.0023 | 0.0015 | 0.0004 | 0.0018 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 14.800 | 0.000 | 16.500 | 204.100 | 3392.000 | 379.500 |
| Celadonite | 2.933 | 82.710 | 40.000 | 0.000 | 0.000 | 15.380 |
| Clinochlore-7A | 5.844 | 10.690 | 6.456 | 0.000 | 0.000 | 4.888 |
| $CO_2$ ND 12596 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Total |
|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.906 | 15.800 | 6.785 | 5.914 | 153.700 | 19.070 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 3.097 | 5.053 | 0.000 | 0.000 | 0.000 | 1.681 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 416.500 | 849.500 | 1070.000 | 722.200 | 1372.000 | 759.400 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 14.140 | 0.000 | 15.890 | 203.400 | 3391.000 | 378.900 |
| Celadonite | 0.000 | 24.340 | 11.050 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 4.254 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.596 | 0.007 | 0.574 | 0.596 | 0.600 | 0.596 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 5.435 | 0.000 | 0.000 | 1.724 | 50.980 | 10.570 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 29.200 | 12.220 | 3.281 | 79.640 | 12.190 |
| Phlogopite | 3.521 | 38.600 | 20.800 | 0.311 | 12.630 | 14.680 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 420.900 | 977.100 | 1129.000 | 728.700 | 1532.000 | 803.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –0.658 | 0.000 | –0.615 | –0.658 | –0.665 | –0.657 |
| Celadonite | –2.933 | –58.380 | –28.950 | 0.000 | 0.000 | –15.380 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Total |
|---|---|---|---|---|---|---|
| Clinochlore-7A | –1.590 | –10.690 | –6.456 | 0.000 | 0.000 | –4.888 |
| $CO_2$ ND 12596 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.596 | 0.007 | 0.574 | 0.596 | 0.600 | 0.596 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –0.906 | –15.800 | –6.785 | –5.914 | –153.700 | –19.070 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 2.338 | –5.053 | 0.000 | 1.724 | 50.980 | 8.893 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 29.200 | 12.220 | 3.281 | 79.640 | 12.190 |
| Phlogopite | 3.521 | 38.600 | 20.800 | 0.311 | 12.630 | 14.680 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 4.433 | 127.600 | 59.850 | 6.474 | 159.200 | 44.550 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | |
| $CaCO_3$ | 5.05E-06 | 2.49E-06 | 5.05E-06 | 5.05E-06 | 5.05E-06 | 5.05E-06 |
| $CaHCO_3^+$ | 1.30E-04 | 2.25E-04 | 2.62E-04 | 1.92E-04 | 1.32E-04 | 1.91E-04 |
| $CO_2$ | 1.43E-04 | 1.65E-03 | 7.53E-04 | 3.04E-04 | 1.56E-04 | 3.25E-04 |
| $CO_3^{2-}$ | 8.46E-08 | 8.13E-08 | 1.14E-07 | 8.19E-08 | 4.43E-08 | 9.10E-08 |
| $FeCO_3$ | 5.21E-11 | 1.63E-10 | 1.43E-10 | 4.54E-11 | 3.33E-12 | 7.06E-11 |
| $FeCO_3^+$ | 4.91E-21 | 1.54E-19 | 4.47E-20 | 1.57E-20 | 1.24E-20 | 1.56E-20 |
| $FeHCO_3^+$ | 1.32E-08 | 1.45E-07 | 7.28E-08 | 1.70E-08 | 8.56E-10 | 2.63E-08 |
| $HCO_3^-$ | 1.12E-04 | 3.96E-04 | 3.09E-04 | 1.60E-04 | 6.80E-05 | 1.77E-04 |
| $MgCO_3$ | 3.26E-08 | 6.62E-08 | 3.26E-08 | 3.26E-08 | 3.26E-08 | 3.26E-08 |
| $MgHCO_3^+$ | 4.26E-06 | 3.03E-05 | 8.57E-06 | 6.27E-06 | 4.31E-06 | 6.25E-06 |
| $NaCO_3^-$ | 1.68E-09 | 1.02E-09 | 1.76E-09 | 1.69E-09 | 2.05E-09 | 1.67E-09 |
| $NaHCO_3$ | 3.27E-05 | 5.83E-05 | 6.17E-05 | 4.93E-05 | 7.22E-05 | 4.58E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | –6.584E-01 | 0.000E+00 | –6.147E-01 | –6.575E-01 | –6.648E-01 | –6.573E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.193E+00 | 1.338E-02 | 1.147E+00 | 1.191E+00 | 1.199E+00 | 1.191E+00 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 5.342E-01 | 1.338E-02 | 5.323E-01 | 5.337E-01 | 5.342E-01 | 5.337E-01 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.432E-04 | 1.654E-03 | 7.527E-04 | 3.044E-04 | 1.560E-04 | 3.252E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 2.845E-04 | 7.117E-04 | 6.465E-04 | 4.127E-04 | 2.816E-04 | 4.257E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 5.346E-01 | 1.574E-02 | 5.337E-01 | 5.344E-01 | 5.346E-01 | 5.345E-01 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Total |
| Water, $g/cm^3$ | 0.075 | 0.027 | 0.029 | 0.039 | 0.006 | 0.026 |
| Water, $kg/m^3$ | 75.447 | 26.828 | 29.271 | 38.584 | 5.581 | 25.964 |
| Mineral $CO_2$, $moles/m^3$ | 4.030E+01 | 3.589E-01 | 1.558E+01 | 2.059E+01 | 2.982E+00 | 1.386E+01 |
| Dissolved $CO_2$, $moles/m^3$ | 1.080E-02 | 4.437E-02 | 2.203E-02 | 1.175E-02 | 8.707E-04 | 8.444E-03 |
| Solution $CO_2$, $moles/m^3$ | 2.147E-02 | 1.909E-02 | 1.892E-02 | 1.592E-02 | 1.572E-03 | 1.105E-02 |
| Total $CO_2$, $moles/m^3$ | 4.034E+01 | 4.224E-01 | 1.562E+01 | 2.062E+01 | 2.984E+00 | 1.388E+01 |
| Mineral $CO_2$, $moles/ft^3$ | 1.141E+00 | 1.016E-02 | 4.412E-01 | 5.831E-01 | 8.443E-02 | 3.924E-01 |
| Dissolved $CO_2$, $moles/ft^3$ | 3.059E-04 | 1.257E-03 | 6.239E-04 | 3.326E-04 | 2.465E-05 | 2.391E-04 |
| Solution $CO_2$, $moles/ft^3$ | 6.079E-04 | 5.406E-04 | 5.358E-04 | 4.509E-04 | 4.451E-05 | 3.130E-04 |
| Total $CO_2$, $moles/ft^3$ | 1.142E+00 | 1.196E-02 | 4.424E-01 | 5.839E-01 | 8.450E-02 | 3.929E-01 |
| Mineral $CO_2$, $kg/m^3$ | 1.774E+00 | 1.580E-02 | 6.857E-01 | 9.063E-01 | 1.312E-01 | 6.098E-01 |
| Dissolved $CO_2$, $kg/m^3$ | 4.755E-04 | 1.953E-03 | 9.696E-04 | 5.169E-04 | 3.832E-05 | 3.716E-04 |
| Solution $CO_2$, $kg/m^3$ | 9.447E-04 | 8.403E-04 | 8.328E-04 | 7.007E-04 | 6.917E-05 | 4.864E-04 |
| Total $CO_2$, $kg/m^3$ | 1.775E+00 | 1.859E-02 | 6.875E-01 | 9.075E-01 | 1.313E-01 | 6.107E-01 |
| Mineral $CO_2$, $lb/ft^3$ | 1.107E-01 | 9.861E-04 | 4.281E-02 | 5.658E-02 | 8.191E-03 | 3.807E-02 |
| Dissolved $CO_2$, $lb/ft^3$ | 2.968E-05 | 1.219E-04 | 6.053E-05 | 3.227E-05 | 2.392E-06 | 2.320E-05 |
| Solution $CO_2$, $lb/ft^3$ | 5.898E-05 | 5.245E-05 | 5.199E-05 | 4.375E-05 | 4.318E-06 | 3.037E-05 |
| Total $CO_2$, $lb/ft^3$ | 1.108E-01 | 1.160E-03 | 4.292E-02 | 5.665E-02 | 8.198E-03 | 3.812E-02 |
| Weighted Average of Zones | | | | | | |
| Total Thickness, m | 139.9 | | | | | |
| Mineral $CO_2$, $kg/m^3$ | 5.789E-01 | | | | | |
| Dissolved $CO_2$, $kg/m^3$ | 4.608E-04 | | | | | |
| Solution $CO_2$, $kg/m^3$ | 4.802E-04 | | | | | |
| Total $CO_2$, $kg/m^3$ | 5.799E-01 | | | | | |
| Mineral $CO_2$, $lb/ft^3$ | 3.614E-02 | | | | | |
| Dissolved $CO_2$, $lb/ft^3$ | 2.876E-05 | | | | | |
| Solution $CO_2$, $lb/ft^3$ | 2.998E-05 | | | | | |
| Total $CO_2$, $lb/ft^3$ | 3.620E-02 | | | | | |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Total |
| **Minerals with $CO_2$** | | | | | | |
| pH | 5.346 | 5.141 | 5.108 | 4.141 | 4.112 | 4.877 |
| pE | 0.816 | 1.259 | 1.339 | 4.334 | 4.715 | 1.921 |
| Activity | 0.845 | 0.895 | 0.873 | 0.834 | 0.792 | 0.876 |
| Ionic Strength | 3.376 | 2.174 | 2.713 | 3.596 | 4.328 | 2.527 |
| Total Solution $CO_2$, moles | 1.64E+00 | 1.65E+00 | 1.55E+00 | 1.23E+00 | 1.12E+00 | 1.46E+00 |
| Solution, moles | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.8700 | 3.4180 | 2.3430 | 1.2120 | 0.8121 | 2.3580 |
| Ca | 0.0000 | 0.0000 | 0.0000 | 0.2973 | 0.2995 | 0.0163 |
| Cl | 5.3350 | 5.3350 | 5.3350 | 5.3350 | 5.3350 | 5.3350 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0003 | 0.2789 | 0.2314 | 0.0415 | 0.0302 | 0.7224 |
| Mg | 0.5524 | 0.3954 | 0.3545 | 0.0098 | 0.0094 | 0.0005 |
| Na | 4.7190 | 4.7190 | 4.7190 | 4.7190 | 4.7190 | 4.7190 |
| S | 0.0072 | 0.0072 | 0.0072 | 0.0072 | 0.0072 | 0.0072 |
| Si | 0.0017 | 0.0031 | 0.0023 | 0.0015 | 0.0011 | 0.0024 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 14.800 | 0.000 | 16.500 | 204.100 | 3392.000 | 379.500 |
| Celadonite | 2.933 | 82.710 | 40.000 | 0.000 | 0.000 | 15.380 |
| Clinochlore-7A | 5.844 | 10.690 | 6.456 | 0.000 | 0.000 | 4.888 |
| $CO_2$ ND 12596 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.906 | 15.800 | 6.785 | 5.914 | 153.700 | 19.070 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 3.097 | 5.053 | 0.000 | 0.000 | 0.000 | 1.681 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 416.500 | 849.500 | 1070.000 | 722.200 | 1372.000 | 759.400 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Total |
|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 202.500 | 3354.000 | 335.100 |
| Celadonite | 0.000 | 24.230 | 18.890 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 1.257 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 283.400 | 296.100 | 281.200 | 297.800 | 261.300 | 253.300 |
| Dolomite | 15.040 | 0.243 | 16.750 | 1.528 | 38.470 | 44.650 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 8.431 | 0.000 | 0.000 | 1.474 | 38.400 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.024 |
| Muscovite | 0.000 | 29.290 | 12.320 | 3.551 | 92.230 | 23.120 |
| Phlogopite | 3.521 | 38.440 | 12.680 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 423.900 | 977.700 | 1122.000 | 729.300 | 1557.000 | 827.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –14.800 | 0.000 | –16.500 | –1.582 | –38.530 | –44.420 |
| Celadonite | –2.933 | –58.490 | –21.110 | 0.000 | 0.000 | –15.380 |
| Clinochlore-7A | –4.587 | –10.690 | –6.456 | 0.000 | 0.000 | –4.888 |
| $CO_2$ ND 12596 | –16.620 | –3.887 | –18.800 | –2.151 | –38.700 | –46.700 |
| Dolomite | 15.040 | 0.243 | 16.750 | 1.528 | 38.470 | 44.650 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –0.906 | –15.800 | –6.785 | –5.914 | –153.700 | –19.070 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 5.335 | –5.053 | 0.000 | 1.474 | 38.400 | –1.681 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.024 |
| Muscovite | 0.000 | 29.290 | 12.320 | 3.551 | 92.230 | 23.120 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Total |
|---|---|---|---|---|---|---|
| Phlogopite | 3.521 | 38.440 | 12.680 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 7.430 | 128.200 | 52.570 | 7.096 | 184.400 | 67.860 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | |
| $CaCO_3$ | 5.94E-10 | 2.83E-09 | 2.82E-09 | 5.05E-06 | 5.05E-06 | 5.05E-06 |
| $CaHCO_3^+$ | 8.59E-08 | 7.09E-07 | 7.38E-07 | 1.15E-02 | 1.16E-02 | 2.28E-03 |
| $CO_2$ | 1.23E+00 | 1.44E+00 | 1.34E+00 | 1.20E+00 | 1.10E+00 | 1.38E+00 |
| $CO_3^{2-}$ | 2.27E-05 | 8.99E-06 | 7.78E-06 | 8.80E-08 | 7.24E-08 | 2.69E-06 |
| $FeCO_3$ | 9.68E-09 | 5.29E-09 | 4.88E-09 | 4.80E-11 | 2.26E-11 | 2.17E-09 |
| $FeCO_3^+$ | 2.36E-16 | 3.88E-16 | 4.16E-16 | 3.80E-15 | 4.05E-15 | 7.16E-16 |
| $FeHCO_3^+$ | 1.38E-05 | 1.30E-05 | 1.26E-05 | 1.07E-06 | 5.10E-07 | 9.63E-06 |
| $HCO_3^-$ | 1.69E-01 | 1.21E-01 | 1.06E-01 | 1.03E-02 | 8.66E-03 | 6.35E-02 |
| $MgCO_3$ | 2.77E-04 | 5.82E-05 | 5.84E-05 | 3.26E-08 | 3.26E-08 | 3.26E-08 |
| $MgHCO_3^+$ | 2.03E-01 | 7.39E-02 | 7.74E-02 | 3.75E-04 | 3.79E-04 | 7.44E-05 |
| $NaCO_3^-$ | 4.16E-07 | 1.12E-07 | 1.19E-07 | 1.80E-09 | 1.81E-09 | 3.96E-08 |
| $NaHCO_3$ | 4.47E-02 | 1.78E-02 | 2.11E-02 | 3.14E-03 | 3.60E-03 | 1.18E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | –14.800 | 0.000 | –16.500 | –1.582 | –38.530 | –44.420 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 30.080 | 0.487 | 33.500 | 3.056 | 76.940 | 89.300 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 15.280 | 0.487 | 17.000 | 1.474 | 38.410 | 44.880 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.225 | 1.442 | 1.343 | 1.199 | 1.098 | 1.382 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.416 | 0.212 | 0.204 | 0.025 | 0.024 | 0.078 |
| Total $CO_2$, moles/kg $H_2O$ | 16.921 | 2.141 | 18.547 | 2.698 | 39.532 | 46.340 |
| Water, g/$cm^3$ | 0.075 | 0.027 | 0.029 | 0.039 | 0.006 | 0.026 |
| Water, kg/$m^3$ | 75.447 | 26.828 | 29.271 | 38.584 | 5.581 | 25.964 |
| Mineral $CO_2$, moles/$m^3$ | 1152.832 | 13.054 | 497.600 | 56.873 | 214.376 | 1165.271 |
| Dissolved $CO_2$, moles/$m^3$ | 92.423 | 38.686 | 39.310 | 46.262 | 6.128 | 35.882 |
| Solution $CO_2$, moles/$m^3$ | 31.385 | 5.699 | 5.984 | 0.976 | 0.135 | 2.016 |
| Total $CO_2$, moles/$m^3$ | 1276.639 | 57.440 | 542.894 | 104.111 | 220.639 | 1203.169 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Total |
| Mineral $CO_2$, moles/$ft^3$ | 32.645 | 0.370 | 14.091 | 1.610 | 6.070 | 32.997 |
| Dissolved $CO_2$, moles/$ft^3$ | 2.617 | 1.095 | 1.113 | 1.310 | 0.174 | 1.016 |
| Solution $CO_2$, moles/$ft^3$ | 0.889 | 0.161 | 0.169 | 0.028 | 0.004 | 0.057 |
| Total $CO_2$, moles/$ft^3$ | 36.151 | 1.627 | 15.373 | 2.948 | 6.248 | 34.070 |
| Mineral $CO_2$, kg/$m^3$ | 50.736 | 0.575 | 21.899 | 2.503 | 9.435 | 51.284 |
| Dissolved $CO_2$, kg/$m^3$ | 4.068 | 1.703 | 1.730 | 2.036 | 0.270 | 1.579 |
| Solution $CO_2$, kg/$m^3$ | 1.381 | 0.251 | 0.263 | 0.043 | 0.006 | 0.089 |
| Total $CO_2$, kg/$m^3$ | 56.185 | 2.528 | 23.893 | 4.582 | 9.710 | 52.951 |
| Mineral $CO_2$, lb/$ft^3$ | 3.167 | 0.036 | 1.367 | 0.156 | 0.589 | 3.201 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.254 | 0.106 | 0.108 | 0.127 | 0.017 | 0.099 |
| Solution $CO_2$, lb/$ft^3$ | 0.086 | 0.016 | 0.016 | 0.003 | 0.000 | 0.006 |
| Total $CO_2$, lb/$ft^3$ | 3.507 | 0.158 | 1.492 | 0.286 | 0.606 | 3.306 |
| Weighted Average of Zones | | | | | | |
| Total Thickness, m | 139.9 | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 17.424 | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.420 | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.284 | | | | | |
| Total $CO_2$, kg/$m^3$ | 19.128 | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 1.088 | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.089 | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.018 | | | | | |
| Total $CO_2$, lb/$ft^3$ | 1.194 | | | | | |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Total |
|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | |
| pH | –0.744 | –0.444 | –0.703 | –1.777 | –1.847 | –1.055 |
| pE | 2.410 | 1.892 | 2.435 | 5.357 | 4.587 | 3.154 |
| Activity | –0.016 | –0.029 | –0.027 | –0.020 | 0.220 | 0.001 |
| Ionic Strength | –0.113 | 0.066 | 0.026 | –0.019 | –2.485 | –0.699 |
| Total Solution $CO_2$, moles | 1.641 | 1.652 | 1.546 | 1.224 | 1.122 | 1.458 |
| Solution, moles | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.870 | 3.413 | 2.341 | 1.211 | 0.812 | 2.357 |
| Ca | –0.305 | –0.237 | –0.284 | –0.008 | –0.009 | –0.289 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.000 | 0.183 | 0.188 | 0.041 | 0.030 | 0.722 |
| Mg | 0.542 | 0.364 | 0.345 | 0.000 | 0.003 | –0.010 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Total |
|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –14.140 | 0.000 | –15.890 | –0.900 | –37.000 | –43.800 |
| Celadonite | 0.000 | –0.110 | 7.840 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | –2.997 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 283.400 | 296.100 | 281.200 | 297.800 | 261.300 | 253.300 |
| Dolomite | 14.444 | 0.237 | 16.177 | 0.932 | 37.871 | 44.055 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 2.996 | 0.000 | 0.000 | –0.250 | –12.580 | –10.570 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.024 |
| Muscovite | 0.000 | 0.090 | 0.100 | 0.270 | 12.590 | 10.930 |
| Phlogopite | 0.000 | –0.160 | –8.120 | –0.311 | –12.630 | –14.680 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 3.000 | 0.600 | –7.000 | 0.600 | 25.000 | 23.300 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –14.142 | 0.000 | –15.885 | –0.925 | –37.865 | –43.763 |
| Celadonite | 0.000 | –0.110 | 7.840 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | –2.997 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 16.620 | 3.887 | 18.800 | 2.151 | 38.700 | 46.700 |
| Dolomite | 14.444 | 0.237 | 16.177 | 0.932 | 37.871 | 44.055 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 2.997 | 0.000 | 0.000 | –0.250 | –12.580 | –10.574 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.024 |
| Muscovite | 0.000 | 0.090 | 0.100 | 0.270 | 12.590 | 10.930 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Total |
|---|---|---|---|---|---|---|
| Phlogopite | 0.000 | –0.160 | –8.120 | –0.311 | –12.630 | –14.680 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 2.997 | 0.600 | –7.280 | 0.622 | 25.200 | 23.310 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | |
| $CaCO_3$ | –5.05E-06 | –2.48E-06 | –5.04E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $CaHCO_3^+$ | –1.30E-04 | –2.24E-04 | –2.61E-04 | 1.13E-02 | 1.14E-02 | 2.08E-03 |
| $CO_2$ | 1.22E+00 | 1.44E+00 | 1.34E+00 | 1.20E+00 | 1.10E+00 | 1.38E+00 |
| $CO_3^{2-}$ | 2.26E-05 | 8.91E-06 | 7.67E-06 | 6.04E-09 | 2.81E-08 | 2.60E-06 |
| $FeCO_3$ | 9.63E-09 | 5.13E-09 | 4.73E-09 | 2.59E-12 | 1.93E-11 | 2.10E-09 |
| $FeCO_3^+$ | 2.36E-16 | 3.87E-16 | 4.16E-16 | 3.79E-15 | 4.05E-15 | 7.16E-16 |
| $FeHCO_3^+$ | 1.37E-05 | 1.29E-05 | 1.25E-05 | 1.06E-06 | 5.09E-07 | 9.60E-06 |
| $HCO_3^-$ | 1.68E-01 | 1.20E-01 | 1.06E-01 | 1.01E-02 | 8.59E-03 | 6.33E-02 |
| $MgCO_3$ | 2.77E-04 | 5.82E-05 | 5.84E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $MgHCO_3^+$ | 2.02E-01 | 7.38E-02 | 7.73E-02 | 3.69E-04 | 3.74E-04 | 6.81E-05 |
| $NaCO_3^-$ | 4.14E-07 | 1.11E-07 | 1.17E-07 | 1.10E-10 | –2.34E-10 | 3.79E-08 |
| $NaHCO_3$ | 4.46E-02 | 1.77E-02 | 2.10E-02 | 3.09E-03 | 3.52E-03 | 1.17E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | –14.142 | 0.000 | –15.885 | –0.925 | –37.865 | –43.763 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 28.887 | 0.473 | 32.353 | 1.865 | 75.741 | 88.109 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 14.746 | 0.473 | 16.468 | 0.940 | 37.876 | 44.346 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.225 | 1.440 | 1.342 | 1.199 | 1.098 | 1.382 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.416 | 0.212 | 0.204 | 0.025 | 0.024 | 0.077 |
| Total $CO_2$, moles/kg $H_2O$ | 16.386 | 2.125 | 18.014 | 2.164 | 38.998 | 45.805 |
| Water, $g/cm^3$ | 0.075 | 0.027 | 0.029 | 0.039 | 0.006 | 0.026 |
| Water, $kg/m^3$ | 75.447 | 26.828 | 29.271 | 38.584 | 5.581 | 25.964 |

Continued…

**Table B-36. Summary of ND 12596 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Total |
| Mineral $CO_2$, moles/$m^3$ | 1112.528 | 12.696 | 482.019 | 36.281 | 211.394 | 1151.414 |
| Dissolved $CO_2$, moles/$m^3$ | 92.412 | 38.641 | 39.288 | 46.251 | 6.127 | 35.874 |
| Solution $CO_2$, moles/$m^3$ | 31.363 | 5.680 | 5.965 | 0.960 | 0.134 | 2.005 |
| Total $CO_2$, moles/$m^3$ | 1236.303 | 57.017 | 527.273 | 83.491 | 217.655 | 1189.293 |
| Mineral $CO_2$, moles/$ft^3$ | 31.503 | 0.359 | 13.649 | 1.027 | 5.986 | 32.605 |
| Dissolved $CO_2$, moles/$ft^3$ | 2.617 | 1.094 | 1.113 | 1.310 | 0.174 | 1.016 |
| Solution $CO_2$, moles/$ft^3$ | 0.888 | 0.161 | 0.169 | 0.027 | 0.004 | 0.057 |
| Total $CO_2$, moles/$ft^3$ | 35.008 | 1.615 | 14.931 | 2.364 | 6.163 | 33.677 |
| Mineral $CO_2$, kg/$m^3$ | 48.962 | 0.559 | 21.214 | 1.597 | 9.303 | 50.674 |
| Dissolved $CO_2$, kg/$m^3$ | 4.067 | 1.701 | 1.729 | 2.035 | 0.270 | 1.579 |
| Solution $CO_2$, kg/$m^3$ | 1.380 | 0.250 | 0.263 | 0.042 | 0.006 | 0.088 |
| Total $CO_2$, kg/$m^3$ | 54.410 | 2.509 | 23.205 | 3.674 | 9.579 | 52.341 |
| Mineral $CO_2$, lb/$ft^3$ | 3.057 | 0.035 | 1.324 | 0.100 | 0.581 | 3.163 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.254 | 0.106 | 0.108 | 0.127 | 0.017 | 0.099 |
| Solution $CO_2$, lb/$ft^3$ | 0.086 | 0.016 | 0.016 | 0.003 | 0.000 | 0.006 |
| Total $CO_2$, lb/$ft^3$ | 3.397 | 0.157 | 1.449 | 0.229 | 0.598 | 3.267 |
| Weighted Average of Zones | | | | | | |
| Total Thickness, m | 139.9 | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 16.845 | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.419 | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.283 | | | | | |
| Total $CO_2$, kg/$m^3$ | 18.548 | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 1.052 | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.089 | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.018 | | | | | |
| Total $CO_2$, lb/$ft^3$ | 1.158 | | | | | |

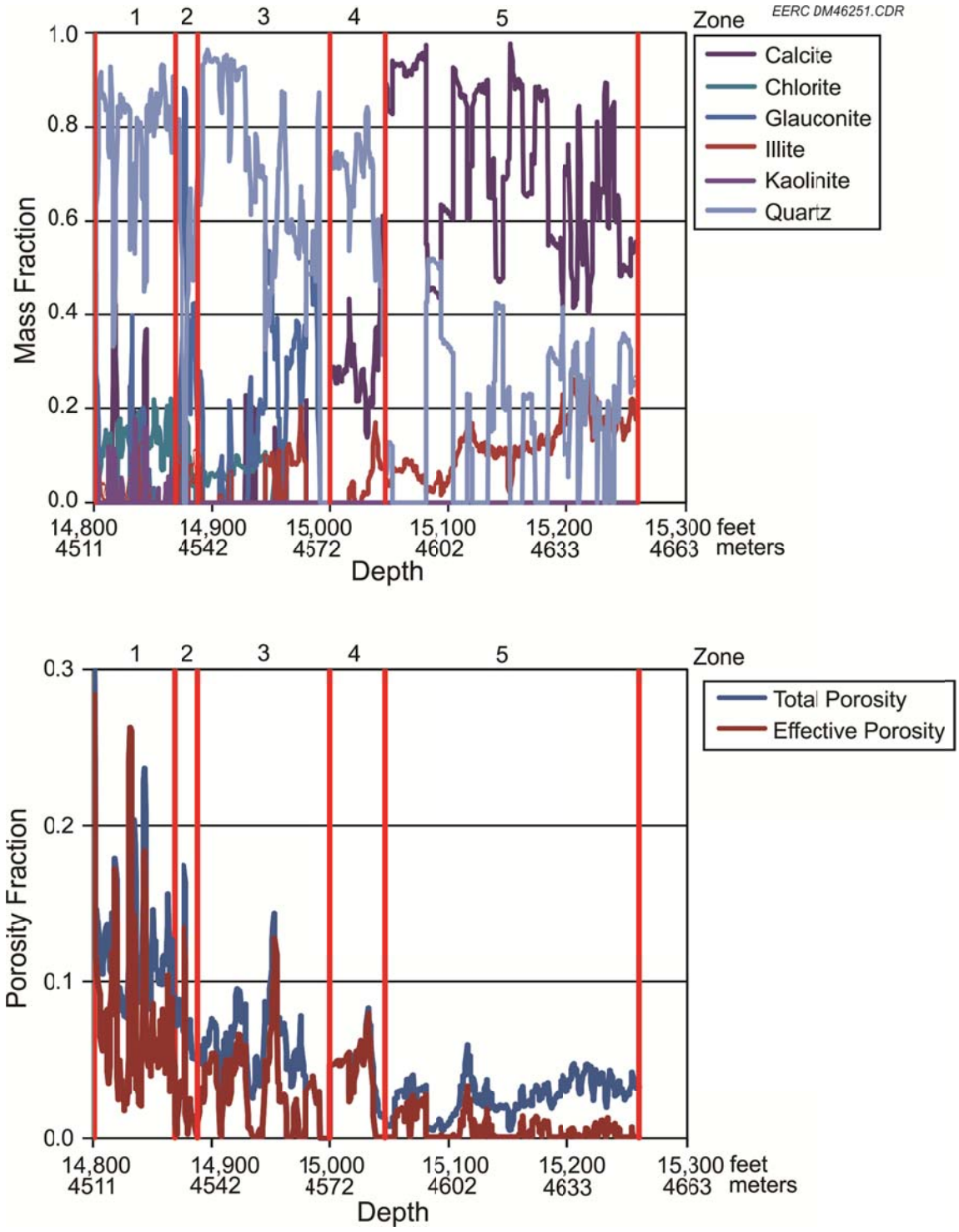



Figure B-9. ND 12596 mineral composition and porosity as a function of depth.

**ND 12596 CAP ROCK**

For the ND 12596 well, 148 feet (45 meters) of cap rock data was available from the top of the COSS zone upward. The same water composition was used in the cap rock calculations as was used in the COSS portion.

Zone 1 of the cap rock comprises roughly equal amounts of mica, quartz, and shale. Zones 2 and 3 comprise primarily quartz with a moderate amount of illite clay. Zone 4 is made up of quartz and shale, with quartz predominating. The porosity of the cap rock is much higher than the aquifer rock, ranging from 0.055 to 0.353. Well log data suggest that the cap rock may be extensively fractured over the range of mineral data examined.

The zones showed similar relative changes with $CO_2$ as compared to the baseline calculations. There are small decreases in kaolinite and phlogopite with small increases in dolomite, muscovite, and quartz.

The amount of $CO_2$ dissolved in the formation water is approximately 1.2 moles/kg (52.8 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 8.2 kg/m$^3$ (0.5 lb/ft$^3$) of formation rock. The apparent high degree of interaction of $CO_2$ with the cap rock appears to be due to the high cap rock porosity as well as the approximations used for the PHREEQC calculations using shale.

## Table B-37. Average Mineral and Porosity for the ND 12596 Cap Rock Zones

Well Name: ND 12596
API Identification: 33-053-02268-0000
State Identification: ND 12596

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Mica | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 4652.0 | 4465.9 | Average | 0.239 | 0.193 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | 0.000 | 0.000 | 0.437 | 0.000 | 0.212 | 0.321 |
| End | 4673.0 | 4472.3 | Minimum | 0.037 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 21.0 | 6.4 | Maximum | 0.341 | 0.315 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.021 | 0.000 | 0.000 | 1.000 | 0.000 | 0.560 | 0.463 |
| Number of Values | 43 | | Standard deviation | 0.093 | 0.090 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.081 | 0.000 | 0.000 | 0.218 | 0.000 | 0.155 | 0.158 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 4673.0 | 4472.3 | Average | 0.145 | 0.111 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.211 | 0.000 | 0.000 | 0.678 | 0.000 | 0.023 | 0.087 |
| End | 4698.0 | 4480.0 | Minimum | 0.038 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.554 | 0.000 | 0.000 | 0.000 |
| Thickness | 25.0 | 7.6 | Maximum | 0.258 | 0.218 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.323 | 0.000 | 0.000 | 0.767 | 0.000 | 0.160 | 0.317 |
| Number of Values | 51 | | Standard deviation | 0.056 | 0.052 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.107 | 0.000 | 0.000 | 0.052 | 0.000 | 0.049 | 0.112 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 4698.0 | 4480.0 | Average | 0.080 | 0.055 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.224 | 0.000 | 0.000 | 0.749 | 0.000 | 0.017 | 0.010 |
| End | 4788.0 | 4507.4 | Minimum | 0.042 | 0.016 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.246 | 0.000 | 0.000 | 0.000 |
| Thickness | 90.0 | 27.4 | Maximum | 0.360 | 0.327 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.320 | 0.000 | 0.000 | 1.000 | 0.000 | 0.467 | 0.287 |
| Number of Values | 180 | | Standard deviation | 0.049 | 0.048 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.058 | 0.000 | 0.000 | 0.069 | 0.000 | 0.058 | 0.049 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 4788.0 | 4507.4 | Average | 0.385 | 0.353 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.129 | 0.000 | 0.584 | 0.287 |
| End | 4800.0 | 4511.0 | Minimum | 0.362 | 0.329 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.303 | 0.262 |
| Thickness | 12.0 | 3.7 | Maximum | 0.419 | 0.390 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.423 | 0.000 | 0.730 | 0.315 |
| Number of Values | 24 | | Standard deviation | 0.019 | 0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.115 | 0.000 | 0.114 | 0.016 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 4652.0 | 4465.9 | Average | 0.139 | 0.109 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.176 | 0.000 | 0.000 | 0.642 | 0.000 | 0.092 | 0.090 |
| End | 4800.0 | 4511.0 | Minimum | 0.037 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 148.0 | 45.1 | Maximum | 0.419 | 0.390 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.323 | 0.000 | 0.000 | 1.000 | 0.000 | 0.730 | 0.463 |
| Number of Values | 298 | | Standard deviation | 0.108 | 0.103 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.110 | 0.000 | 0.000 | 0.214 | 0.000 | 0.181 | 0.148 |

## Table B-38. Summary of ND 12596 Cap Rock Calculation Results

Well Name: ND 12596
API Identification: 33-053-02268-0000
State Identification: ND 12596

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Start, m | 4465.9 | 4472.3 | 4480.0 | 4507.4 | 4465.9 |
| End, m | 4472.3 | 4480.0 | 4507.4 | 4511.0 | 4511.0 |
| Thickness, m | 6.4 | 7.6 | 27.4 | 3.7 | 45.1 |
| Start, ft | 14,652.0 | 14,673.0 | 14,698.0 | 14,788.0 | 14,652.0 |
| End, ft | 14,673.0 | 14,698.0 | 14,788.0 | 14,800.0 | 14,800.0 |
| Thickness, ft | 21.0 | 25.0 | 90.0 | 12.0 | 148.0 |
| **Minerals Without $CO_2$** | | | | | |
| pH | 5.465 | 5.459 | 5.451 | 5.465 | 5.460 |
| pE | 0.307 | 0.384 | 0.495 | 0.311 | 0.372 |
| Activity | 0.858 | 0.850 | 0.839 | 0.858 | 0.852 |
| Ionic Strength | 3.531 | 3.671 | 3.877 | 3.538 | 3.649 |
| Total Solution $CO_2$, moles | 1.472E-03 | 1.447E-03 | 1.412E-03 | 1.471E-03 | 1.451E-03 |
| Solution, moles | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0015 | 0.0014 | 0.0012 | 0.0015 | 0.0014 |
| Ca | 0.2349 | 0.2348 | 0.2347 | 0.2349 | 0.2348 |
| Cl | 5.3350 | 5.3350 | 5.3350 | 5.3350 | 5.3350 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0021 | 0.0020 | 0.0018 | 0.0021 | 0.0020 |
| Mg | 0.0797 | 0.0798 | 0.0799 | 0.0797 | 0.0797 |
| Na | 4.7190 | 4.7190 | 4.7190 | 4.7190 | 4.7190 |
| S | 0.0072 | 0.0072 | 0.0072 | 0.0072 | 0.0072 |
| Si | 0.0015 | 0.0014 | 0.0013 | 0.0015 | 0.0014 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 2.350 | 13.020 | 28.270 | 0.558 | 11.250 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 4.150 | 2.198 | 0.551 | 1.584 | 2.337 |
| Maximum Microcline | 0.823 | 0.436 | 0.109 | 0.314 | 0.463 |
| Muscovite | 13.810 | 38.610 | 90.640 | 2.078 | 37.450 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 59.390 | 18.790 | 16.120 | 54.670 | 45.640 |
| Rutile | 0.785 | 0.416 | 0.104 | 0.300 | 0.442 |
| Sanidine High | 0.235 | 0.124 | 0.031 | 0.090 | 0.132 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.008 | 0.008 | 0.009 | 0.008 | 0.008 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 3.803 | 5.905 | 9.760 | 1.293 | 5.420 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 16.130 | 45.940 | 105.400 | 2.821 | 43.920 |
| Phlogopite | 0.186 | 1.075 | 2.346 | 0.037 | 0.928 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 63.950 | 33.380 | 45.630 | 56.070 | 58.480 |
| Rutile | 0.785 | 0.416 | 0.104 | 0.300 | 0.442 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation:<br>Zone: | Cap Rock<br>Zone 1 | Cap Rock<br>Zone 2 | Cap Rock<br>Zone 3 | Cap Rock<br>Zone 4 | Cap Rock<br>Total |
|---|---|---|---|---|---|
| Change (initial – final), moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.008 | 0.008 | 0.009 | 0.008 | 0.008 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −2.350 | −13.020 | −28.270 | −0.558 | −11.250 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.347 | 3.707 | 9.209 | −0.291 | 3.083 |
| Maximum Microcline | −0.823 | −0.436 | −0.109 | −0.314 | −0.463 |
| Muscovite | 2.323 | 7.339 | 14.800 | 0.743 | 6.462 |
| Phlogopite | 0.186 | 1.075 | 2.346 | 0.037 | 0.928 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 4.561 | 14.590 | 29.510 | 1.401 | 12.840 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | −0.235 | −0.124 | −0.031 | −0.090 | −0.132 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | |
| $CaCO_3$ | 1.55E-06 | 1.55E-06 | 1.54E-06 | 1.55E-06 | 1.55E-06 |
| $CaHCO_3^+$ | 1.69E-04 | 1.68E-04 | 1.68E-04 | 1.69E-04 | 1.69E-04 |
| $CO_2$ | 1.00E-03 | 9.82E-04 | 9.54E-04 | 1.00E-03 | 9.85E-04 |
| $CO_3^{2-}$ | 3.33E-08 | 3.20E-08 | 3.02E-08 | 3.32E-08 | 3.22E-08 |
| $FeCO_3$ | 1.95E-11 | 1.67E-11 | 1.33E-11 | 1.94E-11 | 1.71E-11 |
| $FeCO_3^+$ | 1.46E-19 | 1.47E-19 | 1.49E-19 | 1.46E-19 | 1.47E-19 |
| $FeHCO_3^+$ | 2.08E-08 | 1.79E-08 | 1.43E-08 | 2.07E-08 | 1.83E-08 |
| $HCO_3^-$ | 1.86E-04 | 1.79E-04 | 1.70E-04 | 1.86E-04 | 1.80E-04 |
| $MgCO_3$ | 1.06E-07 | 1.06E-07 | 1.07E-07 | 1.06E-07 | 1.06E-07 |
| $MgHCO_3^+$ | 5.82E-05 | 5.85E-05 | 5.91E-05 | 5.82E-05 | 5.85E-05 |
| $NaCO_3^-$ | 6.72E-10 | 6.73E-10 | 6.73E-10 | 6.72E-10 | 6.72E-10 |
| $NaHCO_3$ | 5.55E-05 | 5.69E-05 | 5.90E-05 | 5.55E-05 | 5.67E-05 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.678E-02 | 1.689E-02 | 1.704E-02 | 1.679E-02 | 1.688E-02 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.678E-02 | 1.689E-02 | 1.704E-02 | 1.679E-02 | 1.688E-02 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.002E-03 | 9.821E-04 | 9.538E-04 | 1.001E-03 | 9.852E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 4.697E-04 | 4.648E-04 | 4.577E-04 | 4.695E-04 | 4.656E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 1.825E-02 | 1.834E-02 | 1.845E-02 | 1.826E-02 | 1.833E-02 |
| Water, $g/cm^3$ | 0.193 | 0.111 | 0.055 | 0.055 | 0.109 |
| Water, $kg/m^3$ | 193.158 | 111.246 | 54.947 | 54.947 | 108.560 |
| Mineral $CO_2$, $moles/m^3$ | 3.242E+00 | 1.879E+00 | 9.364E-01 | 9.225E-01 | 1.832E+00 |
| Dissolved $CO_2$, $moles/m^3$ | 1.935E-01 | 1.093E-01 | 5.241E-02 | 5.500E-02 | 1.070E-01 |
| Solution $CO_2$, $moles/m^3$ | 9.073E-02 | 5.171E-02 | 2.515E-02 | 2.580E-02 | 5.055E-02 |
| Total $CO_2$, $moles/m^3$ | 3.526E+00 | 2.040E+00 | 1.014E+00 | 1.003E+00 | 1.990E+00 |
| Mineral $CO_2$, $moles/ft^3$ | 9.179E-02 | 5.322E-02 | 2.652E-02 | 2.612E-02 | 5.188E-02 |
| Dissolved $CO_2$, $moles/ft^3$ | 5.481E-03 | 3.094E-03 | 1.484E-03 | 1.557E-03 | 3.029E-03 |
| Solution $CO_2$, $moles/ft^3$ | 2.569E-03 | 1.464E-03 | 7.122E-04 | 7.306E-04 | 1.431E-03 |
| Total $CO_2$, $moles/ft^3$ | 9.984E-02 | 5.778E-02 | 2.871E-02 | 2.841E-02 | 5.634E-02 |
| Mineral $CO_2$, $kg/m^3$ | 1.427E-01 | 8.271E-02 | 4.121E-02 | 4.060E-02 | 8.064E-02 |
| Dissolved $CO_2$, $kg/m^3$ | 8.518E-03 | 4.808E-03 | 2.306E-03 | 2.421E-03 | 4.707E-03 |
| Solution $CO_2$, $kg/m^3$ | 3.993E-03 | 2.276E-03 | 1.107E-03 | 1.135E-03 | 2.225E-03 |
| Total $CO_2$, $kg/m^3$ | 1.552E-01 | 8.980E-02 | 4.462E-02 | 4.415E-02 | 8.757E-02 |
| Mineral $CO_2$, $lb/ft^3$ | 8.906E-03 | 5.163E-03 | 2.573E-03 | 2.534E-03 | 5.034E-03 |
| Dissolved $CO_2$, $lb/ft^3$ | 5.317E-04 | 3.002E-04 | 1.440E-04 | 1.511E-04 | 2.938E-04 |
| Solution $CO_2$, $lb/ft^3$ | 2.493E-04 | 1.421E-04 | 6.910E-05 | 7.088E-05 | 1.389E-04 |
| Total $CO_2$, $lb/ft^3$ | 9.687E-03 | 5.606E-03 | 2.786E-03 | 2.756E-03 | 5.467E-03 |
| Weighted Average of Zones | | | | | |
| Total Thickness, m | 45.1 | | | | |
| Mineral $CO_2$, $kg/m^3$ | 6.257E-02 | | | | |
| Dissolved $CO_2$, $kg/m^3$ | 3.620E-03 | | | | |
| Solution $CO_2$, $kg/m^3$ | 1.716E-03 | | | | |
| Total $CO_2$, $kg/m^3$ | 6.790E-02 | | | | |
| Mineral $CO_2$, $lb/ft^3$ | 3.906E-03 | | | | |
| Dissolved $CO_2$, $lb/ft^3$ | 2.260E-04 | | | | |
| Solution $CO_2$, $lb/ft^3$ | 1.071E-04 | | | | |
| Total $CO_2$, $lb/ft^3$ | 4.239E-03 | | | | |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| **Minerals with $CO_2$** | | | | | |
| pH | 4.979 | 5.167 | 5.161 | 3.927 | 5.168 |
| pE | 1.873 | 1.392 | 1.476 | 4.957 | 1.383 |
| Activity | 0.836 | 0.827 | 0.816 | 0.836 | 0.828 |
| Ionic Strength | 3.541 | 3.718 | 3.924 | 3.528 | 3.696 |
| Total Solution $CO_2$, moles | 1.37E+00 | 1.44E+00 | 1.41E+00 | 1.21E+00 | 1.45E+00 |
| Solution, moles | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.3900 | 1.3770 | 1.2350 | 1.2200 | 1.3960 |
| Ca | 0.0000 | 0.0000 | 0.0000 | 0.1665 | 0.0000 |
| Cl | 5.3350 | 5.3350 | 5.3350 | 5.3350 | 5.3350 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0062 | 0.0037 | 0.0034 | 0.0692 | 0.0037 |
| Mg | 0.4032 | 0.4463 | 0.4345 | 0.1217 | 0.4478 |
| Na | 4.7190 | 4.7190 | 4.7190 | 4.7190 | 4.7190 |
| S | 0.0072 | 0.0072 | 0.0072 | 0.0072 | 0.0072 |
| Si | 0.0015 | 0.0014 | 0.0013 | 0.0015 | 0.0014 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 2.350 | 13.020 | 28.270 | 0.558 | 11.250 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 4.150 | 2.198 | 0.551 | 1.584 | 2.337 |
| Maximum Microcline | 0.823 | 0.436 | 0.109 | 0.314 | 0.463 |
| Muscovite | 13.810 | 38.610 | 90.640 | 2.078 | 37.450 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 59.390 | 18.790 | 16.120 | 54.670 | 45.640 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Rutile | 0.785 | 0.416 | 0.104 | 0.300 | 0.442 |
| Sanidine High | 0.235 | 0.124 | 0.031 | 0.090 | 0.132 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 298.100 | 298.200 | 298.300 | 298.600 | 298.100 |
| Dolomite | 0.243 | 0.243 | 0.243 | 0.077 | 0.243 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 3.623 | 5.707 | 9.566 | 1.357 | 5.221 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 16.320 | 46.140 | 105.600 | 2.791 | 44.120 |
| Phlogopite | 0.000 | 0.875 | 2.149 | 0.000 | 0.727 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 64.330 | 33.780 | 46.020 | 56.150 | 58.880 |
| Rutile | 0.785 | 0.416 | 0.104 | 0.300 | 0.442 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | −1.858 | −1.845 | −1.703 | −1.356 | −1.864 |
| Dolomite | 0.243 | 0.243 | 0.243 | 0.077 | 0.243 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −2.350 | −13.020 | −28.270 | −0.558 | −11.250 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.527 | 3.510 | 9.015 | −0.227 | 2.885 |
| Maximum Microcline | −0.823 | −0.436 | −0.109 | −0.314 | −0.463 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Muscovite | 2.505 | 7.538 | 14.990 | 0.713 | 6.661 |
| Phlogopite | 0.000 | 0.875 | 2.149 | 0.000 | 0.727 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 4.933 | 14.990 | 29.900 | 1.475 | 13.240 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | −0.235 | −0.124 | −0.031 | −0.090 | −0.132 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | |
| $CaCO_3$ | 3.13E-09 | 1.27E-09 | 1.26E-09 | 1.06E-06 | 1.27E-09 |
| $CaHCO_3^+$ | 1.04E-06 | 2.71E-07 | 2.67E-07 | 3.95E-03 | 2.70E-07 |
| $CO_2$ | 1.19E+00 | 1.17E+00 | 1.14E+00 | 1.20E+00 | 1.17E+00 |
| $CO_3^{2-}$ | 4.11E-06 | 9.67E-06 | 9.26E-06 | 3.26E-08 | 9.74E-06 |
| $FeCO_3$ | 1.99E-09 | 3.94E-09 | 3.35E-09 | 1.85E-11 | 4.02E-09 |
| $FeCO_3^+$ | 5.46E-16 | 3.53E-16 | 3.58E-16 | 6.17E-15 | 3.53E-16 |
| $FeHCO_3^+$ | 6.49E-06 | 8.23E-06 | 6.97E-06 | 6.81E-07 | 8.38E-06 |
| $HCO_3^-$ | 7.02E-02 | 1.06E-01 | 1.01E-01 | 6.28E-03 | 1.07E-01 |
| $MgCO_3$ | 5.25E-05 | 1.29E-04 | 1.31E-04 | 1.56E-07 | 1.29E-04 |
| $MgHCO_3^+$ | 8.83E-02 | 1.39E-01 | 1.40E-01 | 2.96E-03 | 1.39E-01 |
| $NaCO_3^-$ | 8.21E-08 | 2.01E-07 | 2.03E-07 | 6.59E-10 | 2.01E-07 |
| $NaHCO_3$ | 2.08E-02 | 3.33E-02 | 3.49E-02 | 1.88E-03 | 3.32E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.487 | 0.487 | 0.487 | 0.154 | 0.487 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.487 | 0.487 | 0.487 | 0.154 | 0.487 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.191 | 1.165 | 1.137 | 1.199 | 1.170 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.179 | 0.278 | 0.277 | 0.015 | 0.279 |
| Total $CO_2$, moles/kg $H_2O$ | 1.857 | 1.930 | 1.900 | 1.368 | 1.935 |
| Water, $g/cm^3$ | 0.193 | 0.111 | 0.055 | 0.055 | 0.109 |
| Water, $kg/m^3$ | 193.158 | 111.246 | 54.947 | 54.947 | 108.560 |
| Mineral $CO_2$, $moles/m^3$ | 93.991 | 54.132 | 26.737 | 8.438 | 52.825 |
| Dissolved $CO_2$, $moles/m^3$ | 230.051 | 129.602 | 62.475 | 65.882 | 127.016 |
| Solution $CO_2$, $moles/m^3$ | 34.640 | 30.947 | 15.204 | 0.828 | 30.276 |
| Total $CO_2$, $moles/m^3$ | 358.682 | 214.681 | 104.416 | 75.147 | 210.117 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Mineral $CO_2$, moles/$ft^3$ | 2.662 | 1.533 | 0.757 | 0.239 | 1.496 |
| Dissolved $CO_2$, moles/$ft^3$ | 6.514 | 3.670 | 1.769 | 1.866 | 3.597 |
| Solution $CO_2$, moles/$ft^3$ | 0.981 | 0.876 | 0.431 | 0.023 | 0.857 |
| Total $CO_2$, moles/$ft^3$ | 10.157 | 6.079 | 2.957 | 2.128 | 5.950 |
| Mineral $CO_2$, kg/$m^3$ | 4.137 | 2.382 | 1.177 | 0.371 | 2.325 |
| Dissolved $CO_2$, kg/$m^3$ | 10.125 | 5.704 | 2.750 | 2.899 | 5.590 |
| Solution $CO_2$, kg/$m^3$ | 1.524 | 1.362 | 0.669 | 0.036 | 1.332 |
| Total $CO_2$, kg/$m^3$ | 15.786 | 9.448 | 4.595 | 3.307 | 9.247 |
| Mineral $CO_2$, lb/$ft^3$ | 0.258 | 0.149 | 0.073 | 0.023 | 0.145 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.632 | 0.356 | 0.172 | 0.181 | 0.349 |
| Solution $CO_2$, lb/$ft^3$ | 0.095 | 0.085 | 0.042 | 0.002 | 0.083 |
| Total $CO_2$, lb/$ft^3$ | 0.985 | 0.590 | 0.287 | 0.206 | 0.577 |
| Weighted Average of Zones | | | | | |
| Total Thickness, m | 45.1 | | | | |
| Mineral $CO_2$, kg/$m^3$ | 1.735 | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 4.307 | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.856 | | | | |
| Total $CO_2$, kg/$m^3$ | 6.898 | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.108 | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.269 | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.053 | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.431 | | | | |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | |
| pH | −0.486 | −0.292 | −0.290 | −1.538 | −0.292 |
| pE | 1.566 | 1.008 | 0.981 | 4.646 | 1.011 |
| Activity | −0.022 | −0.023 | −0.023 | −0.022 | −0.024 |
| Ionic Strength | 0.010 | 0.047 | 0.047 | −0.010 | 0.047 |
| Total Solution $CO_2$, moles | 1.369 | 1.442 | 1.413 | 1.213 | 1.448 |
| Solution, moles | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.389 | 1.376 | 1.234 | 1.219 | 1.395 |
| Ca | −0.235 | −0.235 | −0.235 | −0.068 | −0.235 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.004 | 0.002 | 0.002 | 0.067 | 0.002 |
| Mg | 0.324 | 0.367 | 0.355 | 0.042 | 0.368 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 298.100 | 298.200 | 298.300 | 298.600 | 298.100 |
| Dolomite | 0.235 | 0.235 | 0.235 | 0.068 | 0.235 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.180 | −0.198 | -0.194 | 0.064 | −0.199 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.190 | 0.200 | 0.200 | −0.030 | 0.200 |
| Phlogopite | −0.186 | −0.200 | −0.197 | −0.037 | −0.201 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.380 | 0.400 | 0.390 | 0.080 | 0.400 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12596 | 1.858 | 1.845 | 1.703 | 1.356 | 1.864 |
| Dolomite | 0.235 | 0.235 | 0.235 | 0.068 | 0.235 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.180 | −0.197 | −0.194 | 0.064 | −0.198 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.182 | 0.199 | 0.190 | −0.030 | 0.199 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Phlogopite | −0.186 | −0.200 | −0.197 | −0.037 | −0.201 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.372 | 0.400 | 0.390 | 0.074 | 0.400 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | |
| $CaCO_3$ | −1.55E-06 | −1.55E-06 | −1.54E-06 | −4.98E-07 | −1.55E-06 |
| $CaHCO_3^+$ | −1.68E-04 | −1.68E-04 | −1.68E-04 | 3.78E-03 | −1.68E-04 |
| $CO_2$ | 1.19E+00 | 1.16E+00 | 1.14E+00 | 1.20E+00 | 1.17E+00 |
| $CO_3^{2-}$ | 4.07E-06 | 9.64E-06 | 9.23E-06 | -6.30E-10 | 9.70E-06 |
| $FeCO_3$ | 1.97E-09 | 3.93E-09 | 3.33E-09 | -8.90E-13 | 4.00E-09 |
| $FeCO_3^+$ | 5.46E-16 | 3.52E-16 | 3.58E-16 | 6.17E-15 | 3.53E-16 |
| $FeHCO_3^+$ | 6.47E-06 | 8.21E-06 | 6.96E-06 | 6.60E-07 | 8.36E-06 |
| $HCO_3^-$ | 7.00E-02 | 1.06E-01 | 1.01E-01 | 6.09E-03 | 1.06E-01 |
| $MgCO_3$ | 5.24E-05 | 1.29E-04 | 1.31E-04 | 5.01E-08 | 1.29E-04 |
| $MgHCO_3^+$ | 8.83E-02 | 1.39E-01 | 1.40E-01 | 2.90E-03 | 1.39E-01 |
| $NaCO_3^-$ | 8.14E-08 | 2.00E-07 | 2.03E-07 | -1.26E-11 | 2.00E-07 |
| $NaHCO_3$ | 2.07E-02 | 3.33E-02 | 3.48E-02 | 1.82E-03 | 3.32E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.470 | 0.470 | 0.470 | 0.137 | 0.470 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.470 | 0.470 | 0.470 | 0.137 | 0.470 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.190 | 1.164 | 1.136 | 1.198 | 1.169 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.179 | 0.278 | 0.276 | 0.015 | 0.278 |
| Total $CO_2$, moles/kg $H_2O$ | 1.839 | 1.911 | 1.882 | 1.349 | 1.917 |
| Water, g/cm$^3$ | 0.193 | 0.111 | 0.055 | 0.353 | 0.109 |
| Water, kg/m$^3$ | 193.158 | 111.246 | 54.947 | 353.383 | 108.560 |
| Mineral $CO_2$, moles/m$^3$ | 90.749 | 52.253 | 25.801 | 48.333 | 50.993 |
| Dissolved $CO_2$, moles/m$^3$ | 229.858 | 129.492 | 62.422 | 423.352 | 126.909 |
| Solution $CO_2$, moles/m$^3$ | 34.549 | 30.896 | 15.179 | 5.157 | 30.226 |
| Total $CO_2$, moles/m$^3$ | 355.156 | 212.641 | 103.402 | 476.842 | 208.128 |

Continued…

**Table B-38. Summary of ND 12596 Cap Rock Calculation Results (continued)**

| Formation: | Cap Rock | Cap Rock | Cap Rock | Cap Rock | Cap Rock |
|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Total |
| Mineral $CO_2$, moles/$ft^3$ | 2.570 | 1.480 | 0.731 | 1.369 | 1.444 |
| Dissolved $CO_2$, moles/$ft^3$ | 6.509 | 3.667 | 1.768 | 11.988 | 3.594 |
| Solution $CO_2$, moles/$ft^3$ | 0.978 | 0.875 | 0.430 | 0.146 | 0.856 |
| Total $CO_2$, moles/$ft^3$ | 10.057 | 6.021 | 2.928 | 13.503 | 5.894 |
| Mineral $CO_2$, kg/$m^3$ | 3.994 | 2.300 | 1.135 | 2.127 | 2.244 |
| Dissolved $CO_2$, kg/$m^3$ | 10.116 | 5.699 | 2.747 | 18.632 | 5.585 |
| Solution $CO_2$, kg/$m^3$ | 1.521 | 1.360 | 0.668 | 0.227 | 1.330 |
| Total $CO_2$, kg/$m^3$ | 15.630 | 9.358 | 4.551 | 20.986 | 9.160 |
| Mineral $CO_2$, lb/$ft^3$ | 0.249 | 0.144 | 0.071 | 0.133 | 0.140 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.632 | 0.356 | 0.172 | 1.163 | 0.349 |
| Solution $CO_2$, lb/$ft^3$ | 0.095 | 0.085 | 0.042 | 0.014 | 0.083 |
| Total $CO_2$, lb/$ft^3$ | 0.976 | 0.584 | 0.284 | 1.310 | 0.572 |
| Weighted Average of Zones | | | | | |
| Total Thickness, m | 45.1 | | | | |
| Mineral $CO_2$, kg/$m^3$ | 1.818 | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 5.579 | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.870 | | | | |
| Total $CO_2$, kg/$m^3$ | 8.268 | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.114 | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.348 | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.054 | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.516 | | | | |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.443 | | | | |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.153 | | | | |
| Solution $CO_2$, moles/kg $H_2O$ | 0.241 | | | | |
| Total $CO_2$, moles/kg $H_2O$ | 1.838 | | | | |
| Total $CO_2$, moles/$m^3$ | 187.855 | | | | |
| Total $CO_2$, moles/$ft^3$ | 5.320 | | | | |
| Total $CO_2$, kg/$m^3$ | 8.268 | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.516 | | | | |

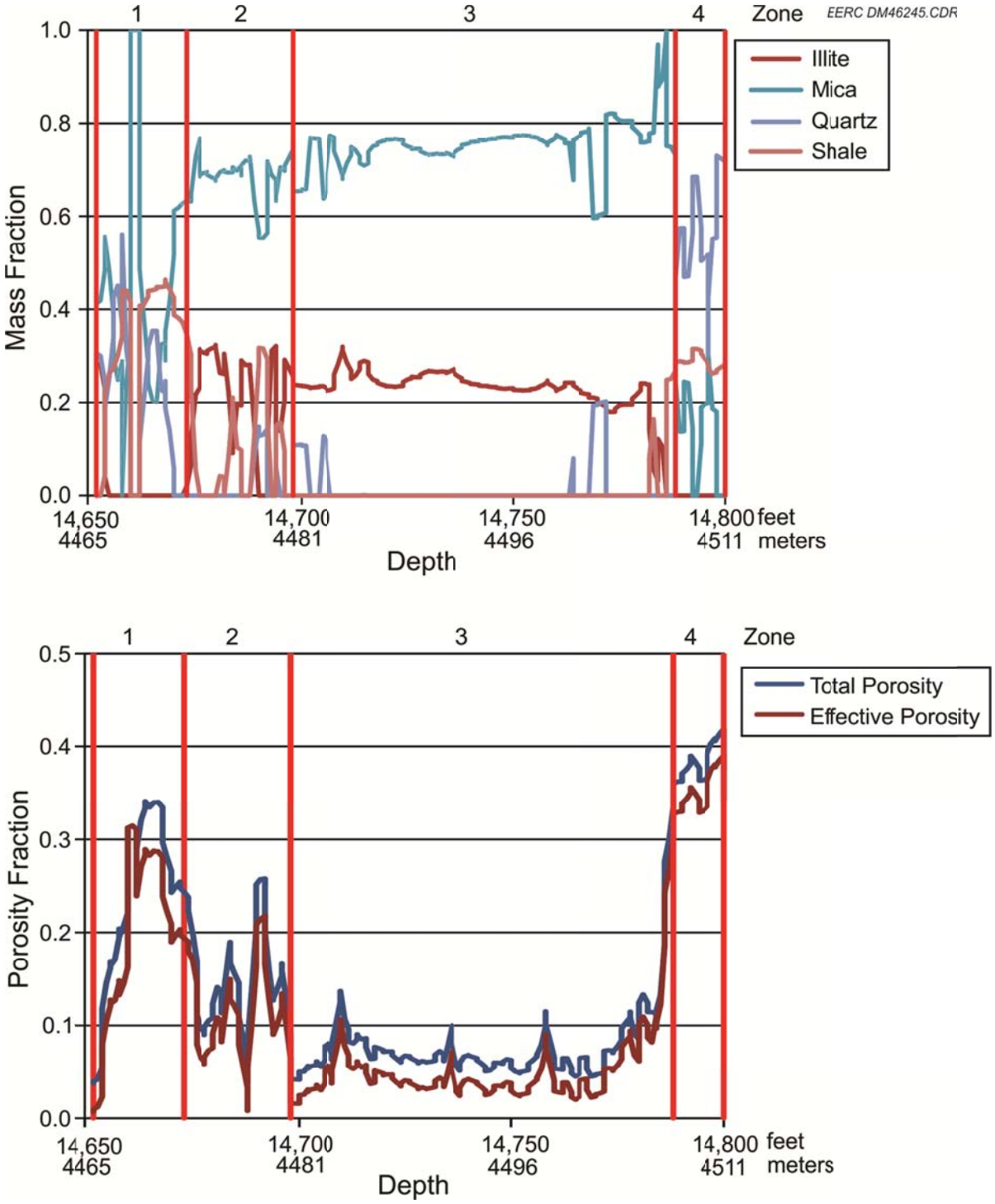



Figure B-10. ND 12596 mineral composition and porosity as a function of depth.

**MT API 21606**

The water composition used for MT API 21606 is from the MT API 21500 well 20 miles (32 km) to the south. Mineral data were available for 80% of COSS represented in this well. The total aquifer thickness is not known, as the well did not penetrate into the Precambrian.

Zones 1, 3, and 5 comprise mainly quartz and illite, with quartz predominating. Zones 2, 4, and 7 are predominantly quartz. Zone 6 is predominantly quartz with a moderate amount of dolomite present, while Zone 8 is made up of quartz, illite, and biotite. The porosity ranges from 0.013 to 0.135. Zones 2 and 6 have porosities higher than the other zones.

The zones are similar in interaction with $CO_2$. Small additional amounts of kaolinite dissolve, with corresponding increases in dolomite, quartz, and muscovite. Small amounts of pyrite also dissolve with the formation of siderite.

The amount of $CO_2$ dissolved in the formation water generally ranges from 0.77 to 0.86 moles/kg (33.88 to 37.84 g/kg). The exception is Zone 8 with a very low 0.40 moles/kg (17.6 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 5.4 kg/m$^3$ (0.3 lb/ft$^3$) of formation rock.

## Table B-39. Average Mineral and Porosity for the MT API 21606 Aquifer Zones

Well Name: MT API 21606
API Identification: 25-091-21606-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 10,372.0 | 3161.4 | Average | 0.071 | 0.063 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.152 | 0.000 | 0.000 | 0.000 | 0.002 | 0.842 | 0.004 |
| End | 10,383.0 | 3164.7 | Minimum | 0.032 | 0.019 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.580 | 0.000 |
| Thickness | 11.0 | 3.4 | Maximum | 0.118 | 0.099 | 0.000 | 0.004 | 0.001 | 0.000 | 0.000 | 0.420 | 0.000 | 0.000 | 0.000 | 0.012 | 1.000 | 0.056 |
| Number of Values | 24 | | Standard deviation | 0.028 | 0.025 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.152 | 0.000 | 0.000 | 0.000 | 0.003 | 0.149 | 0.013 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 10,383.0 | 3164.7 | Average | 0.138 | 0.135 | 0.000 | 0.008 | 0.000 | 0.059 | 0.000 | 0.050 | 0.000 | 0.000 | 0.000 | 0.002 | 0.881 | 0.000 |
| End | 10,392.0 | 3167.5 | Minimum | 0.049 | 0.049 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.407 | 0.000 |
| Thickness | 9.0 | 2.7 | Maximum | 0.301 | 0.301 | 0.000 | 0.087 | 0.000 | 0.335 | 0.000 | 0.258 | 0.000 | 0.000 | 0.000 | 0.010 | 1.000 | 0.000 |
| Number of Values | 19 | | Standard deviation | 0.085 | 0.086 | 0.000 | 0.022 | 0.000 | 0.107 | 0.000 | 0.083 | 0.000 | 0.000 | 0.000 | 0.003 | 0.158 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 10,392.0 | 3167.5 | Average | 0.055 | 0.039 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.315 | 0.000 | 0.000 | 0.000 | 0.000 | 0.664 | 0.000 |
| End | 10,406.0 | 3171.8 | Minimum | 0.029 | 0.015 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.031 | 0.000 | 0.000 | 0.000 | 0.000 | 0.374 | 0.000 |
| Thickness | 14.0 | 4.3 | Maximum | 0.117 | 0.110 | 0.000 | 0.000 | 0.000 | 0.265 | 0.000 | 0.594 | 0.000 | 0.000 | 0.000 | 0.013 | 0.956 | 0.000 |
| Number of Values | 28 | | Standard deviation | 0.021 | 0.023 | 0.000 | 0.000 | 0.000 | 0.059 | 0.000 | 0.127 | 0.000 | 0.000 | 0.000 | 0.002 | 0.137 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 10,406.0 | 3171.8 | Average | 0.045 | 0.045 | 0.000 | 0.000 | 0.000 | 0.071 | 0.000 | 0.007 | 0.000 | 0.000 | 0.000 | 0.002 | 0.919 | 0.000 |
| End | 10,414.0 | 3174.2 | Minimum | 0.020 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.755 | 0.000 |
| Thickness | 8.0 | 2.4 | Maximum | 0.077 | 0.077 | 0.000 | 0.000 | 0.000 | 0.245 | 0.000 | 0.117 | 0.000 | 0.000 | 0.000 | 0.010 | 1.000 | 0.000 |
| Number of Values | 16 | | Standard deviation | 0.016 | 0.017 | 0.000 | 0.000 | 0.000 | 0.088 | 0.000 | 0.029 | 0.000 | 0.000 | 0.000 | 0.004 | 0.084 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 10,414.0 | 3174.2 | Average | 0.043 | 0.032 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.227 | 0.000 | 0.006 | 0.000 | 0.002 | 0.764 | 0.000 |
| End | 10,431.0 | 3179.4 | Minimum | 0.018 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.129 | 0.000 | 0.000 | 0.000 | 0.000 | 0.628 | 0.000 |
| Thickness | 17.0 | 5.2 | Maximum | 0.080 | 0.072 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.321 | 0.000 | 0.208 | 0.000 | 0.011 | 0.865 | 0.000 |
| Number of Values | 33 | | Standard deviation | 0.016 | 0.017 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.059 | 0.000 | 0.036 | 0.000 | 0.004 | 0.061 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 10,431.0 | 3179.4 | Average | 0.132 | 0.129 | 0.000 | 0.000 | 0.000 | 0.205 | 0.000 | 0.037 | 0.000 | 0.014 | 0.000 | 0.030 | 0.713 | 0.000 |
| End | 10,458.0 | 3187.6 | Minimum | 0.021 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.035 | 0.000 |
| Thickness | 27.0 | 8.2 | Maximum | 0.168 | 0.168 | 0.000 | 0.000 | 0.000 | 0.659 | 0.000 | 0.303 | 0.000 | 0.373 | 0.000 | 0.097 | 0.986 | 0.000 |
| Number of Values | 55 | | Standard deviation | 0.030 | 0.034 | 0.000 | 0.000 | 0.000 | 0.136 | 0.000 | 0.056 | 0.000 | 0.062 | 0.000 | 0.021 | 0.159 | 0.000 |

Continued…

## Table B-39. Average Mineral and Porosity for the MT API 21606 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 10,458.0 | 3187.6 | Average | 0.095 | 0.091 | 0.005 | 0.000 | 0.000 | 0.080 | 0.000 | 0.079 | 0.000 | 0.006 | 0.000 | 0.011 | 0.819 | 0.000 |
| End | 10,498.0 | 3199.8 | Minimum | 0.031 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 40.0 | 12.2 | Maximum | 0.143 | 0.137 | 0.112 | 0.000 | 0.000 | 0.658 | 0.000 | 0.485 | 0.000 | 0.394 | 0.000 | 0.063 | 1.000 | 0.000 |
| Number of Values | 80 | | Standard deviation | 0.023 | 0.026 | 0.018 | 0.000 | 0.000 | 0.136 | 0.000 | 0.121 | 0.000 | 0.045 | 0.000 | 0.017 | 0.210 | 0.000 |
| Zone 8 | | | | | | | | | | | | | | | | | |
| Start | 10,498.0 | 3199.8 | Average | 0.029 | 0.013 | 0.186 | 0.000 | 0.000 | 0.000 | 0.000 | 0.323 | 0.000 | 0.000 | 0.000 | 0.000 | 0.492 | 0.000 |
| End | 10,518.0 | 3205.9 | Minimum | 0.011 | 0.001 | 0.122 | 0.000 | 0.000 | 0.000 | 0.000 | 0.186 | 0.000 | 0.000 | 0.000 | 0.000 | 0.420 | 0.000 |
| Thickness | 20.0 | 6.1 | Maximum | 0.039 | 0.021 | 0.261 | 0.000 | 0.000 | 0.000 | 0.000 | 0.434 | 0.000 | 0.000 | 0.000 | 0.000 | 0.553 | 0.000 |
| Number of Values | 39 | | Standard deviation | 0.008 | 0.006 | 0.039 | 0.000 | 0.000 | 0.000 | 0.000 | 0.061 | 0.000 | 0.000 | 0.000 | 0.000 | 0.031 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 10,372.0 | 3161.4 | Average | 0.082 | 0.074 | 0.026 | 0.001 | 0.000 | 0.070 | 0.000 | 0.143 | 0.000 | 0.005 | 0.000 | 0.009 | 0.746 | 0.000 |
| End | 10,518.0 | 3205.9 | Minimum | 0.011 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 146.0 | 44.5 | Maximum | 0.301 | 0.301 | 0.261 | 0.087 | 0.001 | 0.659 | 0.000 | 0.594 | 0.000 | 0.394 | 0.000 | 0.097 | 1.000 | 0.056 |
| Number of Values | 294 | | Standard deviation | 0.048 | 0.053 | 0.065 | 0.006 | 0.000 | 0.123 | 0.000 | 0.148 | 0.000 | 0.038 | 0.000 | 0.017 | 0.192 | 0.004 |

**Table B-40. Summary of MT API 21606 Aquifer Minerals and Conditions**

Well Name: MT API 21606
API Identification: 25-091-21606-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Start, ft | 10,372 | 10,383 | 10,392 | 10,406 | 10,414 | 10,431 | 10,458 | 10,498 | 10,372 |
| End, ft | 10,383 | 10,392 | 10,406 | 10,414 | 10,431 | 10,458 | 10,498 | 10,518 | 10,518 |
| Thickness, ft | 11.0 | 9.0 | 14.0 | 8.0 | 17.0 | 27.0 | 40.0 | 20.0 | 146.0 |
| Start, m | 3161.4 | 3164.7 | 3167.5 | 3171.8 | 3174.2 | 3179.4 | 3187.6 | 3199.8 | 3161.4 |
| End, m | 3164.7 | 3167.5 | 3171.8 | 3174.2 | 3179.4 | 3187.6 | 3199.8 | 3205.9 | 3205.9 |
| Thickness, m | 3.4 | 2.7 | 4.3 | 2.4 | 5.2 | 8.2 | 12.2 | 6.1 | 44.5 |
| Temperature, °F | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 |
| Temperature, °C | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 |
| Pressure, psi | 6535 | 6537 | 6539 | 6541 | 6543 | 6547 | 6553 | 6558 | 6547 |
| Pressure, kPa | 45,057 | 45,069 | 45,083 | 45,097 | 45,112 | 45,139 | 45,180 | 45,216 | 45,140 |
| Effective Porosity, fraction | 0.063 | 0.135 | 0.039 | 0.045 | 0.032 | 0.129 | 0.091 | 0.013 | 0.074 |
| Mass Fraction | | | | | | | | | |
| Ankerite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.186 | 0.026 |
| Calcite | 0.000 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.059 | 0.020 | 0.071 | 0.000 | 0.205 | 0.080 | 0.000 | 0.070 |
| Glauconite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.152 | 0.050 | 0.315 | 0.007 | 0.227 | 0.037 | 0.079 | 0.323 | 0.143 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.014 | 0.006 | 0.000 | 0.005 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.002 | 0.002 | 0.000 | 0.002 | 0.002 | 0.030 | 0.011 | 0.000 | 0.009 |
| Quartz | 0.842 | 0.881 | 0.664 | 0.919 | 0.764 | 0.713 | 0.819 | 0.492 | 0.746 |
| Shale | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-41. Summary of Joys Aquifer Calculation Results

Well Name: MT API 21606
API Identification: 25-091-21606-0000

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Start, m | 3161.4 | 3164.7 | 3167.5 | 3171.8 | 3174.2 | 3179.4 | 3187.6 | 3199.8 | 3161.4 |
| End, m | 3164.7 | 3167.5 | 3171.8 | 3174.2 | 3179.4 | 3187.6 | 3199.8 | 3205.9 | 3205.9 |
| Thickness, m | 3.4 | 2.7 | 4.3 | 2.4 | 5.2 | 8.2 | 12.2 | 6.1 | 44.5 |
| Start, ft | 10,372.0 | 10,383.0 | 10,392.0 | 10,406.0 | 10,414.0 | 10,431.0 | 10,458.0 | 10,498.0 | 10,372.0 |
| End, ft | 10,383.0 | 10,392.0 | 10,406.0 | 10,414.0 | 10,431.0 | 10,458.0 | 10,498.0 | 10,518.0 | 10,518.0 |
| Thickness, ft | 11.0 | 9.0 | 14.0 | 8.0 | 17.0 | 27.0 | 40.0 | 20.0 | 146.0 |
| **Minerals Without $CO_2$** | | | | | | | | | |
| pH | 5.798 | 6.192 | 5.691 | 5.723 | 5.694 | 5.720 | 5.718 | 5.754 | 6.128 |
| pE | –2.392 | –2.836 | –2.273 | –2.308 | –2.277 | –2.304 | –2.302 | 8.432 | –2.763 |
| Activity | 0.853 | 0.861 | 0.823 | 0.862 | 0.828 | 0.861 | 0.859 | 0.335 | 0.855 |
| Ionic Strength | 3.862 | 3.706 | 4.399 | 3.675 | 4.306 | 3.683 | 3.727 | 8.835 | 3.829 |
| Total Solution $CO_2$, moles | 5.504E-04 | 3.959E-04 | 6.032E-04 | 6.430E-04 | 6.084E-04 | 6.459E-04 | 6.431E-04 | 3.189E-04 | 4.050E-04 |
| Solution, moles | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0005 | 0.0004 | 0.0005 | 0.0007 | 0.0005 | 0.0007 | 0.0007 | 0.0000 | 0.0004 |
| Ca | 0.3180 | 0.3797 | 0.2821 | 0.2836 | 0.2821 | 0.2822 | 0.2822 | 0.2819 | 0.3758 |
| Cl | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0012 | 0.0005 | 0.0012 | 0.0016 | 0.0012 | 0.0016 | 0.0015 | 0.0001 | 0.0006 |
| Mg | 0.0737 | 0.0124 | 0.1097 | 0.1080 | 0.1096 | 0.1094 | 0.1094 | 0.1103 | 0.0163 |
| Na | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 |
| S | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.0013 | 0.0014 |
| Si | 0.0009 | 0.0010 | 0.0007 | 0.0010 | 0.0008 | 0.0010 | 0.0010 | 0.0002 | 0.0009 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.072 | 1.425 | 0.000 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.188 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21606 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.002 | 5.423 | 7.112 | 21.850 | 0.000 | 20.530 | 12.250 | 212.600 | 17.320 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 15.920 | 2.190 | 53.330 | 1.080 | 47.590 | 1.799 | 5.503 | 177.600 | 12.470 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 1.962 | 0.996 | 0.621 | 0.000 | 0.640 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.610 | 0.216 | 0.254 | 1.058 | 1.366 | 4.678 | 2.542 | 0.000 | 2.627 |
| Quartz | 548.000 | 247.400 | 717.200 | 864.200 | 1023.000 | 219.400 | 365.000 | 1730.000 | 415.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1.229 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21606 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.038 | 5.521 | 7.112 | 21.860 | 0.000 | 20.530 | 12.250 | 212.600 | 17.410 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 5.063 | 0.481 | 17.530 | 0.113 | 17.580 | 1.349 | 2.208 | 58.940 | 4.547 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 8.393 | 1.306 | 27.730 | 0.731 | 24.760 | 1.102 | 3.016 | 91.910 | 6.615 |
| Phlogopite | 1.305 | 0.158 | 4.420 | 0.065 | 3.941 | 0.125 | 0.434 | 14.770 | 1.014 |
| Pyrite | 0.610 | 0.216 | 0.254 | 1.058 | 1.366 | 4.678 | 2.542 | 0.000 | 2.627 |
| Quartz | 564.500 | 249.700 | 772.400 | 865.400 | 1072.000 | 221.300 | 370.700 | 1914.000 | 428.100 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –0.072 | –0.195 | 0.000 | –0.003 | 0.000 | 0.000 | 0.000 | 0.000 | –0.188 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | –0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21606 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Dolomite | 0.036 | 0.098 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.094 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –15.920 | –2.190 | –53.330 | –1.080 | –47.590 | –1.799 | –5.503 | –177.600 | –12.470 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 5.063 | 0.481 | 17.530 | 0.113 | 15.610 | 0.353 | 1.587 | 58.940 | 3.907 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 8.393 | 1.306 | 27.730 | 0.731 | 24.760 | 1.102 | 3.016 | 91.910 | 6.615 |
| Phlogopite | 1.305 | 0.158 | 4.420 | 0.065 | 3.941 | 0.125 | 0.434 | 14.770 | 1.014 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 16.490 | 2.312 | 55.160 | 1.164 | 49.220 | 1.907 | 5.735 | 183.500 | 12.930 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | |
| $CaCO_3$ | 2.33E-06 | 6.21E-06 | 0.0000 | 1.82E-06 | 0.0000 | 0.0000 | 0.0000 | 1.19E-06 | 5.38E-06 |
| $CaHCO_3^+$ | 1.20E-04 | 1.31E-04 | 0.0001 | 1.13E-04 | 0.0001 | 1.13E-04 | 0.0001 | 4.32E-05 | 1.30E-04 |
| $CO_2$ | 2.12E-04 | 8.16E-05 | 0.0003 | 2.80E-04 | 2.56E-04 | 0.0003 | 0.0003 | 1.14E-04 | 9.20E-05 |
| $CO_3^{2-}$ | 4.62E-08 | 1.08E-07 | 0.0000 | 4.27E-08 | 0.0000 | 0.0000 | 0.0000 | 1.18E-08 | 9.17E-08 |
| $FeCO_3$ | 1.96E-11 | 3.73E-11 | 0.0000 | 2.57E-11 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 2.87E-11 |
| $FeCO_3^+$ | 2.59E-22 | 1.79E-22 | 1.78E-22 | 4.18E-22 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.62E-22 |
| $FeHCO_3^+$ | 9.09E-09 | 7.06E-09 | 0.0000 | 1.44E-08 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 6.25E-09 |
| $HCO_3^-$ | 1.19E-04 | 1.14E-04 | 0.0001 | 1.32E-04 | 0.0001 | 0.0001 | 1.31E-04 | 2.81E-05 | 1.11E-04 |
| $MgCO_3$ | 1.43E-07 | 5.35E-08 | 0.0000 | 1.83E-07 | 0.0000 | 0.0000 | 0.0000 | 2.79E-07 | 6.17E-08 |
| $MgHCO_3^+$ | 3.13E-05 | 4.79E-06 | 0.0001 | 4.82E-05 | 0.0001 | 0.0000 | 0.0000 | 4.29E-05 | 6.34E-06 |
| $NaCO_3^-$ | 3.03E-09 | 6.76E-09 | 0.0000 | 2.66E-09 | 0.0000 | 0.0000 | 0.0000 | 2.36E-09 | 5.93E-09 |
| $NaHCO_3$ | 6.57E-05 | 5.85E-05 | 0.0001 | 6.75E-05 | 0.0001 | 0.0001 | 0.0001 | 8.91E-05 | 6.00E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | –7.182E-02 | –1.952E-01 | 0.000E+00 | –2.787E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | –1.875E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 7.190E-02 | 1.954E-01 | 1.466E-04 | 2.738E-03 | 1.255E-04 | –4.902E-05 | –3.450E-05 | 5.690E-04 | 1.877E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 8.000E-05 | 2.400E-04 | 1.466E-04 | –4.900E-05 | 1.255E-04 | –4.902E-05 | –3.450E-05 | 5.690E-04 | 1.800E-04 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 2.118E-04 | 8.158E-05 | 2.527E-04 | 2.797E-04 | 2.562E-04 | 2.818E-04 | 2.798E-04 | 1.141E-04 | 9.204E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 3.386E-04 | 3.144E-04 | 3.505E-04 | 3.634E-04 | 3.522E-04 | 3.641E-04 | 3.632E-04 | 2.048E-04 | 3.129E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 6.304E-04 | 6.359E-04 | 7.498E-04 | 5.941E-04 | 7.339E-04 | 5.969E-04 | 6.085E-04 | 8.879E-04 | 5.849E-04 |
| Water, $g/cm^3$ | 0.063 | 0.135 | 0.039 | 0.045 | 0.032 | 0.129 | 0.091 | 0.013 | 0.074 |
| Water, $kg/m^3$ | 63.327 | 135.450 | 39.459 | 44.676 | 31.965 | 129.218 | 90.886 | 12.627 | 74.280 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Total |
| Mineral $CO_2$, moles/$m^3$ | 5.066E-03 | 3.251E-02 | 5.785E-03 | –2.189E-03 | 4.012E-03 | –6.334E-03 | –3.136E-03 | 7.185E-03 | 1.337E-02 |
| Dissolved $CO_2$, moles/$m^3$ | 1.341E-02 | 1.105E-02 | 9.971E-03 | 1.250E-02 | 8.189E-03 | 3.641E-02 | 2.543E-02 | 1.441E-03 | 6.837E-03 |
| Solution $CO_2$, moles/$m^3$ | 2.144E-02 | 4.258E-02 | 1.383E-02 | 1.623E-02 | 1.126E-02 | 4.705E-02 | 3.301E-02 | 2.586E-03 | 2.324E-02 |
| Total $CO_2$, moles/$m^3$ | 3.992E-02 | 8.614E-02 | 2.959E-02 | 2.654E-02 | 2.346E-02 | 7.713E-02 | 5.530E-02 | 1.121E-02 | 4.345E-02 |
| Mineral $CO_2$, moles/$ft^3$ | 1.435E-04 | 9.205E-04 | 1.638E-04 | –6.199E-05 | 1.136E-04 | –1.794E-04 | –8.879E-05 | 2.035E-04 | 3.786E-04 |
| Dissolved $CO_2$, moles/$ft^3$ | 3.798E-04 | 3.129E-04 | 2.824E-04 | 3.538E-04 | 2.319E-04 | 1.031E-03 | 7.201E-04 | 4.080E-05 | 1.936E-04 |
| Solution $CO_2$, moles/$ft^3$ | 6.072E-04 | 1.206E-03 | 3.916E-04 | 4.597E-04 | 3.188E-04 | 1.332E-03 | 9.347E-04 | 7.323E-05 | 6.582E-04 |
| Total $CO_2$, moles/$ft^3$ | 1.130E-03 | 2.439E-03 | 8.378E-04 | 7.516E-04 | 6.643E-04 | 2.184E-03 | 1.566E-03 | 3.175E-04 | 1.230E-03 |
| Mineral $CO_2$, kg/$m^3$ | 2.230E-04 | 1.431E-03 | 2.546E-04 | –9.634E-05 | 1.765E-04 | –2.788E-04 | –1.380E-04 | 3.162E-04 | 5.884E-04 |
| Dissolved $CO_2$, kg/$m^3$ | 5.903E-04 | 4.863E-04 | 4.388E-04 | 5.499E-04 | 3.604E-04 | 1.603E-03 | 1.119E-03 | 6.341E-05 | 3.009E-04 |
| Solution $CO_2$, kg/$m^3$ | 9.437E-04 | 1.874E-03 | 6.087E-04 | 7.145E-04 | 4.954E-04 | 2.071E-03 | 1.453E-03 | 1.138E-04 | 1.023E-03 |
| Total $CO_2$, kg/$m^3$ | 1.757E-03 | 3.791E-03 | 1.302E-03 | 1.168E-03 | 1.032E-03 | 3.394E-03 | 2.434E-03 | 4.934E-04 | 1.912E-03 |
| Mineral $CO_2$, lb/$ft^3$ | 1.392E-05 | 8.931E-05 | 1.590E-05 | –6.014E-06 | 1.102E-05 | –1.740E-05 | –8.615E-06 | 1.974E-05 | 3.673E-05 |
| Dissolved $CO_2$, lb/$ft^3$ | 3.685E-05 | 3.036E-05 | 2.740E-05 | 3.433E-05 | 2.250E-05 | 1.000E-04 | 6.987E-05 | 3.958E-06 | 1.878E-05 |
| Solution $CO_2$, lb/$ft^3$ | 5.891E-05 | 1.170E-04 | 3.800E-05 | 4.460E-05 | 3.093E-05 | 1.293E-04 | 9.069E-05 | 7.105E-06 | 6.386E-05 |
| Total $CO_2$, lb/$ft^3$ | 1.097E-04 | 2.367E-04 | 8.129E-05 | 7.292E-05 | 6.445E-05 | 2.119E-04 | 1.519E-04 | 3.080E-05 | 1.194E-04 |
| Weighted Average of Zones | | | | | | | | | |
| Total Thickness, m | 44.5 | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 9.864E-05 | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 8.003E-04 | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 1.138E-03 | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 2.037E-03 | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 6.158E-06 | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 4.996E-05 | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 7.106E-05 | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 1.272E-04 | | | | | | | | |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Total |
| **Minerals with $CO_2$** | | | | | | | | | |
| pH | 5.436 | 4.200 | 5.420 | 3.983 | 5.423 | 4.020 | 5.440 | 5.495 | 5.437 |
| pE | –1.756 | –0.398 | –1.735 | –0.184 | –1.739 | –0.228 | –1.761 | 0.111 | –1.758 |
| Activity | 0.830 | 0.846 | 0.801 | 0.846 | 0.806 | 0.845 | 0.835 | 0.336 | 0.832 |
| Ionic Strength | 4.007 | 3.701 | 4.546 | 3.654 | 4.453 | 3.641 | 3.886 | 9.399 | 3.962 |
| Total Solution $CO_2$, moles | 1.41E+00 | 8.85E-01 | 1.35E+00 | 8.79E-01 | 1.36E+00 | 8.84E-01 | 1.43E+00 | 9.04E-01 | 1.42E+00 |
| Solution, moles | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.3620 | 0.8854 | 1.0520 | 0.8805 | 1.1000 | 0.8845 | 1.4540 | 0.1447 | 1.3970 |
| Ca | 0.0000 | 0.3706 | 0.0000 | 0.1700 | 0.0000 | 0.0810 | 0.0000 | 0.0000 | 0.0000 |
| Cl | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 | 5.0970 |
| Fe | 0.0001 | 0.0004 | 0.0001 | 0.0005 | 0.0001 | 0.0006 | 0.0001 | 0.0000 | 0.0001 |
| K | 0.0027 | 0.0508 | 0.0021 | 0.0839 | 0.0022 | 0.0770 | 0.0028 | 0.0001 | 0.0027 |
| Mg | 0.7122 | 0.0123 | 0.6476 | 0.1903 | 0.6577 | 0.2838 | 0.7312 | 0.4324 | 0.7195 |
| Na | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 | 4.3160 |
| S | 0.0470 | 0.0022 | 0.0371 | 0.0023 | 0.0386 | 0.0025 | 0.0499 | 0.0013 | 0.0481 |
| Si | 0.0009 | 0.0010 | 0.0007 | 0.0010 | 0.0008 | 0.0010 | 0.0010 | 0.0002 | 0.0009 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.072 | 1.425 | 0.000 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.188 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.002 | 5.423 | 7.112 | 21.850 | 0.000 | 20.530 | 12.250 | 212.600 | 17.320 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 15.920 | 2.190 | 53.330 | 1.080 | 47.590 | 1.799 | 5.503 | 177.600 | 12.470 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 1.962 | 0.996 | 0.621 | 0.000 | 0.640 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.610 | 0.216 | 0.254 | 1.058 | 1.366 | 4.678 | 2.542 | 0.000 | 2.627 |
| Quartz | 548.000 | 247.400 | 717.200 | 864.200 | 1023.000 | 219.400 | 365.000 | 1730.000 | 415.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.766 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 298.000 | 298.600 | 298.400 | 298.900 | 298.300 | 298.700 | 298.000 | 299.300 | 297.800 |
| Dolomite | 0.356 | 5.994 | 7.394 | 21.970 | 0.282 | 20.740 | 12.530 | 212.900 | 17.790 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 4.747 | 0.399 | 17.260 | 0.171 | 17.300 | 1.337 | 1.909 | 58.730 | 4.190 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 8.710 | 1.413 | 28.000 | 0.714 | 25.040 | 1.152 | 3.316 | 92.110 | 6.972 |
| Phlogopite | 0.986 | 0.000 | 4.146 | 0.000 | 3.664 | 0.000 | 0.133 | 14.570 | 0.655 |
| Pyrite | 0.587 | 0.215 | 0.236 | 1.058 | 1.348 | 4.677 | 2.518 | 0.000 | 2.604 |
| Quartz | 565.100 | 250.100 | 773.000 | 865.500 | 1072.000 | 221.600 | 371.300 | 1914.000 | 428.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.023 | 0.000 | 0.018 | 0.000 | 0.019 | 0.000 | 0.024 | 0.000 | 0.023 |
| Change (initial – final), moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | –0.072 | –0.659 | 0.000 | –0.003 | 0.000 | 0.000 | 0.000 | 0.000 | –0.188 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | –0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | –2.020 | –1.367 | –1.633 | –1.107 | –1.682 | –1.286 | –2.042 | –0.708 | –2.172 |
| Dolomite | 0.354 | 0.571 | 0.282 | 0.115 | 0.282 | 0.201 | 0.282 | 0.282 | 0.470 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | –15.920 | –2.190 | –53.330 | –1.080 | –47.590 | –1.799 | –5.503 | –177.600 | –12.470 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 4.747 | 0.399 | 17.260 | 0.171 | 15.340 | 0.341 | 1.288 | 58.730 | 3.551 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 8.710 | 1.413 | 28.000 | 0.714 | 25.040 | 1.152 | 3.316 | 92.110 | 6.972 |
| Phlogopite | 0.986 | 0.000 | 4.146 | 0.000 | 3.664 | 0.000 | 0.133 | 14.570 | 0.655 |
| Pyrite | –0.023 | 0.000 | –0.018 | 0.000 | –0.019 | –0.001 | –0.024 | 0.000 | –0.023 |
| Quartz | 17.130 | 2.627 | 55.710 | 1.295 | 49.780 | 2.158 | 6.338 | 183.900 | 13.650 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.023 | 0.000 | 0.018 | 0.000 | 0.019 | 0.000 | 0.024 | 0.000 | 0.023 |
| Final Solution, moles | | | | | | | | | |
| $CaCO_3$ | 5.79E-10 | 6.21E-06 | 5.66E-10 | 1.06E-06 | 5.67E-10 | 6.01E-07 | 5.80E-10 | 3.16E-10 | 5.79E-10 |
| $CaHCO_3^+$ | 6.80E-08 | 1.29E-02 | 6.58E-08 | 3.64E-03 | 6.62E-08 | 1.89E-03 | 6.81E-08 | 1.97E-08 | 6.80E-08 |
| $CO_2$ | 8.18E-01 | 8.54E-01 | 7.62E-01 | 8.60E-01 | 7.72E-01 | 8.63E-01 | 8.36E-01 | 4.02E-01 | 8.26E-01 |
| $CO_3^{2-}$ | 3.33E-05 | 1.15E-07 | 2.95E-05 | 4.26E-08 | 3.02E-05 | 5.06E-08 | 3.44E-05 | 1.30E-05 | 3.37E-05 |
| $FeCO_3$ | 6.95E-08 | 2.28E-09 | 6.95E-08 | 9.72E-10 | 6.95E-08 | 1.43E-09 | 6.95E-08 | 0.00E+00 | 6.95E-08 |
| $FeCO_3^+$ | 3.92E-18 | 3.00E-18 | 3.93E-18 | 2.10E-18 | 3.93E-18 | 2.79E-18 | 3.91E-18 | 0.00E+00 | 3.91E-18 |
| $FeHCO_3^+$ | 7.33E-05 | 4.23E-05 | 7.27E-05 | 2.99E-05 | 7.28E-05 | 4.03E-05 | 7.34E-05 | 0.00E+00 | 7.33E-05 |
| $HCO_3^-$ | 1.96E-01 | 1.19E-02 | 1.75E-01 | 7.27E-03 | 1.79E-01 | 7.93E-03 | 2.02E-01 | 5.58E-02 | 1.99E-01 |
| $MgCO_3$ | 5.74E-04 | 5.35E-08 | 5.88E-04 | 3.12E-07 | 5.86E-04 | 5.53E-07 | 5.73E-04 | 1.05E-03 | 5.74E-04 |
| $MgHCO_3^+$ | 2.86E-01 | 4.71E-04 | 2.90E-01 | 4.54E-03 | 2.90E-01 | 7.38E-03 | 2.86E-01 | 2.79E-01 | 2.86E-01 |
| $NaCO_3^-$ | 2.11E-06 | 7.17E-09 | 2.16E-06 | 2.65E-09 | 2.16E-06 | 3.15E-09 | 2.10E-06 | 2.30E-06 | 2.11E-06 |
| $NaHCO_3$ | 1.07E-01 | 6.09E-03 | 1.19E-01 | 3.69E-03 | 1.17E-01 | 4.03E-03 | 1.04E-01 | 1.66E-01 | 1.06E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | –0.072 | –0.659 | 0.000 | –0.003 | 0.000 | 0.000 | 0.000 | 0.000 | –0.188 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.708 | 1.141 | 0.564 | 0.230 | 0.564 | 0.402 | 0.564 | 0.564 | 0.939 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.023 | 0.000 | 0.018 | 0.000 | 0.019 | 0.000 | 0.024 | 0.000 | 0.023 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/kg $H_2O$ | 0.659 | 0.482 | 0.582 | 0.227 | 0.583 | 0.402 | 0.589 | 0.564 | 0.775 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.818 | 0.854 | 0.762 | 0.860 | 0.772 | 0.863 | 0.836 | 0.402 | 0.826 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.589 | 0.031 | 0.584 | 0.019 | 0.586 | 0.021 | 0.593 | 0.502 | 0.591 |
| Total $CO_2$, moles/kg $H_2O$ | 2.067 | 1.367 | 1.928 | 1.106 | 1.941 | 1.286 | 2.017 | 1.468 | 2.192 |
| Water, g/cm$^3$ | 0.063 | 0.135 | 0.039 | 0.045 | 0.032 | 0.129 | 0.091 | 0.013 | 0.074 |
| Water, kg/m$^3$ | 63.327 | 135.450 | 39.459 | 44.676 | 31.965 | 129.218 | 90.886 | 12.627 | 74.280 |
| Mineral $CO_2$, moles/m$^3$ | 41.725 | 65.301 | 22.970 | 10.151 | 18.633 | 51.997 | 53.491 | 7.127 | 57.564 |
| Dissolved $CO_2$, moles/m$^3$ | 51.827 | 115.647 | 30.048 | 38.426 | 24.670 | 111.489 | 75.936 | 5.074 | 61.333 |
| Solution $CO_2$, moles/m$^3$ | 37.324 | 4.250 | 23.059 | 0.856 | 18.728 | 2.749 | 53.885 | 6.336 | 43.920 |
| Total $CO_2$, moles/m$^3$ | 130.876 | 185.198 | 76.078 | 49.433 | 62.031 | 166.235 | 183.312 | 18.536 | 162.817 |
| Mineral $CO_2$, moles/ft$^3$ | 1.182 | 1.849 | 0.650 | 0.287 | 0.528 | 1.472 | 1.515 | 0.202 | 1.630 |
| Dissolved $CO_2$, moles/ft$^3$ | 1.468 | 3.275 | 0.851 | 1.088 | 0.699 | 3.157 | 2.150 | 0.144 | 1.737 |
| Solution $CO_2$, moles/ft$^3$ | 1.057 | 0.120 | 0.653 | 0.024 | 0.530 | 0.078 | 1.526 | 0.179 | 1.244 |
| Total $CO_2$, moles/ft$^3$ | 3.706 | 5.244 | 2.154 | 1.400 | 1.757 | 4.707 | 5.191 | 0.525 | 4.610 |
| Mineral $CO_2$, kg/m$^3$ | 1.836 | 2.874 | 1.011 | 0.447 | 0.820 | 2.288 | 2.354 | 0.314 | 2.533 |
| Dissolved $CO_2$, kg/m$^3$ | 2.281 | 5.090 | 1.322 | 1.691 | 1.086 | 4.907 | 3.342 | 0.223 | 2.699 |
| Solution $CO_2$, kg/m$^3$ | 1.643 | 0.187 | 1.015 | 0.038 | 0.824 | 0.121 | 2.371 | 0.279 | 1.933 |
| Total $CO_2$, kg/m$^3$ | 5.760 | 8.151 | 3.348 | 2.176 | 2.730 | 7.316 | 8.068 | 0.816 | 7.166 |
| Mineral $CO_2$, lb/ft$^3$ | 0.115 | 0.179 | 0.063 | 0.028 | 0.051 | 0.143 | 0.147 | 0.020 | 0.158 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.142 | 0.318 | 0.083 | 0.106 | 0.068 | 0.306 | 0.209 | 0.014 | 0.169 |
| Solution $CO_2$, lb/ft$^3$ | 0.103 | 0.012 | 0.063 | 0.002 | 0.051 | 0.008 | 0.148 | 0.017 | 0.121 |
| Total $CO_2$, lb/ft$^3$ | 0.360 | 0.509 | 0.209 | 0.136 | 0.170 | 0.457 | 0.504 | 0.051 | 0.447 |
| Weighted Average of Zones | | | | | | | | | |
| Total Thickness, m | 44.5 | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 1.644 | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 2.685 | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 1.041 | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 5.370 | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.103 | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.168 | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.065 | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 0.335 | | | | | | | | |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | | |
| pH | –0.362 | –1.992 | –0.271 | –1.740 | –0.271 | –1.700 | –0.278 | –0.259 | –0.691 |
| pE | 0.636 | 2.438 | 0.538 | 2.124 | 0.538 | 2.076 | 0.541 | –8.321 | 1.005 |
| Activity | –0.023 | –0.015 | –0.022 | –0.016 | –0.022 | –0.016 | –0.024 | 0.001 | –0.023 |
| Ionic strength | 0.145 | –0.005 | 0.147 | –0.021 | 0.147 | –0.042 | 0.159 | 0.564 | 0.133 |
| Total solution $CO_2$, moles | 1.407 | 0.885 | 1.345 | 0.879 | 1.357 | 0.883 | 1.427 | 0.903 | 1.417 |
| Solution, moles | | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.361 | 0.885 | 1.052 | 0.880 | 1.100 | 0.884 | 1.453 | 0.145 | 1.397 |
| Ca | –0.318 | –0.009 | –0.282 | –0.114 | –0.282 | –0.201 | –0.282 | –0.282 | –0.376 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| K | 0.001 | 0.050 | 0.001 | 0.082 | 0.001 | 0.075 | 0.001 | 0.000 | 0.002 |
| Mg | 0.638 | 0.000 | 0.538 | 0.082 | 0.548 | 0.174 | 0.622 | 0.322 | 0.703 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.046 | 0.001 | 0.036 | 0.001 | 0.037 | 0.001 | 0.048 | 0.000 | 0.047 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | –0.464 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 298.000 | 298.600 | 298.400 | 298.900 | 298.300 | 298.700 | 298.000 | 299.300 | 297.800 |
| Dolomite | 0.318 | 0.473 | 0.282 | 0.110 | 0.282 | 0.210 | 0.280 | 0.300 | 0.380 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | –0.316 | –0.082 | –0.270 | 0.058 | –0.280 | –0.012 | –0.299 | –0.210 | –0.357 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.317 | 0.107 | 0.270 | –0.017 | 0.280 | 0.050 | 0.300 | 0.200 | 0.357 |
| Phlogopite | –0.319 | –0.158 | –0.274 | –0.065 | –0.277 | –0.125 | –0.301 | –0.200 | –0.360 |
| Pyrite | –0.023 | 0.000 | –0.018 | 0.000 | –0.018 | –0.001 | –0.024 | 0.000 | –0.023 |
| Quartz | 0.600 | 0.400 | 0.600 | 0.100 | 0.000 | 0.300 | 0.600 | 0.000 | 0.800 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.023 | 0.000 | 0.018 | 0.000 | 0.019 | 0.000 | 0.024 | 0.000 | 0.023 |
| Change (initial – final), moles | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | –0.464 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 6436 | 2.020 | 1.367 | 1.633 | 1.107 | 1.682 | 1.286 | 2.042 | 0.708 | 2.172 |
| Dolomite | 0.318 | 0.473 | 0.282 | 0.114 | 0.282 | 0.201 | 0.282 | 0.282 | 0.376 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | –0.316 | –0.082 | –0.270 | 0.058 | –0.270 | –0.012 | –0.299 | –0.210 | –0.356 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.317 | 0.107 | 0.270 | –0.017 | 0.280 | 0.050 | 0.300 | 0.200 | 0.357 |
| Phlogopite | –0.319 | –0.158 | –0.274 | –0.065 | –0.277 | –0.125 | –0.301 | –0.200 | –0.360 |
| Pyrite | –0.023 | 0.000 | –0.018 | 0.000 | –0.019 | –0.001 | –0.024 | 0.000 | –0.023 |
| Quartz | 0.640 | 0.315 | 0.550 | 0.131 | 0.560 | 0.251 | 0.603 | 0.400 | 0.720 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.023 | 0.000 | 0.018 | 0.000 | 0.019 | 0.000 | 0.024 | 0.000 | 0.023 |
| Final Solution, moles | | | | | | | | | |
| $CaCO_3$ | –2.32E-06 | 0.00E+00 | –1.77E-06 | –7.55E-07 | –1.77E-06 | –1.20E-06 | –1.80E-06 | –1.19E-06 | –5.38E-06 |
| $CaHCO_3^+$ | –1.20E-04 | 1.27E-02 | –1.12E-04 | 3.53E-03 | –1.12E-04 | 1.78E-03 | –1.13E-04 | –4.32E-05 | –1.30E-04 |
| $CO_2$ | 8.18E-01 | 8.54E-01 | 7.61E-01 | 8.60E-01 | 7.72E-01 | 8.63E-01 | 8.35E-01 | 4.02E-01 | 8.26E-01 |
| $CO_3^{2-}$ | 3.33E-05 | 7.00E-09 | 2.95E-05 | –8.00E-11 | 3.01E-05 | 8.19E-09 | 3.43E-05 | 1.30E-05 | 3.36E-05 |
| $FeCO_3$ | 6.94E-08 | 2.24E-09 | 6.94E-08 | 9.46E-10 | 6.94E-08 | 1.40E-09 | 6.94E-08 | 0.00E+00 | 6.94E-08 |
| $FeCO_3^+$ | 3.92E-18 | 3.00E-18 | 3.93E-18 | 2.10E-18 | 3.93E-18 | 2.79E-18 | 3.91E-18 | 0.00E+00 | 3.91E-18 |
| $FeHCO_3^+$ | 7.33E-05 | 4.23E-05 | 7.26E-05 | 2.99E-05 | 7.28E-05 | 4.03E-05 | 7.33E-05 | 0.00E+00 | 7.33E-05 |
| $HCO_3^-$ | 1.96E-01 | 1.18E-02 | 1.75E-01 | 7.14E-03 | 1.78E-01 | 7.80E-03 | 2.02E-01 | 5.58E-02 | 1.98E-01 |
| $MgCO_3$ | 5.74E-04 | 0.00E+00 | 5.87E-04 | 1.30E-07 | 5.86E-04 | 3.68E-07 | 5.73E-04 | 1.05E-03 | 5.74E-04 |
| $MgHCO_3^+$ | 2.86E-01 | 4.66E-04 | 2.90E-01 | 4.49E-03 | 2.90E-01 | 7.33E-03 | 2.86E-01 | 2.79E-01 | 2.86E-01 |
| $NaCO_3^-$ | 2.11E-06 | 4.07E-10 | 2.16E-06 | –6.00E-12 | 2.16E-06 | 5.06E-10 | 2.10E-06 | 2.29E-06 | 2.10E-06 |
| $NaHCO_3$ | 1.07E-01 | 6.03E-03 | 1.18E-01 | 3.62E-03 | 1.17E-01 | 3.96E-03 | 1.04E-01 | 1.66E-01 | 1.06E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | –0.464 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.636 | 0.946 | 0.564 | 0.227 | 0.564 | 0.402 | 0.564 | 0.564 | 0.752 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.023 | 0.000 | 0.018 | 0.000 | 0.019 | 0.000 | 0.024 | 0.000 | 0.023 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.659 | 0.482 | 0.582 | 0.227 | 0.583 | 0.402 | 0.589 | 0.564 | 0.775 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.818 | 0.854 | 0.761 | 0.860 | 0.772 | 0.863 | 0.835 | 0.402 | 0.826 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.589 | 0.031 | 0.584 | 0.019 | 0.586 | 0.021 | 0.593 | 0.502 | 0.591 |
| Total $CO_2$, moles/kg $H_2O$ | 2.066 | 1.367 | 1.927 | 1.106 | 1.940 | 1.286 | 2.016 | 1.467 | 2.191 |
| Water, $g/cm^3$ | 0.063 | 0.135 | 0.039 | 0.045 | 0.032 | 0.129 | 0.091 | 0.013 | 0.074 |
| Water, $kg/m^3$ | 63.327 | 135.450 | 39.459 | 44.676 | 31.965 | 129.218 | 90.886 | 12.627 | 74.280 |

Continued. . .

**Table B-41. Summary of MT API 21606 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Total |
| Mineral $CO_2$, moles/$m^3$ | 41.720 | 65.268 | 22.964 | 10.153 | 18.629 | 52.004 | 53.494 | 7.120 | 57.550 |
| Dissolved $CO_2$, moles/$m^3$ | 51.814 | 115.636 | 30.038 | 38.413 | 24.662 | 111.453 | 75.910 | 5.072 | 61.326 |
| Solution $CO_2$, moles/$m^3$ | 37.303 | 4.207 | 23.046 | 0.840 | 18.717 | 2.702 | 53.852 | 6.333 | 43.897 |
| Total $CO_2$, moles/$m^3$ | 130.836 | 185.112 | 76.048 | 49.406 | 62.007 | 166.158 | 183.257 | 18.525 | 162.774 |
| Mineral $CO_2$, moles/$ft^3$ | 1.181 | 1.848 | 0.650 | 0.288 | 0.528 | 1.473 | 1.515 | 0.202 | 1.630 |
| Dissolved $CO_2$, moles/$ft^3$ | 1.467 | 3.274 | 0.851 | 1.088 | 0.698 | 3.156 | 2.150 | 0.144 | 1.737 |
| Solution $CO_2$, moles/$ft^3$ | 1.056 | 0.119 | 0.653 | 0.024 | 0.530 | 0.077 | 1.525 | 0.179 | 1.243 |
| Total $CO_2$, moles/$ft^3$ | 3.705 | 5.242 | 2.153 | 1.399 | 1.756 | 4.705 | 5.189 | 0.525 | 4.609 |
| Mineral $CO_2$, kg/$m^3$ | 1.836 | 2.872 | 1.011 | 0.447 | 0.820 | 2.289 | 2.354 | 0.313 | 2.533 |
| Dissolved $CO_2$, kg/$m^3$ | 2.280 | 5.089 | 1.322 | 1.691 | 1.085 | 4.905 | 3.341 | 0.223 | 2.699 |
| Solution $CO_2$, kg/$m^3$ | 1.642 | 0.185 | 1.014 | 0.037 | 0.824 | 0.119 | 2.370 | 0.279 | 1.932 |
| Total $CO_2$, kg/$m^3$ | 5.758 | 8.147 | 3.347 | 2.174 | 2.729 | 7.313 | 8.065 | 0.815 | 7.164 |
| Mineral $CO_2$, lb/$ft^3$ | 0.115 | 0.179 | 0.063 | 0.028 | 0.051 | 0.143 | 0.147 | 0.020 | 0.158 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.142 | 0.318 | 0.083 | 0.106 | 0.068 | 0.306 | 0.209 | 0.014 | 0.168 |
| Solution $CO_2$, lb/$ft^3$ | 0.102 | 0.012 | 0.063 | 0.002 | 0.051 | 0.007 | 0.148 | 0.017 | 0.121 |
| Total $CO_2$, lb/$ft^3$ | 0.359 | 0.509 | 0.209 | 0.136 | 0.170 | 0.457 | 0.503 | 0.051 | 0.447 |
| Weighted Average of Zones | | | | | | | | | |
| Total Thickness, m | 44.5 | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 1.643 | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.684 | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 1.040 | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 5.367 | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.103 | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.168 | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.065 | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.335 | | | | | | | | |

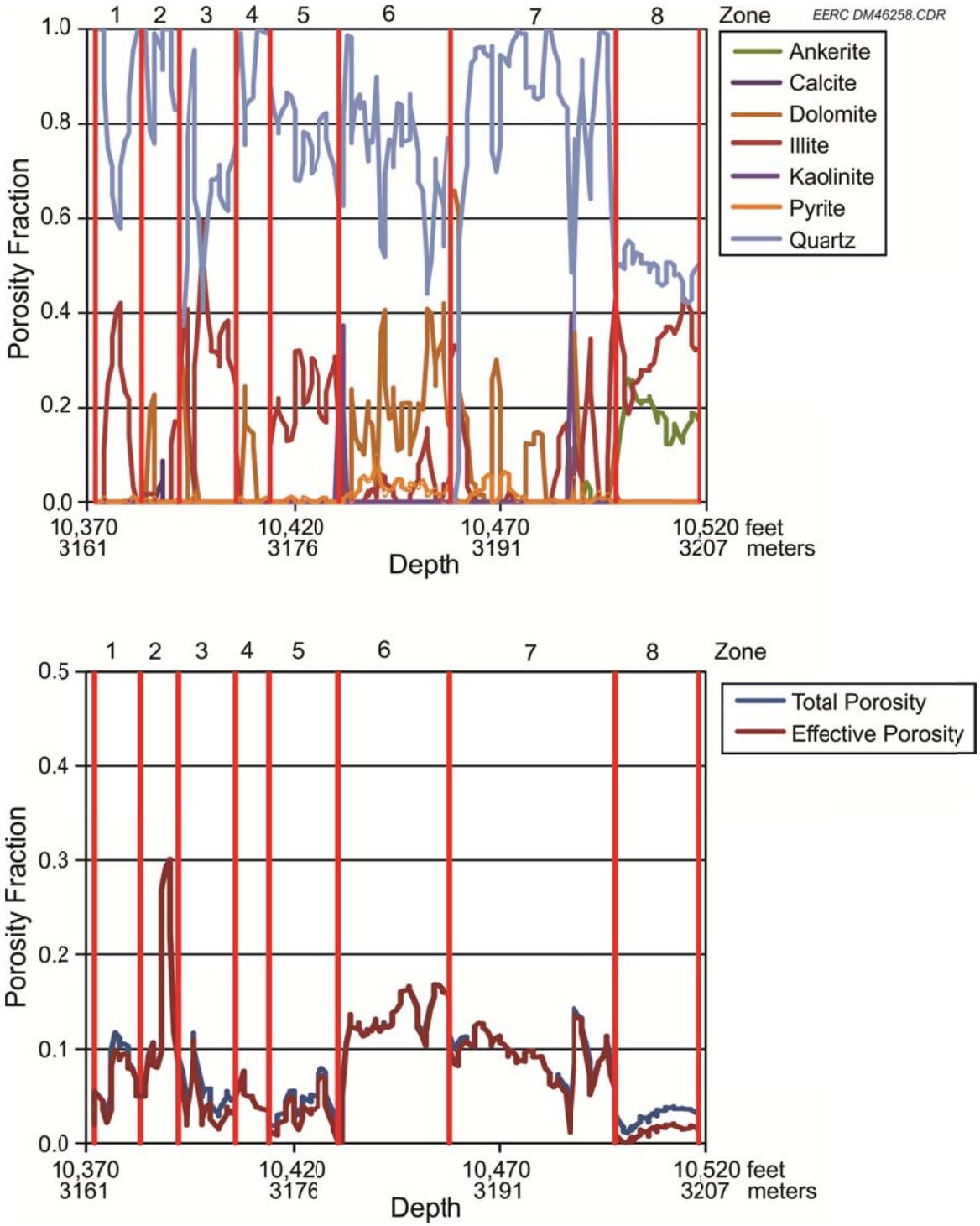



Figure B-11. MT API 21606 mineral composition and porosity as a function of depth.

**ND 12831**

The water composition used for ND 12831 is from the ND 1636 well 3 miles (4 km) to the southeast. Mineral data were available for 98% of the COSS represented in this well. The total aquifer thickness is 346 feet (105.5 meters) as the well appears to penetrate into the Precambrian.

The geology of the COSS penetrated by the well is somewhat complex, resulting in the assignment of 11 zones. Zones 1, 4, 6, and 8 comprise mainly quartz, with minor amounts of calcite, glauconite, and illite. Zones 2 and 10 are mainly quartz with moderate glauconite and minor calcite. Zone 3 comprises quartz and calcite in nearly equal amounts. Finally, Zones 5, 7, 9, and 11 are a mixture of quartz, illite, and glauconite with a small to moderate amount of calcite. Zone 6 has a high porosity of 0.149; the porosities of the other zones range from 0.019 to 0.080.

There are large decreases in calcite and celadonite (glauconite) with similar increases in dolomite, muscovite, and quartz. Only a small amount of pyrite dissolves, with the formation of an equivalent amount of siderite.

The amount of $CO_2$ dissolved in the formation water ranges from 1.1 to 1.3 moles/kg (48.4 to 57.2 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 47.6 kg/m$^3$ (3.0 lb/ft$^3$) of formation rock. Zones 2, 5, 7, 9 10, and 11 show the highest amounts of $CO_2$ reacting per unit rock volume, with the formation of dolomite being the principal mineral-trapping mechanism.

## Table B-42. Average Mineral and Porosity for the ND 12831 Aquifer Zones

Well Name: ND 12831
API Identification: 33-1-5-01389-0000
State Identification: ND 12831

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankertite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | | |
| Start | 13,700.0 | 4175.8 | Average | 0.019 | 0.019 | 0.000 | 0.098 | 0.000 | 0.000 | 0.047 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.855 | 0.000 | 0.000 |
| End | 13,712.0 | 4179.4 | Minimum | 0.014 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.387 | 0.000 | 0.000 |
| Thickness | 12.0 | 3.7 | Maximum | 0.032 | 0.032 | 0.000 | 0.499 | 0.000 | 0.000 | 0.216 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 | 0.000 |
| Number of Values | 26 | | Standard deviation | 0.006 | 0.006 | 0.000 | 0.168 | 0.000 | 0.000 | 0.071 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.216 | 0.000 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | | |
| Start | 13,712.0 | 4179.4 | Average | 0.072 | 0.072 | 0.005 | 0.089 | 0.000 | 0.000 | 0.209 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.696 | 0.000 | 0.000 |
| End | 13,802.0 | 4206.9 | Minimum | 0.028 | 0.028 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.391 | 0.000 | 0.000 |
| Thickness | 90.0 | 27.4 | Maximum | 0.150 | 0.150 | 0.195 | 0.412 | 0.000 | 0.000 | 0.380 | 0.000 | 0.000 | 0.000 | 0.000 | 0.093 | 0.947 | 0.000 | 0.000 |
| Number of Values | 181 | | Standard deviation | 0.023 | 0.023 | 0.024 | 0.121 | 0.000 | 0.000 | 0.066 | 0.000 | 0.000 | 0.000 | 0.000 | 0.010 | 0.116 | 0.000 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | | |
| Start | 13,802.0 | 4206.9 | Average | 0.058 | 0.058 | 0.000 | 0.432 | 0.000 | 0.000 | 0.007 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.561 | 0.000 | 0.000 |
| End | 13,814.0 | 4210.5 | Minimum | 0.017 | 0.017 | 0.000 | 0.107 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 12.0 | 3.7 | Maximum | 0.083 | 0.083 | 0.000 | 0.998 | 0.000 | 0.000 | 0.066 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.893 | 0.000 | 0.000 |
| Number of Values | 24 | | Standard deviation | 0.021 | 0.021 | 0.000 | 0.278 | 0.000 | 0.000 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.274 | 0.000 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | | |
| Start | 13,814.0 | 4210.5 | Average | 0.080 | 0.080 | 0.000 | 0.128 | 0.000 | 0.000 | 0.016 | 0.003 | 0.000 | 0.000 | 0.000 | 0.014 | 0.839 | 0.000 | 0.000 |
| End | 13,848.0 | 4220.9 | Minimum | 0.050 | 0.049 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.489 | 0.000 | 0.000 |
| Thickness | 34.0 | 10.4 | Maximum | 0.132 | 0.129 | 0.000 | 0.508 | 0.000 | 0.000 | 0.262 | 0.063 | 0.000 | 0.000 | 0.000 | 0.169 | 0.968 | 0.000 | 0.000 |
| Number of Values | 68 | | Standard deviation | 0.025 | 0.025 | 0.000 | 0.113 | 0.000 | 0.000 | 0.041 | 0.012 | 0.000 | 0.000 | 0.000 | 0.039 | 0.106 | 0.000 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | | |
| Start | 13,848.0 | 4220.9 | Average | 0.074 | 0.042 | 0.000 | 0.029 | 0.000 | 0.004 | 0.140 | 0.317 | 0.000 | 0.000 | 0.000 | 0.030 | 0.481 | 0.000 | 0.000 |
| End | 13,906.0 | 4238.6 | Minimum | 0.041 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.065 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 58.0 | 17.7 | Maximum | 0.121 | 0.109 | 0.000 | 0.808 | 0.000 | 0.166 | 0.528 | 0.479 | 0.000 | 0.000 | 0.000 | 0.101 | 0.879 | 0.000 | 0.000 |
| Number of Values | 114 | | Standard deviation | 0.022 | 0.028 | 0.000 | 0.122 | 0.000 | 0.021 | 0.180 | 0.105 | 0.000 | 0.000 | 0.000 | 0.024 | 0.243 | 0.000 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | | |
| Start | 13,906.0 | 4238.6 | Average | 0.151 | 0.149 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.026 | 0.000 | 0.000 | 0.000 | 0.088 | 0.885 | 0.000 | 0.000 |
| End | 13,920.0 | 4242.8 | Minimum | 0.107 | 0.103 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.058 | 0.815 | 0.000 | 0.000 |
| Thickness | 14.0 | 4.3 | Maximum | 0.168 | 0.168 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.107 | 0.000 | 0.000 | 0.000 | 0.109 | 0.926 | 0.000 | 0.000 |
| Number of Values | 28 | | Standard deviation | 0.018 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.031 | 0.000 | 0.000 | 0.000 | 0.013 | 0.028 | 0.000 | 0.000 |

Continued…

## Table B-42. Average Mineral and Porosity for the ND 12831 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankertite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | | |
| Start | 13,920.0 | 4242.8 | Average | 0.047 | 0.021 | 0.000 | 0.230 | 0.000 | 0.000 | 0.178 | 0.248 | 0.000 | 0.000 | 0.000 | 0.038 | 0.307 | 0.000 | 0.000 |
| End | 13,949.0 | 4251.7 | Minimum | 0.033 | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.092 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 29.0 | 8.8 | Maximum | 0.130 | 0.117 | 0.000 | 0.711 | 0.000 | 0.000 | 0.573 | 0.448 | 0.000 | 0.000 | 0.000 | 0.091 | 0.837 | 0.000 | 0.000 |
| Number of Values | 59 | | Standard deviation | 0.017 | 0.015 | 0.000 | 0.249 | 0.000 | 0.000 | 0.192 | 0.103 | 0.000 | 0.000 | 0.000 | 0.024 | 0.200 | 0.000 | 0.000 |
| Zone 8 | | | | | | | | | | | | | | | | | | |
| Start | 13,949.0 | 4251.7 | Average | 0.063 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.066 | 0.000 | 0.000 | 0.000 | 0.066 | 0.868 | 0.000 | 0.000 |
| End | 13,956.0 | 4253.8 | Minimum | 0.056 | 0.049 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.052 | 0.000 | 0.000 | 0.000 | 0.048 | 0.827 | 0.000 | 0.000 |
| Thickness | 7.0 | 2.1 | Maximum | 0.069 | 0.061 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.094 | 0.000 | 0.000 | 0.000 | 0.092 | 0.900 | 0.000 | 0.000 |
| Number of Values | 13 | | Standard deviation | 0.005 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.013 | 0.000 | 0.000 | 0.000 | 0.016 | 0.027 | 0.000 | 0.000 |
| Zone 9 | | | | | | | | | | | | | | | | | | |
| Start | 13,956.0 | 4253.8 | Average | 0.048 | 0.025 | 0.000 | 0.182 | 0.000 | 0.000 | 0.069 | 0.220 | 0.000 | 0.000 | 0.000 | 0.060 | 0.468 | 0.000 | 0.000 |
| End | 13,972.0 | 4258.7 | Minimum | 0.042 | 0.016 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.130 | 0.000 | 0.000 | 0.000 | 0.012 | 0.152 | 0.000 | 0.000 |
| Thickness | 16.0 | 4.9 | Maximum | 0.061 | 0.048 | 0.000 | 0.426 | 0.000 | 0.000 | 0.396 | 0.315 | 0.000 | 0.000 | 0.000 | 0.101 | 0.799 | 0.000 | 0.000 |
| Number of Values | 33 | | Standard deviation | 0.004 | 0.007 | 0.000 | 0.164 | 0.000 | 0.000 | 0.129 | 0.055 | 0.000 | 0.000 | 0.000 | 0.023 | 0.182 | 0.000 | 0.000 |
| Zone 10 | | | | | | | | | | | | | | | | | | |
| Start | 13,972.0 | 4258.7 | Average | 0.047 | 0.047 | 0.000 | 0.116 | 0.000 | 0.000 | 0.324 | 0.000 | 0.000 | 0.000 | 0.000 | 0.081 | 0.479 | 0.000 | 0.000 |
| End | 13,999.0 | 4266.9 | Minimum | 0.034 | 0.034 | 0.000 | 0.000 | 0.000 | 0.000 | 0.129 | 0.000 | 0.000 | 0.000 | 0.000 | 0.037 | 0.197 | 0.000 | 0.000 |
| Thickness | 27.0 | 8.2 | Maximum | 0.057 | 0.057 | 0.000 | 0.482 | 0.000 | 0.000 | 0.611 | 0.000 | 0.000 | 0.000 | 0.000 | 0.116 | 0.651 | 0.000 | 0.000 |
| Number of Values | 35 | | Standard deviation | 0.008 | 0.008 | 0.000 | 0.145 | 0.000 | 0.000 | 0.103 | 0.000 | 0.000 | 0.000 | 0.000 | 0.020 | 0.131 | 0.000 | 0.000 |
| Zone 11 | | | | | | | | | | | | | | | | | | |
| Start | 13,999.0 | 4266.9 | Average | 0.062 | 0.039 | 0.000 | 0.071 | 0.000 | 0.000 | 0.157 | 0.221 | 0.000 | 0.000 | 0.000 | 0.062 | 0.489 | 0.000 | 0.000 |
| End | 14,038.0 | 4278.8 | Minimum | 0.039 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.125 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 39.0 | 11.9 | Maximum | 0.101 | 0.088 | 0.000 | 0.716 | 0.000 | 0.000 | 0.810 | 0.308 | 0.000 | 0.000 | 0.000 | 0.135 | 0.766 | 0.000 | 0.000 |
| Number of Values | 84 | | Standard deviation | 0.018 | 0.021 | 0.000 | 0.142 | 0.000 | 0.000 | 0.269 | 0.047 | 0.000 | 0.000 | 0.000 | 0.042 | 0.248 | 0.000 | 0.000 |
| Total Volume | | | | | | | | | | | | | | | | | | |
| Start | 13,700.0 | 4175.8 | Average | 0.068 | 0.056 | 0.001 | 0.106 | 0.000 | 0.001 | 0.140 | 0.118 | 0.000 | 0.000 | 0.000 | 0.030 | 0.603 | 0.000 | 0.000 |
| End | 14,038.0 | 4278.8 | Minimum | 0.014 | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 338.0 | 103.0 | Maximum | 0.168 | 0.168 | 0.195 | 0.998 | 0.000 | 0.166 | 0.810 | 0.479 | 0.000 | 0.000 | 0.000 | 0.169 | 1.000 | 0.000 | 0.000 |
| Number of Values | 665 | | Standard deviation | 0.030 | 0.035 | 0.013 | 0.171 | 0.000 | 0.009 | 0.167 | 0.144 | 0.000 | 0.000 | 0.000 | 0.037 | 0.249 | 0.000 | 0.000 |

## Table B-43. Summary of ND 12831 Aquifer Minerals and Conditions

Well Name: ND 12831
API Identification: 33-1-5-01389-0000
State Identification: ND 12831

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, ft | 13,700 | 13,712 | 13,802 | 13,814 | 13,848 | 13,906 | 13,920 | 13,949 | 13,956 | 13,972 | 13,999 | 13,700 |
| End, ft | 13,712 | 13,802 | 13,814 | 13,848 | 13,906 | 13,920 | 13,949 | 13,956 | 13,972 | 13,999 | 14,038 | 14,038 |
| Thickness, ft | 12.0 | 90.0 | 12.0 | 34.0 | 58.0 | 14.0 | 29.0 | 7.0 | 16.0 | 27.0 | 39.0 | 338.0 |
| Start, m | 4175.8 | 4179.4 | 4206.9 | 4210.5 | 4220.9 | 4238.6 | 4242.8 | 4251.7 | 4253.8 | 4258.7 | 4266.9 | 4175.8 |
| End, m | 4179.4 | 4206.9 | 4210.5 | 4220.9 | 4238.6 | 4242.8 | 4251.7 | 4253.8 | 4258.7 | 4266.9 | 4278.8 | 4278.8 |
| Thickness, m | 3.7 | 27.4 | 3.7 | 10.4 | 17.7 | 4.3 | 8.8 | 2.1 | 4.9 | 8.2 | 11.9 | 103.0 |
| Temperature, °F | 278.0 | 278.0 | 278.0 | 278.0 | 278.0 | 278.0 | 278.0 | 278.0 | 278.0 | 278.0 | 278.0 | 278.0 |
| Temperature, °C | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 | 136.7 |
| Pressure, psi | 8229 | 8238 | 8247 | 8251 | 8259 | 8265 | 8269 | 8272 | 8274 | 8278 | 8284 | 8257 |
| Pressure, kPa | 56,734 | 56,797 | 56,859 | 56,887 | 56,943 | 56,987 | 57,013 | 57,035 | 57,049 | 57,075 | 57,115 | 56,933 |
| Effective Porosity, fraction | 0.019 | 0.072 | 0.058 | 0.080 | 0.042 | 0.149 | 0.021 | 0.057 | 0.025 | 0.047 | 0.039 | 0.056 |
| Mass Fraction | | | | | | | | | | | | |
| Ankertite | 0.000 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Calcite | 0.098 | 0.089 | 0.432 | 0.128 | 0.029 | 0.000 | 0.230 | 0.000 | 0.182 | 0.116 | 0.071 | 0.106 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Glauconite | 0.047 | 0.209 | 0.007 | 0.016 | 0.140 | 0.000 | 0.178 | 0.000 | 0.069 | 0.324 | 0.157 | 0.140 |
| Illite | 0.000 | 0.000 | 0.000 | 0.003 | 0.317 | 0.026 | 0.248 | 0.066 | 0.220 | 0.000 | 0.221 | 0.118 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.001 | 0.000 | 0.014 | 0.030 | 0.088 | 0.038 | 0.066 | 0.060 | 0.081 | 0.062 | 0.030 |
| Quartz | 0.855 | 0.696 | 0.561 | 0.839 | 0.481 | 0.885 | 0.307 | 0.868 | 0.468 | 0.479 | 0.489 | 0.603 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-44. Summary of ND 12831 Aquifer Calculation Results

Well Name: ND 12831
API Identification: 33-1-5-01389-0000
State Identification: ND 12831

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, m | 4175.8 | 4179.4 | 4206.9 | 4210.5 | 4220.9 | 4238.6 | 4242.8 | 4251.7 | 4253.8 | 4258.7 | 4266.9 | 4175.8 |
| End, m | 4179.4 | 4206.9 | 4210.5 | 4220.9 | 4238.6 | 4242.8 | 4251.7 | 4253.8 | 4258.7 | 4266.9 | 4278.8 | 4278.8 |
| Thickness, m | 3.7 | 27.4 | 3.7 | 10.4 | 17.7 | 4.3 | 8.8 | 2.1 | 4.9 | 8.2 | 11.9 | 103.0 |
| Start, ft | 13,700.0 | 13,712.0 | 13,802.0 | 13,814.0 | 13,848.0 | 13,906.0 | 13,920.0 | 13,949.0 | 13,956.0 | 13,972.0 | 13,999.0 | 13,700.0 |
| End, ft | 13,712.0 | 13,802.0 | 13,814.0 | 13,848.0 | 13,906.0 | 13,920.0 | 13,949.0 | 13,956.0 | 13,972.0 | 13,999.0 | 14,038.0 | 14,038.0 |
| Thickness, ft | 12.0 | 90.0 | 12.0 | 34.0 | 58.0 | 14.0 | 29.0 | 7.0 | 16.0 | 27.0 | 39.0 | 338.0 |
| **Minerals Without $CO_2$** | | | | | | | | | | | | |
| pH | 5.584 | 5.584 | 5.584 | 5.585 | 5.769 | 5.335 | 5.633 | 5.332 | 5.762 | 5.584 | 5.608 | 5.593 |
| pE | 0.553 | −2.320 | −2.320 | −2.320 | −2.544 | −2.082 | −2.372 | −2.078 | −2.536 | −2.320 | −2.346 | −2.330 |
| Activity | 0.832 | 0.832 | 0.832 | 0.832 | 0.861 | 0.832 | 0.888 | 0.827 | 0.848 | 0.832 | 0.864 | 0.845 |
| Ionic Strength | 4.084 | 4.084 | 4.084 | 4.079 | 3.588 | 4.096 | 3.027 | 4.176 | 3.831 | 4.084 | 3.508 | 3.856 |
| Total Solution $CO_2$, moles | 1.503E-03 | 1.503E-03 | 1.503E-03 | 1.504E-03 | 8.434E-04 | 5.837E-04 | 1.660E-03 | 6.034E-04 | 8.199E-04 | 1.503E-03 | 1.587E-03 | 1.536E-03 |
| Solution, moles | | | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0015 | 0.0015 | 0.0015 | 0.0015 | 0.0011 | 0.0006 | 0.0027 | 0.0006 | 0.0009 | 0.0015 | 0.0021 | 0.0017 |
| Ca | 0.5336 | 0.5336 | 0.5336 | 0.5336 | 0.5638 | 0.4635 | 0.5240 | 0.4635 | 0.5640 | 0.5336 | 0.5286 | 0.5317 |
| Cl | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0644 | 0.0644 | 0.0644 | 0.0645 | 0.0012 | 0.0025 | 0.0833 | 0.0024 | 0.0011 | 0.0644 | 0.0739 | 0.0679 |
| Mg | 0.0160 | 0.0160 | 0.0160 | 0.0160 | 0.0174 | 0.1168 | 0.0164 | 0.1169 | 0.0172 | 0.0160 | 0.0164 | 0.0162 |
| Na | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 |
| S | 0.0010 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 |
| Si | 0.0016 | 0.0016 | 0.0016 | 0.0016 | 0.0021 | 0.0016 | 0.0026 | 0.0016 | 0.0018 | 0.0016 | 0.0021 | 0.0018 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 134.000 | 30.840 | 185.100 | 39.390 | 18.440 | 0.000 | 303.000 | 0.000 | 200.600 | 70.060 | 49.600 | 49.800 |
| Celadonite | 14.800 | 16.900 | 0.664 | 1.124 | 21.010 | 0.000 | 54.650 | 0.000 | 17.690 | 45.570 | 25.410 | 15.360 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.944 | 0.000 | 0.000 | 1.254 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.504 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.270 | 53.180 | 1.114 | 85.060 | 8.020 | 63.230 | 0.000 | 40.100 | 14.410 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

## Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.423 | 0.035 | 3.593 | 16.150 | 11.940 | 42.240 | 25.550 | 55.380 | 40.950 | 35.830 | 11.920 |
| Quartz | 1940.000 | 402.300 | 400.900 | 428.600 | 515.400 | 239.300 | 673.100 | 671.800 | 858.300 | 481.600 | 567.300 | 470.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 133.800 | 30.700 | 184.900 | 39.250 | 18.240 | 0.000 | 302.900 | 0.000 | 200.400 | 69.920 | 49.470 | 49.660 |
| Celadonite | 14.640 | 16.740 | 0.502 | 0.828 | 0.000 | 0.000 | 11.910 | 0.000 | 0.000 | 45.400 | 5.174 | 7.987 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.070 | 1.014 | 0.070 | 0.070 | 1.356 | 0.000 | 0.059 | 0.000 | 0.101 | 0.070 | 0.064 | 0.572 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 3.719 | 0.376 | 0.000 | 2.677 | 9.281 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.032 | 0.032 | 0.032 | 0.262 | 41.480 | 0.572 | 72.350 | 4.141 | 44.460 | 0.032 | 34.120 | 12.280 |
| Phlogopite | 0.065 | 0.064 | 0.065 | 0.132 | 11.440 | 0.093 | 21.350 | 0.669 | 11.170 | 0.065 | 10.100 | 3.670 |
| Pyrite | 0.000 | 0.423 | 0.035 | 3.593 | 16.150 | 11.940 | 42.240 | 25.550 | 55.380 | 40.950 | 35.830 | 11.920 |
| Quartz | 1940.000 | 402.600 | 401.200 | 429.600 | 619.400 | 240.500 | 860.700 | 680.100 | 964.900 | 481.900 | 655.900 | 503.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.140 | −0.141 | −0.140 | −0.140 | −0.202 | 0.000 | −0.119 | 0.000 | −0.201 | −0.140 | −0.129 | −0.137 |
| Celadonite | −0.161 | −0.161 | −0.161 | −0.296 | −21.010 | 0.000 | −42.740 | 0.000 | −17.690 | −0.161 | −20.240 | −7.375 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.070 | 0.071 | 0.070 | 0.070 | 0.102 | 0.000 | 0.059 | 0.000 | 0.101 | 0.070 | 0.064 | 0.069 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | −0.270 | −53.180 | −1.114 | −85.060 | −8.020 | −63.230 | 0.000 | −40.100 | −14.410 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 3.719 | 0.376 | 0.000 | 2.677 | 9.281 | 0.000 | 0.000 | 0.000 |

Continued…

## Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.032 | 0.032 | 0.032 | 0.262 | 41.480 | 0.572 | 72.350 | 4.141 | 44.460 | 0.032 | 34.120 | 12.280 |
| Phlogopite | 0.065 | 0.064 | 0.065 | 0.132 | 11.440 | 0.093 | 21.350 | 0.669 | 11.170 | 0.065 | 10.100 | 3.670 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.353 | 0.352 | 0.353 | 0.947 | 104.000 | 1.148 | 187.600 | 8.284 | 106.600 | 0.353 | 88.630 | 32.070 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | | | | |
| $CaCO_3$ | 4.80E-06 | 4.80E-06 | 4.80E-06 | 4.80E-06 | 4.80E-06 | 6.27E-07 | 4.80E-06 | 6.51E-07 | 4.80E-06 | 4.80E-06 | 4.80E-06 | 4.80E-06 |
| $CaHCO_3^+$ | 3.81E-04 | 3.81E-04 | 3.81E-04 | 3.81E-04 | 2.59E-04 | 8.83E-05 | 3.70E-04 | 9.18E-05 | 2.58E-04 | 3.81E-04 | 3.78E-04 | 3.81E-04 |
| $CO_2$ | 8.55E-04 | 8.55E-04 | 8.55E-04 | 8.56E-04 | 3.99E-04 | 4.04E-04 | 9.80E-04 | 4.17E-04 | 3.83E-04 | 8.55E-04 | 9.21E-04 | 8.80E-04 |
| $CO_3^{2-}$ | 4.62E-08 | 4.62E-08 | 4.62E-08 | 4.62E-08 | 4.94E-08 | 6.91E-09 | 6.18E-08 | 7.06E-09 | 4.64E-08 | 4.62E-08 | 5.37E-08 | 4.89E-08 |
| $FeCO_3$ | 0.00E+00 | 6.94E-12 | 6.94E-12 | 6.98E-12 | 8.70E-12 | 7.30E-13 | 2.88E-11 | 7.07E-13 | 6.34E-12 | 6.94E-12 | 1.47E-11 | 9.26E-12 |
| $FeCO_3^+$ | 0.00E+00 | 1.23E-22 | 1.23E-22 | 1.24E-22 | 9.58E-23 | 2.24E-23 | 4.91E-22 | 2.17E-23 | 6.97E-23 | 1.23E-22 | 2.57E-22 | 1.64E-22 |
| $FeHCO_3^+$ | 0.00E+00 | 5.43E-09 | 5.43E-09 | 5.46E-09 | 4.63E-09 | 1.01E-09 | 2.18E-08 | 9.83E-10 | 3.36E-09 | 5.43E-09 | 1.14E-08 | 7.24E-09 |
| $HCO_3^-$ | 1.91E-04 | 1.91E-04 | 1.91E-04 | 1.91E-04 | 1.38E-04 | 5.08E-05 | 2.47E-04 | 5.20E-05 | 1.30E-04 | 1.91E-04 | 2.19E-04 | 2.02E-04 |
| $MgCO_3$ | 2.93E-08 | 2.93E-08 | 2.93E-08 | 2.93E-08 | 2.93E-08 | 3.24E-08 | 2.93E-08 | 3.40E-08 | 2.93E-08 | 2.93E-08 | 2.93E-08 | 2.93E-08 |
| $MgHCO_3^+$ | 1.22E-05 | 1.22E-05 | 1.22E-05 | 1.22E-05 | 8.29E-06 | 2.39E-05 | 1.18E-05 | 2.51E-05 | 8.27E-06 | 1.22E-05 | 1.21E-05 | 1.22E-05 |
| $NaCO_3^-$ | 7.76E-10 | 7.76E-10 | 7.76E-10 | 7.76E-10 | 7.19E-10 | 1.17E-10 | 7.60E-10 | 1.22E-10 | 7.25E-10 | 7.76E-10 | 7.65E-10 | 7.71E-10 |
| $NaHCO_3$ | 5.85E-05 | 5.85E-05 | 5.85E-05 | 5.84E-05 | 3.40E-05 | 1.56E-05 | 4.72E-05 | 1.65E-05 | 3.56E-05 | 5.85E-05 | 5.22E-05 | 5.60E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −1.399E-01 | −1.411E-01 | −1.399E-01 | −1.399E-01 | −2.018E-01 | 0.000E+00 | −1.194E-01 | 0.000E+00 | −2.013E-01 | −1.399E-01 | −1.294E-01 | −1.370E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.396E-01 | 1.417E-01 | 1.395E-01 | 1.394E-01 | 2.030E-01 | 0.000E+00 | 1.178E-01 | 0.000E+00 | 2.014E-01 | 1.395E-01 | 1.284E-01 | 1.375E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | −3.400E-04 | 6.400E-04 | −4.000E-04 | −4.800E-04 | 1.200E-03 | 0.000E+00 | −1.620E-03 | 0.000E+00 | 1.000E-04 | −4.000E-04 | −1.020E-03 | 5.000E-04 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 8.554E-04 | 8.554E-04 | 8.554E-04 | 8.559E-04 | 3.992E-04 | 4.043E-04 | 9.797E-04 | 4.173E-04 | 3.831E-04 | 8.554E-04 | 9.205E-04 | 8.804E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 6.475E-04 | 6.475E-04 | 6.475E-04 | 6.477E-04 | 4.442E-04 | 1.793E-04 | 6.808E-04 | 1.860E-04 | 4.368E-04 | 6.475E-04 | 6.665E-04 | 6.553E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 1.163E-03 | 2.143E-03 | 1.103E-03 | 1.024E-03 | 2.043E-03 | 5.836E-04 | 4.048E-05 | 6.033E-04 | 9.199E-04 | 1.103E-03 | 5.670E-04 | 2.036E-03 |
| Water, $g/cm^3$ | 0.019 | 0.072 | 0.058 | 0.080 | 0.042 | 0.149 | 0.021 | 0.057 | 0.025 | 0.047 | 0.039 | 0.056 |
| Water, $kg/m^3$ | 19.047 | 72.425 | 58.419 | 80.025 | 41.510 | 148.598 | 21.015 | 56.520 | 25.093 | 46.526 | 39.473 | 55.771 |

Continued…

**Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Zone 9 | Zone 10 | Zone 11 | Total |
| Mineral $CO_2$, moles/$m^3$ | −6.476E-03 | 4.635E-02 | −2.337E-02 | −3.841E-02 | 4.981E-02 | 0.000E+00 | −3.404E-02 | 0.000E+00 | 2.509E-03 | −1.861E-02 | −4.026E-02 | 2.789E-02 |
| Dissolved $CO_2$, moles/$m^3$ | 1.629E-02 | 6.195E-02 | 4.997E-02 | 6.849E-02 | 1.657E-02 | 6.008E-02 | 2.059E-02 | 2.359E-02 | 9.613E-03 | 3.980E-02 | 3.633E-02 | 4.910E-02 |
| Solution $CO_2$, moles/$m^3$ | 1.233E-02 | 4.690E-02 | 3.783E-02 | 5.183E-02 | 1.844E-02 | 2.665E-02 | 1.431E-02 | 1.052E-02 | 1.096E-02 | 3.013E-02 | 2.631E-02 | 3.655E-02 |
| Total $CO_2$, moles/$m^3$ | 2.215E-02 | 1.552E-01 | 6.443E-02 | 8.191E-02 | 8.482E-02 | 8.673E-02 | 8.508E-04 | 3.410E-02 | 2.308E-02 | 5.132E-02 | 2.238E-02 | 1.135E-01 |
| Mineral $CO_2$, moles/$ft^3$ | −1.834E-04 | 1.313E-03 | −6.617E-04 | −1.088E-03 | 1.411E-03 | 0.000E+00 | −9.640E-04 | 0.000E+00 | 7.106E-05 | −5.270E-04 | −1.140E-03 | 7.896E-04 |
| Dissolved $CO_2$, moles/$ft^3$ | 4.614E-04 | 1.754E-03 | 1.415E-03 | 1.940E-03 | 4.692E-04 | 1.701E-03 | 5.830E-04 | 6.679E-04 | 2.722E-04 | 1.127E-03 | 1.029E-03 | 1.390E-03 |
| Solution $CO_2$, moles/$ft^3$ | 3.492E-04 | 1.328E-03 | 1.071E-03 | 1.468E-03 | 5.221E-04 | 7.547E-04 | 4.051E-04 | 2.978E-04 | 3.104E-04 | 8.531E-04 | 7.450E-04 | 1.035E-03 |
| Total $CO_2$, moles/$ft^3$ | 6.272E-04 | 4.395E-03 | 1.825E-03 | 2.320E-03 | 2.402E-03 | 2.456E-03 | 2.409E-05 | 9.656E-04 | 6.537E-04 | 1.453E-03 | 6.338E-04 | 3.215E-03 |
| Mineral $CO_2$, kg/$m^3$ | −2.850E-04 | 2.040E-03 | −1.028E-03 | −1.691E-03 | 2.192E-03 | 0.000E+00 | −1.498E-03 | 0.000E+00 | 1.104E-04 | −8.190E-04 | −1.772E-03 | 1.227E-03 |
| Dissolved $CO_2$, kg/$m^3$ | 7.170E-04 | 2.727E-03 | 2.199E-03 | 3.014E-03 | 7.293E-04 | 2.644E-03 | 9.061E-04 | 1.038E-03 | 4.231E-04 | 1.752E-03 | 1.599E-03 | 2.161E-03 |
| Solution $CO_2$, kg/$m^3$ | 5.428E-04 | 2.064E-03 | 1.665E-03 | 2.281E-03 | 8.115E-04 | 1.173E-03 | 6.296E-04 | 4.628E-04 | 4.824E-04 | 1.326E-03 | 1.158E-03 | 1.609E-03 |
| Total $CO_2$, kg/$m^3$ | 9.748E-04 | 6.830E-03 | 2.836E-03 | 3.605E-03 | 3.733E-03 | 3.817E-03 | 3.744E-05 | 1.501E-03 | 1.016E-03 | 2.258E-03 | 9.851E-04 | 4.997E-03 |
| Mineral $CO_2$, lb/$ft^3$ | −1.779E-05 | 1.273E-04 | −6.420E-05 | −1.055E-04 | 1.369E-04 | 0.000E+00 | −9.353E-05 | 0.000E+00 | 6.894E-06 | −5.113E-05 | −1.106E-04 | 7.661E-05 |
| Dissolved $CO_2$, lb/$ft^3$ | 4.476E-05 | 1.702E-04 | 1.373E-04 | 1.882E-04 | 4.553E-05 | 1.651E-04 | 5.656E-05 | 6.480E-05 | 2.641E-05 | 1.093E-04 | 9.983E-05 | 1.349E-04 |
| Solution $CO_2$, lb/$ft^3$ | 3.389E-05 | 1.288E-04 | 1.039E-04 | 1.424E-04 | 5.066E-05 | 7.322E-05 | 3.931E-05 | 2.889E-05 | 3.012E-05 | 8.277E-05 | 7.228E-05 | 1.004E-04 |
| Total $CO_2$, lb/$ft^3$ | 6.086E-05 | 4.264E-04 | 1.770E-04 | 2.250E-04 | 2.330E-04 | 2.383E-04 | 2.337E-06 | 9.369E-05 | 6.342E-05 | 1.410E-04 | 6.149E-05 | 3.119E-04 |
| Weighted Average of Zones | | | | | | | | | | | | |
| Total Thickness, m | 103.0 | | | | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 3.095E-04 | | | | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.811E-03 | | | | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 1.371E-03 | | | | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 3.492E-03 | | | | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 1.932E-05 | | | | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 1.131E-04 | | | | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 8.560E-05 | | | | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 2.180E-04 | | | | | | | | | | | |

Continued…

## Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | | | | | | |
| pH | 4.581 | 4.591 | 4.138 | 4.236 | 4.934 | 3.810 | 4.770 | 5.007 | 4.636 | 4.705 | 4.653 | 4.593 |
| pE | 1.610 | −0.998 | −0.528 | −0.629 | −1.398 | −0.206 | −1.186 | −1.479 | −1.044 | −1.114 | −1.062 | −1.001 |
| Activity | 0.832 | 0.836 | 0.810 | 0.808 | 0.848 | 0.812 | 0.886 | 0.806 | 0.850 | 0.870 | 0.856 | 0.837 |
| Ionic Strength | 3.473 | 3.409 | 4.040 | 4.002 | 3.308 | 4.081 | 2.338 | 4.181 | 3.115 | 2.702 | 3.008 | 3.389 |
| Total Solution $CO_2$, moles | 1.18E+00 | 1.19E+00 | 1.09E+00 | 1.10E+00 | 1.32E+00 | 1.08E+00 | 1.40E+00 | 1.27E+00 | 1.25E+00 | 1.33E+00 | 1.27E+00 | 1.20E+00 |
| Solution, moles | | | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.4830 | 1.5460 | 1.1010 | 1.1160 | 1.8450 | 1.0780 | 3.0800 | 1.2500 | 1.8540 | 2.4050 | 1.9830 | 1.5700 |
| Ca | 0.0554 | 0.0538 | 0.3607 | 0.2340 | 0.0000 | 0.3073 | 0.0338 | 0.0000 | 0.0468 | 0.0390 | 0.0445 | 0.0531 |
| Cl | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 |
| Fe | 0.0000 | 0.0009 | 0.0005 | 0.0005 | 0.0008 | 0.0006 | 0.0009 | 0.0011 | 0.0010 | 0.0012 | 0.0010 | 0.0009 |
| K | 1.0920 | 1.1000 | 0.4424 | 0.7043 | 0.3863 | 0.0811 | 1.2160 | 0.0050 | 1.1270 | 1.1680 | 1.1370 | 1.1020 |
| Mg | 0.0017 | 0.0017 | 0.0109 | 0.0071 | 0.4979 | 0.2406 | 0.0011 | 0.6958 | 0.0015 | 0.0013 | 0.0014 | 0.0017 |
| Na | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 |
| S | 0.0010 | 0.0028 | 0.0020 | 0.0021 | 0.0123 | 0.0022 | 0.0043 | 0.0138 | 0.0030 | 0.0034 | 0.0031 | 0.0029 |
| Si | 0.0020 | 0.0021 | 0.0016 | 0.0016 | 0.0022 | 0.0016 | 0.0036 | 0.0016 | 0.0024 | 0.0029 | 0.0025 | 0.0021 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 134.000 | 30.840 | 185.100 | 39.390 | 18.440 | 0.000 | 303.000 | 0.000 | 200.600 | 70.060 | 49.600 | 49.800 |
| Celadonite | 14.800 | 16.900 | 0.664 | 1.124 | 21.010 | 0.000 | 54.650 | 0.000 | 17.690 | 45.570 | 25.410 | 15.360 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.944 | 0.000 | 0.000 | 1.254 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.504 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.270 | 53.180 | 1.114 | 85.060 | 8.020 | 63.230 | 0.000 | 40.100 | 14.410 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.423 | 0.035 | 3.593 | 16.150 | 11.940 | 42.240 | 25.550 | 55.380 | 40.950 | 35.830 | 11.920 |

Continued…

## Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 1940.000 | 402.300 | 400.900 | 428.600 | 515.400 | 239.300 | 673.100 | 671.800 | 858.300 | 481.600 | 567.300 | 470.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 119.500 | 14.240 | 184.400 | 38.320 | 0.000 | 0.000 | 227.400 | 0.000 | 167.400 | 24.810 | 14.470 | 31.120 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 3.198 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | 283.200 | 281.000 | 298.000 | 297.400 | 278.800 | 298.600 | 220.500 | 297.800 | 264.100 | 251.500 | 262.000 | 278.900 |
| Dolomite | 14.920 | 17.960 | 0.771 | 1.303 | 20.160 | 0.156 | 76.030 | 0.464 | 33.620 | 45.680 | 35.550 | 19.580 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.400 | 0.000 | 2.334 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 13.160 | 15.250 | 0.000 | 0.000 | 0.000 | 0.000 | 31.560 | 0.000 | 0.197 | 43.810 | 13.680 | 10.110 |
| Muscovite | 0.546 | 0.550 | 0.221 | 0.582 | 45.400 | 0.587 | 72.910 | 4.485 | 54.300 | 0.584 | 34.660 | 12.800 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 3.941 | 0.000 | 0.000 | 0.321 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.422 | 0.034 | 3.592 | 16.140 | 11.940 | 42.240 | 25.550 | 55.380 | 40.950 | 35.830 | 11.920 |
| Quartz | 1958.000 | 422.500 | 402.900 | 432.300 | 624.800 | 240.600 | 876.000 | 680.800 | 986.800 | 530.700 | 664.300 | 514.100 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.001 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −14.510 | −16.600 | −0.668 | −1.073 | −18.440 | 0.000 | −75.600 | 0.000 | −33.200 | −45.260 | −35.130 | −18.670 |
| Celadonite | −14.800 | −16.900 | −0.664 | −1.124 | −17.810 | 0.000 | −54.650 | 0.000 | −17.690 | −45.570 | −25.410 | −15.360 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | −16.810 | −18.970 | −1.974 | −2.647 | −21.220 | −1.390 | −79.540 | −2.182 | −35.890 | −48.510 | −37.950 | −21.060 |
| Dolomite | 14.920 | 17.010 | 0.771 | 1.303 | 18.910 | 0.156 | 76.030 | 0.464 | 33.620 | 45.680 | 35.550 | 19.080 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | −0.270 | −53.180 | −1.114 | −85.060 | −8.020 | −63.230 | 0.000 | −40.100 | −14.410 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.400 | 0.000 | 2.334 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 13.160 | 15.250 | 0.000 | 0.000 | 0.000 | 0.000 | 31.560 | 0.000 | 0.197 | 43.810 | 13.680 | 10.110 |
| Muscovite | 0.546 | 0.550 | 0.221 | 0.582 | 45.400 | 0.587 | 72.910 | 4.485 | 54.300 | 0.584 | 34.660 | 12.800 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 3.941 | 0.000 | 0.000 | 0.321 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | −0.001 | 0.000 | −0.001 | −0.006 | −0.001 | −0.002 | −0.006 | −0.001 | −0.001 | −0.001 | −0.001 |

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## Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 18.080 | 20.190 | 1.989 | 3.694 | 109.400 | 1.335 | 202.900 | 8.979 | 128.600 | 49.070 | 96.990 | 43.160 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.001 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | | | | |
| $CaCO_3$ | 4.80E-06 | 4.80E-06 | 4.80E-06 | 4.80E-06 | 3.85E-09 | 9.37E-07 | 4.80E-06 | 1.61E-09 | 4.80E-06 | 4.80E-06 | 4.80E-06 | 4.80E-06 |
| $CaHCO_3^+$ | 4.03E-03 | 3.96E-03 | 1.07E-02 | 8.56E-03 | 1.45E-06 | 4.43E-03 | 2.82E-03 | 4.79E-07 | 3.64E-03 | 3.20E-03 | 3.53E-03 | 3.94E-03 |
| $CO_2$ | 1.15E+00 | 1.16E+00 | 1.07E+00 | 1.08E+00 | 1.18E+00 | 1.07E+00 | 1.34E+00 | 1.06E+00 | 1.21E+00 | 1.28E+00 | 1.23E+00 | 1.17E+00 |
| $CO_3^{2-}$ | 5.67E-07 | 5.97E-07 | 7.15E-08 | 1.12E-07 | 2.96E-06 | 1.59E-08 | 1.41E-06 | 3.91E-06 | 7.54E-07 | 1.05E-06 | 8.21E-07 | 6.08E-07 |
| $FeCO_3$ | 0.00E+00 | 4.79E-09 | 2.03E-10 | 3.52E-10 | 2.28E-08 | 5.57E-11 | 2.28E-08 | 2.28E-08 | 8.46E-09 | 1.86E-08 | 1.04E-08 | 5.00E-09 |
| $FeCO_3^+$ | 0.00E+00 | 1.88E-18 | 2.24E-19 | 3.08E-19 | 3.58E-18 | 1.28E-19 | 6.22E-18 | 2.78E-18 | 3.05E-18 | 5.86E-18 | 3.63E-18 | 1.95E-18 |
| $FeHCO_3^+$ | 0.00E+00 | 3.90E-05 | 4.46E-06 | 6.19E-06 | 8.45E-05 | 2.59E-06 | 1.32E-04 | 6.68E-05 | 6.33E-05 | 1.22E-04 | 7.54E-05 | 4.05E-05 |
| $HCO_3^-$ | 2.47E-02 | 2.55E-02 | 8.31E-03 | 1.04E-02 | 5.78E-02 | 3.92E-03 | 4.42E-02 | 6.08E-02 | 2.97E-02 | 3.67E-02 | 3.14E-02 | 2.58E-02 |
| $MgCO_3$ | 2.93E-08 | 2.93E-08 | 2.93E-08 | 2.93E-08 | 3.66E-05 | 1.50E-07 | 2.93E-08 | 8.76E-05 | 2.93E-08 | 2.93E-08 | 2.93E-08 | 2.93E-08 |
| $MgHCO_3^+$ | 1.29E-04 | 1.27E-04 | 3.42E-04 | 2.74E-04 | 7.22E-02 | 3.72E-03 | 9.02E-05 | 1.36E-01 | 1.17E-04 | 1.02E-04 | 1.13E-04 | 1.26E-04 |
| $NaCO_3^-$ | 8.16E-09 | 8.42E-09 | 1.19E-09 | 1.86E-09 | 4.00E-08 | 2.68E-10 | 1.42E-08 | 6.62E-08 | 9.77E-09 | 1.20E-08 | 1.03E-08 | 8.53E-09 |
| $NaHCO_3$ | 5.90E-03 | 5.93E-03 | 2.50E-03 | 3.10E-03 | 1.27E-02 | 1.20E-03 | 6.15E-03 | 1.90E-02 | 6.06E-03 | 6.15E-03 | 6.10E-03 | 5.96E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −14.510 | −16.600 | −0.668 | −1.073 | −18.440 | 0.000 | −75.600 | 0.000 | −33.200 | −45.260 | −35.130 | −18.670 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 29.840 | 34.020 | 1.542 | 2.606 | 37.820 | 0.312 | 152.060 | 0.927 | 67.240 | 91.360 | 71.100 | 38.160 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.001 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 15.330 | 17.420 | 0.874 | 1.533 | 19.385 | 0.312 | 76.461 | 0.932 | 34.040 | 46.100 | 35.970 | 19.490 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.146 | 1.158 | 1.070 | 1.076 | 1.179 | 1.069 | 1.344 | 1.058 | 1.213 | 1.282 | 1.233 | 1.166 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.035 | 0.036 | 0.022 | 0.022 | 0.143 | 0.013 | 0.053 | 0.216 | 0.040 | 0.046 | 0.041 | 0.036 |
| Total $CO_2$, moles/kg $H_2O$ | 16.511 | 18.614 | 1.966 | 2.631 | 20.707 | 1.394 | 77.858 | 2.207 | 35.293 | 47.428 | 37.244 | 20.692 |
| Water, g/cm$^3$ | 0.019 | 0.072 | 0.058 | 0.080 | 0.042 | 0.149 | 0.021 | 0.057 | 0.025 | 0.047 | 0.039 | 0.056 |
| Water, kg/m$^3$ | 19.047 | 72.425 | 58.419 | 80.025 | 41.510 | 148.598 | 21.015 | 56.520 | 25.093 | 46.526 | 39.473 | 55.771 |
| Mineral $CO_2$, moles/m$^3$ | 291.985 | 1261.645 | 51.041 | 122.678 | 804.674 | 46.392 | 1606.818 | 52.693 | 854.182 | 2144.833 | 1419.839 | 1086.975 |
| Dissolved $CO_2$, moles/m$^3$ | 21.827 | 83.868 | 62.508 | 86.106 | 48.941 | 158.851 | 28.244 | 59.798 | 30.438 | 59.646 | 48.670 | 65.029 |
| Solution $CO_2$, moles/m$^3$ | 0.662 | 2.576 | 1.277 | 1.790 | 5.928 | 1.971 | 1.122 | 12.229 | 0.993 | 2.151 | 1.627 | 2.003 |
| Total $CO_2$, moles/m$^3$ | 314.474 | 1348.089 | 114.826 | 210.574 | 859.542 | 207.214 | 1636.184 | 124.719 | 885.614 | 2206.630 | 1470.136 | 1154.007 |
| Mineral $CO_2$, moles/ft$^3$ | 8.268 | 35.726 | 1.445 | 3.474 | 22.786 | 1.314 | 45.500 | 1.492 | 24.188 | 60.735 | 40.206 | 30.780 |
| Dissolved $CO_2$, moles/ft$^3$ | 0.618 | 2.375 | 1.770 | 2.438 | 1.386 | 4.498 | 0.800 | 1.693 | 0.862 | 1.689 | 1.378 | 1.841 |
| Solution $CO_2$, moles/ft$^3$ | 0.019 | 0.073 | 0.036 | 0.051 | 0.168 | 0.056 | 0.032 | 0.346 | 0.028 | 0.061 | 0.046 | 0.057 |
| Total $CO_2$, moles/ft$^3$ | 8.905 | 38.174 | 3.252 | 5.963 | 24.340 | 5.868 | 46.332 | 3.532 | 25.078 | 62.485 | 41.630 | 32.678 |

Continued…

**Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, kg/m$^3$ | 12.850 | 55.525 | 2.246 | 5.399 | 35.414 | 2.042 | 70.716 | 2.319 | 37.593 | 94.394 | 62.487 | 47.838 |
| Dissolved $CO_2$, kg/m$^3$ | 0.961 | 3.691 | 2.751 | 3.790 | 2.154 | 6.991 | 1.243 | 2.632 | 1.340 | 2.625 | 2.142 | 2.862 |
| Solution $CO_2$, kg/m$^3$ | 0.029 | 0.113 | 0.056 | 0.079 | 0.261 | 0.087 | 0.049 | 0.538 | 0.044 | 0.095 | 0.072 | 0.088 |
| Total $CO_2$, kg/m$^3$ | 13.840 | 59.329 | 5.053 | 9.267 | 37.828 | 9.119 | 72.008 | 5.489 | 38.976 | 97.114 | 64.701 | 50.788 |
| Mineral $CO_2$, lb/ft$^3$ | 0.802 | 3.466 | 0.140 | 0.337 | 2.211 | 0.127 | 4.415 | 0.145 | 2.347 | 5.893 | 3.901 | 2.986 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.060 | 0.230 | 0.172 | 0.237 | 0.134 | 0.436 | 0.078 | 0.164 | 0.084 | 0.164 | 0.134 | 0.179 |
| Solution $CO_2$, lb/ft$^3$ | 0.002 | 0.007 | 0.004 | 0.005 | 0.016 | 0.005 | 0.003 | 0.034 | 0.003 | 0.006 | 0.004 | 0.006 |
| Total $CO_2$, lb/ft$^3$ | 0.864 | 3.704 | 0.315 | 0.579 | 2.362 | 0.569 | 4.495 | 0.343 | 2.433 | 6.063 | 4.039 | 3.171 |
| Weighted Average of Zones | | | | | | | | | | | | |
| Total Thickness, m | 103.0 | | | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 44.671 | | | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 2.836 | | | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 0.123 | | | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 47.630 | | | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 2.789 | | | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.177 | | | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.008 | | | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 2.973 | | | | | | | | | | | |

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## Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | | | | | |
| pH | −1.003 | −0.993 | −1.446 | −1.349 | −0.835 | −1.525 | −0.863 | −0.325 | −1.126 | −0.879 | −0.955 | −1.000 |
| pE | 1.057 | 1.322 | 1.792 | 1.691 | 1.146 | 1.876 | 1.186 | 0.599 | 1.492 | 1.206 | 1.284 | 1.329 |
| Activity | 0.000 | 0.004 | −0.022 | −0.024 | −0.013 | −0.020 | −0.002 | −0.021 | 0.002 | 0.038 | −0.008 | −0.008 |
| Ionic Strength | −0.611 | −0.675 | −0.044 | −0.077 | −0.280 | −0.015 | −0.689 | 0.005 | −0.716 | −1.382 | −0.500 | −0.467 |
| Total Solution $CO_2$, moles | 1.178 | 1.191 | 1.090 | 1.097 | 1.320 | 1.081 | 1.395 | 1.273 | 1.251 | 1.326 | 1.272 | 1.200 |
| Solution, moles | | | | | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.481 | 1.544 | 1.099 | 1.114 | 1.844 | 1.077 | 3.077 | 1.249 | 1.853 | 2.403 | 1.981 | 1.568 |
| Ca | −0.478 | −0.480 | −0.173 | −0.300 | −0.564 | −0.156 | −0.490 | −0.463 | −0.517 | −0.495 | −0.484 | −0.479 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.001 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| K | 1.028 | 1.036 | 0.378 | 0.640 | 0.385 | 0.079 | 1.133 | 0.003 | 1.126 | 1.104 | 1.063 | 1.034 |
| Mg | −0.014 | −0.014 | −0.005 | −0.009 | 0.481 | 0.124 | -0.015 | 0.579 | -0.016 | -0.015 | -0.015 | -0.014 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.002 | 0.001 | 0.001 | 0.011 | 0.001 | 0.003 | 0.013 | 0.002 | 0.002 | 0.002 | 0.002 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

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## Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −14.300 | −16.460 | −0.500 | −0.930 | −18.240 | 0.000 | −75.500 | 0.000 | −33.000 | −45.110 | −35.000 | −18.540 |
| Celadonite | −14.640 | −16.740 | −0.502 | −0.828 | 3.198 | 0.000 | −11.910 | 0.000 | 0.000 | −45.400 | −5.174 | −7.987 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | 283.200 | 281.000 | 298.000 | 297.400 | 278.800 | 298.600 | 220.500 | 297.800 | 264.100 | 251.500 | 262.000 | 278.900 |
| Dolomite | 14.850 | 16.946 | 0.701 | 1.233 | 18.804 | 0.156 | 75.971 | 0.464 | 33.519 | 45.610 | 35.486 | 19.008 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | −3.719 | 0.025 | 0.000 | −0.343 | −9.281 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 13.160 | 15.250 | 0.000 | 0.000 | 0.000 | 0.000 | 31.560 | 0.000 | 0.197 | 43.810 | 13.680 | 10.110 |
| Muscovite | 0.514 | 0.518 | 0.189 | 0.320 | 3.920 | 0.015 | 0.560 | 0.344 | 9.840 | 0.552 | 0.540 | 0.520 |
| Phlogopite | −0.065 | −0.064 | −0.065 | −0.132 | −7.499 | −0.093 | −21.350 | −0.348 | −11.170 | −0.065 | −10.100 | −3.670 |
| Pyrite | 0.000 | −0.001 | 0.000 | −0.001 | −0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 18.000 | 19.900 | 1.700 | 2.700 | 5.400 | 0.100 | 15.300 | 0.700 | 21.900 | 48.800 | 8.400 | 11.100 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.001 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −14.370 | −16.459 | −0.528 | −0.933 | −18.238 | 0.000 | −75.481 | 0.000 | −32.999 | −45.120 | −35.001 | −18.533 |
| Celadonite | −14.639 | −16.739 | −0.502 | −0.828 | 3.200 | 0.000 | −11.910 | 0.000 | 0.000 | −45.409 | −5.170 | −7.985 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 12831 | 16.810 | 18.970 | 1.974 | 2.647 | 21.220 | 1.390 | 79.540 | 2.182 | 35.890 | 48.510 | 37.950 | 21.060 |
| Dolomite | 14.850 | 16.939 | 0.701 | 1.233 | 18.809 | 0.156 | 75.971 | 0.464 | 33.519 | 45.610 | 35.486 | 19.011 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | −3.719 | 0.025 | 0.000 | −0.343 | −9.281 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 13.160 | 15.250 | 0.000 | 0.000 | 0.000 | 0.000 | 31.560 | 0.000 | 0.197 | 43.810 | 13.680 | 10.110 |
| Muscovite | 0.514 | 0.518 | 0.189 | 0.320 | 3.920 | 0.015 | 0.560 | 0.344 | 9.840 | 0.552 | 0.540 | 0.520 |
| Phlogopite | −0.065 | −0.064 | −0.065 | −0.132 | −7.499 | −0.093 | −21.350 | −0.348 | −11.170 | −0.065 | −10.100 | −3.670 |
| Pyrite | 0.000 | −0.001 | 0.000 | −0.001 | −0.006 | −0.001 | −0.002 | −0.006 | −0.001 | −0.001 | −0.001 | −0.001 |

Continued…

**Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 17.727 | 19.838 | 1.636 | 2.747 | 5.400 | 0.187 | 15.300 | 0.695 | 22.000 | 48.717 | 8.360 | 11.090 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.001 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | | | | |
| $CaCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | -4.80E-06 | 3.11E-07 | 0.00E+00 | -6.50E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $CaHCO_3^+$ | 3.65E-03 | 3.58E-03 | 1.03E-02 | 8.18E-03 | -2.58E-04 | 4.34E-03 | 2.45E-03 | -9.13E-05 | 3.39E-03 | 2.82E-03 | 3.15E-03 | 3.56E-03 |
| $CO_2$ | 1.15E+00 | 1.16E+00 | 1.07E+00 | 1.08E+00 | 1.18E+00 | 1.07E+00 | 1.34E+00 | 1.06E+00 | 1.21E+00 | 1.28E+00 | 1.23E+00 | 1.17E+00 |
| $CO_3^{2-}$ | 5.21E-07 | 5.51E-07 | 2.53E-08 | 6.62E-08 | 2.91E-06 | 8.99E-09 | 1.35E-06 | 3.90E-06 | 7.07E-07 | 1.00E-06 | 7.68E-07 | 5.59E-07 |
| $FeCO_3$ | 0.00E+00 | 4.78E-09 | 1.96E-10 | 3.45E-10 | 2.28E-08 | 5.50E-11 | 2.27E-08 | 2.28E-08 | 8.45E-09 | 1.86E-08 | 1.04E-08 | 4.99E-09 |
| $FeCO_3^+$ | 0.00E+00 | 1.88E-18 | 2.24E-19 | 3.08E-19 | 3.58E-18 | 1.28E-19 | 6.22E-18 | 2.77E-18 | 3.05E-18 | 5.85E-18 | 3.63E-18 | 1.95E-18 |
| $FeHCO_3^+$ | 0.00E+00 | 3.90E-05 | 4.46E-06 | 6.18E-06 | 8.45E-05 | 2.59E-06 | 1.32E-04 | 6.68E-05 | 6.33E-05 | 1.22E-04 | 7.54E-05 | 4.04E-05 |
| $HCO_3^-$ | 2.45E-02 | 2.53E-02 | 8.11E-03 | 1.02E-02 | 5.77E-02 | 3.87E-03 | 4.40E-02 | 6.07E-02 | 2.96E-02 | 3.65E-02 | 3.12E-02 | 2.56E-02 |
| $MgCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.66E-05 | 1.18E-07 | 0.00E+00 | 8.75E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $MgHCO_3^+$ | 1.17E-04 | 1.15E-04 | 3.30E-04 | 2.62E-04 | 7.22E-02 | 3.69E-03 | 7.83E-05 | 1.36E-01 | 1.08E-04 | 9.01E-05 | 1.01E-04 | 1.14E-04 |
| $NaCO_3^-$ | 7.38E-09 | 7.64E-09 | 4.14E-10 | 1.08E-09 | 3.93E-08 | 1.51E-10 | 1.34E-08 | 6.61E-08 | 9.04E-09 | 1.12E-08 | 9.54E-09 | 7.76E-09 |
| $NaHCO_3$ | 5.84E-03 | 5.87E-03 | 2.44E-03 | 3.04E-03 | 1.26E-02 | 1.18E-03 | 6.10E-03 | 1.90E-02 | 6.03E-03 | 6.10E-03 | 6.05E-03 | 5.90E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −14.370 | −16.459 | −0.528 | −0.933 | −18.238 | 0.000 | −75.481 | 0.000 | −32.999 | −45.120 | −35.001 | −18.533 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 29.700 | 33.878 | 1.403 | 2.467 | 37.617 | 0.312 | 151.942 | 0.927 | 67.039 | 91.221 | 70.972 | 38.023 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.001 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 15.330 | 17.419 | 0.874 | 1.533 | 19.384 | 0.312 | 76.462 | 0.932 | 34.040 | 46.100 | 35.971 | 19.490 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.145 | 1.157 | 1.069 | 1.075 | 1.179 | 1.069 | 1.343 | 1.058 | 1.213 | 1.281 | 1.232 | 1.165 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.034 | 0.035 | 0.021 | 0.022 | 0.142 | 0.013 | 0.053 | 0.216 | 0.039 | 0.046 | 0.041 | 0.035 |
| Total $CO_2$, moles/kg $H_2O$ | 16.510 | 18.611 | 1.964 | 2.630 | 20.705 | 1.394 | 77.858 | 2.206 | 35.292 | 47.427 | 37.244 | 20.690 |
| Water, g/cm$^3$ | 0.019 | 0.072 | 0.058 | 0.080 | 0.042 | 0.149 | 0.021 | 0.057 | 0.025 | 0.047 | 0.039 | 0.056 |
| Water, kg/m$^3$ | 19.047 | 72.425 | 58.419 | 80.025 | 41.510 | 148.598 | 21.015 | 56.520 | 25.093 | 46.526 | 39.473 | 55.771 |
| Mineral $CO_2$, moles/m$^3$ | 291.991 | 1261.599 | 51.064 | 122.716 | 804.624 | 46.392 | 1606.852 | 52.693 | 854.180 | 2144.851 | 1419.879 | 1086.947 |
| Dissolved $CO_2$, moles/m$^3$ | 21.811 | 83.806 | 62.458 | 86.038 | 48.924 | 158.791 | 28.223 | 59.774 | 30.429 | 59.606 | 48.634 | 64.980 |
| Solution $CO_2$, moles/m$^3$ | 0.649 | 2.529 | 1.239 | 1.738 | 5.909 | 1.944 | 1.108 | 12.218 | 0.982 | 2.121 | 1.601 | 1.966 |
| Total $CO_2$, moles/m$^3$ | 314.451 | 1347.934 | 114.762 | 210.493 | 859.457 | 207.127 | 1636.183 | 124.685 | 885.591 | 2206.578 | 1470.113 | 1153.893 |
| Mineral $CO_2$, moles/ft$^3$ | 8.268 | 35.725 | 1.446 | 3.475 | 22.785 | 1.314 | 45.501 | 1.492 | 24.188 | 60.736 | 40.207 | 30.779 |
| Dissolved $CO_2$, moles/ft$^3$ | 0.618 | 2.373 | 1.769 | 2.436 | 1.385 | 4.496 | 0.799 | 1.693 | 0.862 | 1.688 | 1.377 | 1.840 |
| Solution $CO_2$, moles/ft$^3$ | 0.018 | 0.072 | 0.035 | 0.049 | 0.167 | 0.055 | 0.031 | 0.346 | 0.028 | 0.060 | 0.045 | 0.056 |
| Total $CO_2$, moles/ft$^3$ | 8.904 | 38.169 | 3.250 | 5.961 | 24.337 | 5.865 | 46.332 | 3.531 | 25.077 | 62.484 | 41.629 | 32.675 |
| Mineral $CO_2$, kg/m$^3$ | 12.851 | 55.523 | 2.247 | 5.401 | 35.411 | 2.042 | 70.718 | 2.319 | 37.592 | 94.395 | 62.489 | 47.837 |
| Dissolved $CO_2$, kg/m$^3$ | 0.960 | 3.688 | 2.749 | 3.787 | 2.153 | 6.988 | 1.242 | 2.631 | 1.339 | 2.623 | 2.140 | 2.860 |
| Solution $CO_2$, kg/m$^3$ | 0.029 | 0.111 | 0.055 | 0.077 | 0.260 | 0.086 | 0.049 | 0.538 | 0.043 | 0.093 | 0.070 | 0.087 |
| Total $CO_2$, kg/m$^3$ | 13.839 | 59.323 | 5.051 | 9.264 | 37.825 | 9.116 | 72.008 | 5.487 | 38.975 | 97.112 | 64.700 | 50.783 |

Continued…

**Table B-44. Summary of ND 12831 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Zone 9 | Zone 10 | Zone 11 | Total |
| Mineral $CO_2$, lb/ft$^3$ | 0.802 | 3.466 | 0.140 | 0.337 | 2.211 | 0.127 | 4.415 | 0.145 | 2.347 | 5.893 | 3.901 | 2.986 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.060 | 0.230 | 0.172 | 0.236 | 0.134 | 0.436 | 0.078 | 0.164 | 0.084 | 0.164 | 0.134 | 0.179 |
| Solution $CO_2$, lb/ft$^3$ | 0.002 | 0.007 | 0.003 | 0.005 | 0.016 | 0.005 | 0.003 | 0.034 | 0.003 | 0.006 | 0.004 | 0.005 |
| Total $CO_2$, lb/ft$^3$ | 0.864 | 3.703 | 0.315 | 0.578 | 2.361 | 0.569 | 4.495 | 0.343 | 2.433 | 6.062 | 4.039 | 3.170 |
| Weighted Average of Zones | | | | | | | | | | | | |
| Total Thickness, m | 103.0 | | | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 44.670 | | | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 2.835 | | | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 0.121 | | | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 47.626 | | | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 2.789 | | | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.177 | | | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.008 | | | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 2.973 | | | | | | | | | | | |

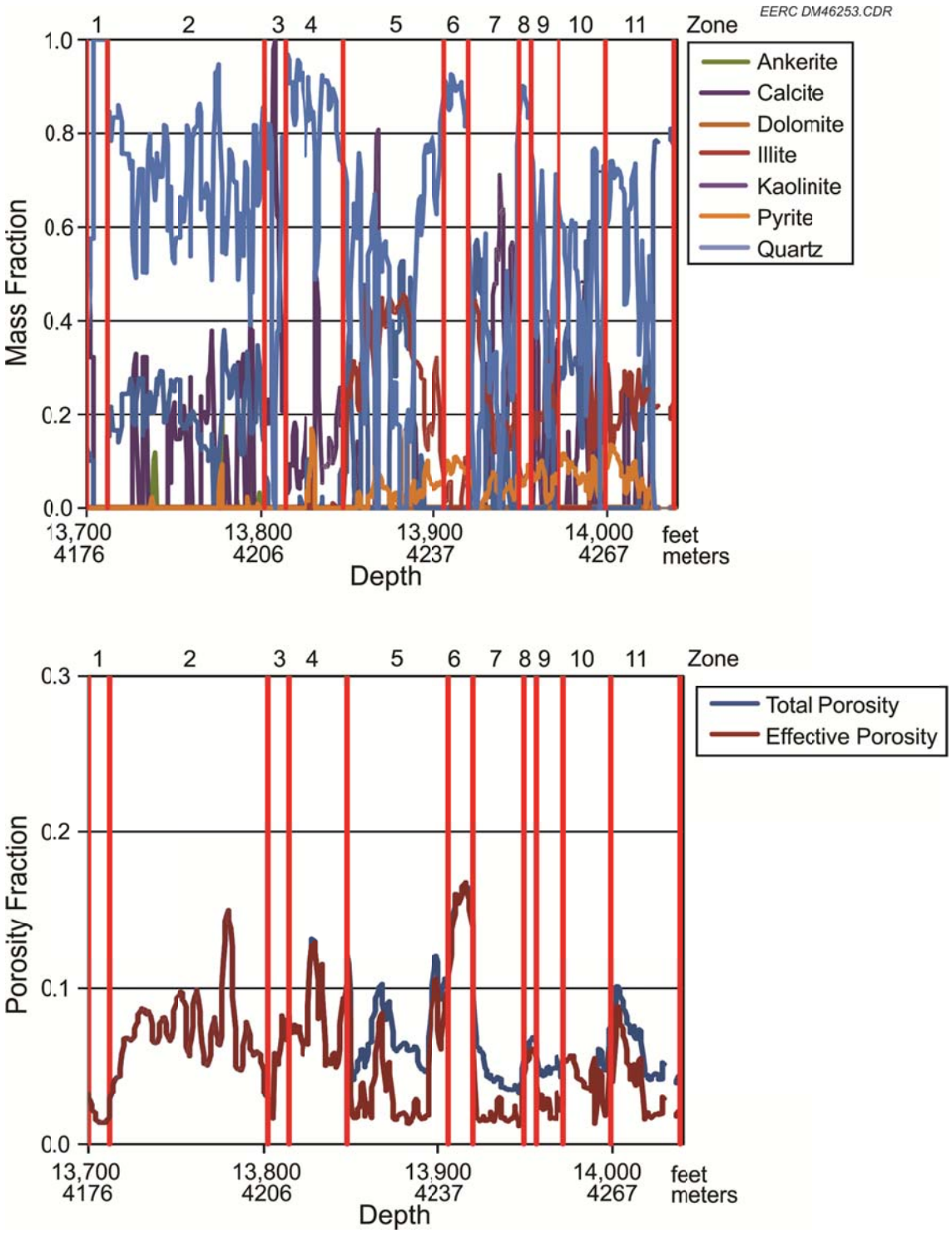



Figure B-12. ND 12831 mineral composition and porosity as a function of depth.

**MT API 21748**

The water composition used for MT API 21748 is from the MT API 05112 well 10 miles (16 km) to the south. Mineral data were available for 95% of the COSS represented in this well. The total COSS thickness is not known, as the well did not penetrate into the Precambrian.

Zone 1 is almost exclusively quartz. Zone 2 is primarily quartz, with moderate amounts of illite clay and dolomite. There are approximately equal amounts of quartz, illite, and muscovite in Zones 3 and 4. Zone 5 is similar, but with a moderate amount of dolomite as well. Zone 6 contains moderate glauconite and illite along with quartz. The porosity ranges from 0.049 to 0.146, with Zone 1 having the highest value.

Small additional amounts of kaolinite, calcite, and phlogopite dissolve, with corresponding increases in dolomite, quartz, and muscovite. Small amounts of pyrite also dissolve with the formation of siderite.

The amount of $CO_2$ dissolved in the formation water generally ranges from 0.82 to 0.93 moles/kg. The total average amount of $CO_2$ reacting with the minerals and formation water is 15.0 kg/m$^3$ (0.9 lb/ft$^3$) of formation rock.

## Table B-45. Average Mineral and Porosity for the MT API 21748 Aquifer Zones

Well Name: MT API 21748
API Identification: 25-091-21748-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 9847.0 | 3001.4 | Average | 0.150 | 0.146 | 0.000 | 0.000 | 0.000 | 0.017 | 0.000 | 0.032 | 0.000 | 0.000 | 0.000 | 0.000 | 0.951 | 0.000 |
| End | 9921.0 | 3023.9 | Minimum | 0.113 | 0.062 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.527 | 0.000 |
| Thickness | 74.0 | 22.6 | Maximum | 0.181 | 0.181 | 0.000 | 0.000 | 0.000 | 0.473 | 0.000 | 0.409 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 150 | | Standard deviation | 0.012 | 0.018 | 0.000 | 0.000 | 0.000 | 0.053 | 0.000 | 0.064 | 0.000 | 0.000 | 0.000 | 0.000 | 0.080 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 9921.0 | 3023.9 | Average | 0.113 | 0.097 | 0.000 | 0.006 | 0.000 | 0.128 | 0.000 | 0.163 | 0.000 | 0.000 | 0.002 | 0.014 | 0.687 | 0.000 |
| End | 9997.0 | 3047.1 | Minimum | 0.028 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.290 | 0.000 |
| Thickness | 76.0 | 23.2 | Maximum | 0.211 | 0.211 | 0.000 | 0.223 | 0.000 | 0.572 | 0.000 | 0.528 | 0.000 | 0.000 | 0.144 | 0.112 | 1.000 | 0.000 |
| Number of Values | 151 | | Standard deviation | 0.047 | 0.058 | 0.000 | 0.031 | 0.000 | 0.155 | 0.000 | 0.159 | 0.000 | 0.000 | 0.015 | 0.033 | 0.165 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 9997.0 | 3047.1 | Average | 0.063 | 0.049 | 0.000 | 0.051 | 0.000 | 0.000 | 0.000 | 0.276 | 0.000 | 0.000 | 0.325 | 0.031 | 0.317 | 0.000 |
| End | 10,087.0 | 3074.5 | Minimum | 0.009 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 90.0 | 27.4 | Maximum | 0.096 | 0.096 | 0.000 | 0.568 | 0.000 | 0.000 | 0.000 | 0.623 | 0.000 | 0.000 | 1.000 | 0.149 | 0.788 | 0.000 |
| Number of Values | 180 | | Standard deviation | 0.015 | 0.021 | 0.000 | 0.141 | 0.000 | 0.000 | 0.000 | 0.213 | 0.000 | 0.000 | 0.346 | 0.031 | 0.150 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 10,087.0 | 3074.5 | Average | 0.070 | 0.049 | 0.000 | 0.015 | 0.000 | 0.009 | 0.000 | 0.414 | 0.000 | 0.004 | 0.136 | 0.031 | 0.392 | 0.000 |
| End | 10,358.0 | 3157.1 | Minimum | 0.017 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 271.0 | 82.6 | Maximum | 0.239 | 0.239 | 0.000 | 0.291 | 0.000 | 0.732 | 0.000 | 0.704 | 0.000 | 0.569 | 1.000 | 0.232 | 0.967 | 0.000 |
| Number of Values | 543 | | Standard deviation | 0.032 | 0.036 | 0.000 | 0.054 | 0.000 | 0.073 | 0.000 | 0.199 | 0.000 | 0.043 | 0.254 | 0.036 | 0.191 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 10,358.0 | 3157.1 | Average | 0.099 | 0.082 | 0.000 | 0.004 | 0.000 | 0.179 | 0.000 | 0.207 | 0.000 | 0.000 | 0.211 | 0.023 | 0.376 | 0.000 |
| End | 10,542.0 | 3213.2 | Minimum | 0.024 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 184.0 | 56.1 | Maximum | 0.305 | 0.305 | 0.000 | 0.261 | 0.000 | 1.000 | 0.000 | 0.697 | 0.000 | 0.000 | 1.000 | 0.134 | 1.000 | 0.000 |
| Number of Values | 368 | | Standard deviation | 0.065 | 0.075 | 0.000 | 0.026 | 0.000 | 0.340 | 0.000 | 0.237 | 0.000 | 0.000 | 0.296 | 0.032 | 0.255 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 10,542.0 | 3213.2 | Average | 0.095 | 0.059 | 0.000 | 0.001 | 0.000 | 0.068 | 0.129 | 0.230 | 0.000 | 0.033 | 0.019 | 0.011 | 0.509 | 0.000 |
| End | 10,708.0 | 3263.8 | Minimum | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 166.0 | 50.6 | Maximum | 0.270 | 0.252 | 0.000 | 0.107 | 0.000 | 1.000 | 0.851 | 0.769 | 0.000 | 0.605 | 0.697 | 0.100 | 0.851 | 0.000 |
| Number of Values | 331 | | Standard deviation | 0.065 | 0.068 | 0.000 | 0.009 | 0.000 | 0.216 | 0.234 | 0.155 | 0.000 | 0.128 | 0.094 | 0.020 | 0.222 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 9847.0 | 3001.4 | Average | 0.091 | 0.071 | 0.000 | 0.012 | 0.000 | 0.067 | 0.025 | 0.265 | 0.000 | 0.008 | 0.126 | 0.021 | 0.478 | 0.000 |
| End | 10,708.0 | 3263.8 | Minimum | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 861.0 | 262.4 | Maximum | 0.305 | 0.305 | 0.000 | 0.568 | 0.000 | 1.000 | 0.851 | 0.769 | 0.000 | 0.605 | 1.000 | 0.232 | 1.000 | 0.000 |
| Number of Values | 1723 | | Standard deviation | 0.053 | 0.060 | 0.000 | 0.059 | 0.000 | 0.206 | 0.114 | 0.224 | 0.000 | 0.062 | 0.253 | 0.032 | 0.266 | 0.000 |

**Table B-46. Summary MT API 21748 Aquifer Mineral and Conditions**

Well Name: MT API 21748
API Identification: 25-091-21748-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Start, ft | 9847 | 9921 | 9997 | 10,087 | 10,358 | 10,542 | 9847 |
| End, ft | 9921 | 9997 | 10087 | 10,358 | 10,542 | 10,708 | 10,708 |
| Thickness, ft | 74.0 | 76.0 | 90.0 | 271.0 | 184.0 | 166.0 | 861.0 |
| Start, m | 3001.4 | 3023.9 | 3047.1 | 3074.5 | 3157.1 | 3213.2 | 3001.4 |
| End, m | 3023.9 | 3047.1 | 3074.5 | 3157.1 | 3213.2 | 3263.8 | 3263.8 |
| Thickness, m | 22.6 | 23.2 | 27.4 | 82.6 | 56.1 | 50.6 | 262.4 |
| Temperature, °F | 219.0 | 219.0 | 219.0 | 219.0 | 219.0 | 219.0 | 219.0 |
| Temperature, °C | 103.9 | 103.9 | 103.9 | 103.9 | 103.9 | 103.9 | 103.9 |
| Pressure, psi | 6548 | 6561 | 6576 | 6608 | 6648 | 6679 | 6617 |
| Pressure, kPa | 45,145 | 45,237 | 45,338 | 45,558 | 45,836 | 46,049 | 45,625 |
| Effective Porosity, fraction | 0.146 | 0.097 | 0.049 | 0.049 | 0.082 | 0.059 | 0.071 |
| Mass Fraction | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.006 | 0.051 | 0.015 | 0.004 | 0.001 | 0.012 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.017 | 0.128 | 0.000 | 0.009 | 0.179 | 0.068 | 0.067 |
| Glauconite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.129 | 0.025 |
| Illite | 0.032 | 0.163 | 0.276 | 0.414 | 0.207 | 0.230 | 0.265 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.033 | 0.008 |
| Muscovite | 0.000 | 0.002 | 0.325 | 0.136 | 0.211 | 0.019 | 0.126 |
| Pyrite | 0.000 | 0.014 | 0.031 | 0.031 | 0.023 | 0.011 | 0.021 |
| Quartz | 0.951 | 0.687 | 0.317 | 0.392 | 0.376 | 0.509 | 0.478 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-47. Summary of MT API 21748 Aquifer Calculation Results

Well Name: MT API 21748
API Identification: 25-091-21748-0000

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Start, m | 3001.4 | 3023.9 | 3047.1 | 3074.5 | 3157.1 | 3213.2 | 3001.4 |
| End, m | 3023.9 | 3047.1 | 3074.5 | 3157.1 | 3213.2 | 3263.8 | 3263.8 |
| Thickness, m | 22.6 | 23.2 | 27.4 | 82.6 | 56.1 | 50.6 | 262.4 |
| Start, ft | 9847.0 | 9921.0 | 9997.0 | 10,087.0 | 10,358.0 | 10,542.0 | 9847.0 |
| End, ft | 9921.0 | 9997.0 | 10,087.0 | 10,358.0 | 10,542.0 | 10,708.0 | 10,708.0 |
| Thickness, ft | 74.0 | 76.0 | 90.0 | 271.0 | 184.0 | 166.0 | 861.0 |
| **Minerals Without $CO_2$** | | | | | | | |
| pH | 5.924 | 6.256 | 6.244 | 6.236 | 6.254 | 6.280 | 6.255 |
| pE | 9.100 | −2.866 | −2.851 | −2.842 | −2.863 | −2.891 | −2.864 |
| Activity | 0.865 | 0.860 | 0.840 | 0.823 | 0.856 | 0.885 | 0.857 |
| Ionic Strength | 3.541 | 3.660 | 4.038 | 4.336 | 3.735 | 3.137 | 3.706 |
| Total Solution $CO_2$, moles | 5.253E-04 | 3.972E-04 | 3.846E-04 | 3.751E-04 | 3.947E-04 | 4.160E-04 | 3.956E-04 |
| Solution, moles | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0005 | 0.0004 | 0.0003 | 0.0003 | 0.0004 | 0.0005 | 0.0004 |
| Ca | 0.2535 | 0.2896 | 0.2898 | 0.2899 | 0.2897 | 0.2896 | 0.2896 |
| Cl | 4.8500 | 4.8500 | 4.8500 | 4.8500 | 4.8500 | 4.8500 | 4.8500 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0010 | 0.0004 | 0.0004 | 0.0003 | 0.0004 | 0.0005 | 0.0004 |
| Mg | 0.0455 | 0.0097 | 0.0095 | 0.0094 | 0.0096 | 0.0097 | 0.0096 |
| Na | 4.2580 | 4.2580 | 4.2580 | 4.2580 | 4.2580 | 4.2580 | 4.2580 |
| S | 0.0032 | 0.0032 | 0.0032 | 0.0032 | 0.0032 | 0.0032 | 0.0032 |
| Si | 0.0010 | 0.0009 | 0.0008 | 0.0007 | 0.0009 | 0.0012 | 0.0009 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1.510 | 27.610 | 8.027 | 1.186 | 0.418 | 4.180 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 13.070 | 2.095 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 1.388 | 17.560 | 0.000 | 2.483 | 30.230 | 15.960 | 13.090 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 1.299 | 10.720 | 38.950 | 57.860 | 16.740 | 25.960 | 24.940 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.852 | 0.000 | 5.484 | 1.060 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.131 | 44.270 | 18.260 | 16.480 | 2.107 | 11.410 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 2.912 | 13.880 | 13.960 | 6.022 | 3.926 | 6.423 |
| Quartz | 244.200 | 288.200 | 286.500 | 350.300 | 195.000 | 367.400 | 287.800 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1.437 | 27.530 | 7.954 | 1.113 | 0.346 | 4.108 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 1.389 | 17.600 | 0.037 | 2.521 | 30.270 | 16.000 | 13.120 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.434 | 3.574 | 12.980 | 20.140 | 5.581 | 5.425 | 7.976 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.671 | 5.671 | 64.390 | 48.150 | 25.130 | 24.230 | 25.690 |
| Phlogopite | 0.108 | 0.893 | 3.245 | 4.821 | 1.394 | 6.519 | 2.776 |
| Pyrite | 0.000 | 2.912 | 13.880 | 13.960 | 6.022 | 3.926 | 6.423 |
| Quartz | 245.600 | 299.300 | 326.700 | 410.100 | 212.300 | 424.800 | 318.500 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | −0.072 | −0.071 | −0.073 | −0.073 | −0.072 | −0.072 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −13.070 | −2.095 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Dolomite | 0.002 | 0.038 | 0.037 | 0.038 | 0.038 | 0.038 | 0.038 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −1.299 | −10.720 | −38.950 | −57.860 | −16.740 | −25.960 | −24.940 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.434 | 3.574 | 12.980 | 19.290 | 5.581 | −0.059 | 6.915 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.671 | 5.540 | 20.120 | 29.900 | 8.651 | 22.130 | 14.280 |
| Phlogopite | 0.108 | 0.893 | 3.245 | 4.821 | 1.394 | 6.519 | 2.776 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 1.343 | 11.080 | 40.240 | 59.790 | 17.300 | 57.320 | 30.660 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | 2.69E-06 | 6.25E-06 | 6.25E-06 | 6.25E-06 | 6.25E-06 | 6.25E-06 | 6.25E-06 |
| $CaHCO_3^+$ | 1.07E-04 | 1.15E-04 | 1.15E-04 | 1.14E-04 | 1.15E-04 | 1.13E-04 | 1.15E-04 |
| $CO_2$ | 1.83E-04 | 7.73E-05 | 7.23E-05 | 6.85E-05 | 7.63E-05 | 8.48E-05 | 7.67E-05 |
| $CO_3^{2-}$ | 7.02E-08 | 1.38E-07 | 1.24E-07 | 1.15E-07 | 1.35E-07 | 1.62E-07 | 1.36E-07 |
| $FeCO_3$ | 0.00E+00 | 2.26E-11 | 1.42E-11 | 9.92E-12 | 2.06E-11 | 4.39E-11 | 2.13E-11 |
| $FeCO_3^+$ | 0.00E+00 | 1.02E-22 | 6.41E-23 | 4.47E-23 | 9.28E-23 | 1.94E-22 | 9.61E-23 |
| $FeHCO_3^+$ | 0.00E+00 | 3.69E-09 | 2.32E-09 | 1.61E-09 | 3.37E-09 | 7.07E-09 | 3.49E-09 |
| $HCO_3^-$ | 1.39E-04 | 1.26E-04 | 1.14E-04 | 1.06E-04 | 1.24E-04 | 1.45E-04 | 1.25E-04 |
| $MgCO_3$ | 1.27E-07 | 5.47E-08 | 5.47E-08 | 5.47E-08 | 5.47E-08 | 5.47E-08 | 5.47E-08 |
| $MgHCO_3^+$ | 2.13E-05 | 4.22E-06 | 4.22E-06 | 4.19E-06 | 4.22E-06 | 4.16E-06 | 4.22E-06 |
| $NaCO_3^-$ | 4.64E-09 | 9.43E-09 | 9.44E-09 | 9.47E-09 | 9.43E-09 | 9.42E-09 | 9.43E-09 |
| $NaHCO_3$ | 7.18E-05 | 6.85E-05 | 7.28E-05 | 7.62E-05 | 6.93E-05 | 6.23E-05 | 6.90E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | −7.246E-02 | −7.142E-02 | −7.312E-02 | −7.252E-02 | −7.215E-02 | −7.246E-02 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 3.110E-03 | 7.572E-02 | 7.334E-02 | 7.644E-02 | 7.578E-02 | 7.526E-02 | 7.568E-02 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 3.110E-03 | 3.260E-03 | 1.920E-03 | 3.320E-03 | 3.260E-03 | 3.110E-03 | 3.220E-03 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.833E-04 | 7.734E-05 | 7.231E-05 | 6.850E-05 | 7.633E-05 | 8.477E-05 | 7.671E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 3.419E-04 | 3.198E-04 | 3.124E-04 | 3.066E-04 | 3.184E-04 | 3.313E-04 | 3.190E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 3.635E-03 | 3.657E-03 | 2.305E-03 | 3.695E-03 | 3.655E-03 | 3.526E-03 | 3.616E-03 |
| Water, $g/cm^3$ | 0.146 | 0.097 | 0.049 | 0.049 | 0.082 | 0.059 | 0.071 |
| Water, $kg/m^3$ | 145.539 | 96.810 | 49.068 | 49.200 | 82.103 | 59.497 | 70.751 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Total |
| Mineral $CO_2$, moles/$m^3$ | 4.526E-01 | 3.156E-01 | 9.421E-02 | 1.633E-01 | 2.677E-01 | 1.850E-01 | 2.278E-01 |
| Dissolved $CO_2$, moles/$m^3$ | 2.668E-02 | 7.487E-03 | 3.548E-03 | 3.370E-03 | 6.267E-03 | 5.044E-03 | 5.427E-03 |
| Solution $CO_2$, moles/$m^3$ | 4.976E-02 | 3.096E-02 | 1.533E-02 | 1.508E-02 | 2.614E-02 | 1.971E-02 | 2.257E-02 |
| Total $CO_2$, moles/$m^3$ | 5.291E-01 | 3.540E-01 | 1.131E-01 | 1.818E-01 | 3.001E-01 | 2.098E-01 | 2.558E-01 |
| Mineral $CO_2$, moles/$ft^3$ | 1.282E-02 | 8.937E-03 | 2.668E-03 | 4.625E-03 | 7.579E-03 | 5.240E-03 | 6.451E-03 |
| Dissolved $CO_2$, moles/$ft^3$ | 7.554E-04 | 2.120E-04 | 1.005E-04 | 9.543E-05 | 1.775E-04 | 1.428E-04 | 1.537E-04 |
| Solution $CO_2$, moles/$ft^3$ | 1.409E-03 | 8.768E-04 | 4.340E-04 | 4.271E-04 | 7.402E-04 | 5.581E-04 | 6.390E-04 |
| Total $CO_2$, moles/$ft^3$ | 1.498E-02 | 1.003E-02 | 3.202E-03 | 5.148E-03 | 8.497E-03 | 5.941E-03 | 7.244E-03 |
| Mineral $CO_2$, kg/$m^3$ | 1.992E-02 | 1.389E-02 | 4.146E-03 | 7.189E-03 | 1.178E-02 | 8.143E-03 | 1.003E-02 |
| Dissolved $CO_2$, kg/$m^3$ | 1.174E-03 | 3.295E-04 | 1.562E-04 | 1.483E-04 | 2.758E-04 | 2.220E-04 | 2.389E-04 |
| Solution $CO_2$, kg/$m^3$ | 2.190E-03 | 1.363E-03 | 6.746E-04 | 6.638E-04 | 1.150E-03 | 8.674E-04 | 9.932E-04 |
| Total $CO_2$, kg/$m^3$ | 2.328E-02 | 1.558E-02 | 4.977E-03 | 8.001E-03 | 1.321E-02 | 9.233E-03 | 1.126E-02 |
| Mineral $CO_2$, lb/$ft^3$ | 1.244E-03 | 8.671E-04 | 2.588E-04 | 4.488E-04 | 7.354E-04 | 5.084E-04 | 6.259E-04 |
| Dissolved $CO_2$, lb/$ft^3$ | 7.329E-05 | 2.057E-05 | 9.748E-06 | 9.259E-06 | 1.722E-05 | 1.386E-05 | 1.491E-05 |
| Solution $CO_2$, lb/$ft^3$ | 1.367E-04 | 8.507E-05 | 4.211E-05 | 4.144E-05 | 7.182E-05 | 5.415E-05 | 6.200E-05 |
| Total $CO_2$, lb/$ft^3$ | 1.454E-03 | 9.727E-04 | 3.107E-04 | 4.995E-04 | 8.244E-04 | 5.764E-04 | 7.028E-04 |
| Weighted Average of Zones | | | | | | | |
| Total Thickness, m | 262.4 | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 9.722E-03 | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.947E-04 | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 1.001E-03 | | | | | | |
| Total $CO_2$, kg/$m^3$ | 1.102E-02 | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 6.069E-04 | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 1.840E-05 | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 6.249E-05 | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 6.878E-04 | | | | | | |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Total |
| **Minerals with $CO_2$** | | | | | | | |
| pH | 4.061 | 5.487 | 4.245 | 5.477 | 5.485 | 5.499 | 5.488 |
| pE | 10.967 | −1.802 | −0.418 | −1.788 | −1.799 | −1.817 | −1.803 |
| Activity | 0.849 | 0.837 | 0.841 | 0.817 | 0.833 | 0.858 | 0.839 |
| Ionic Strength | 3.502 | 3.805 | 3.719 | 4.200 | 3.889 | 3.350 | 3.775 |
| Total Solution $CO_2$, moles | 9.07E-01 | 1.49E+00 | 8.98E-01 | 1.45E+00 | 1.51E+00 | 1.59E+00 | 1.51E+00 |
| Solution, moles | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.9020 | 1.4930 | 0.8336 | 1.2380 | 1.4610 | 1.9670 | 1.5380 |
| Ca | 0.0798 | 0.0000 | 0.2840 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Cl | 4.8500 | 4.8500 | 4.8500 | 4.8500 | 4.8500 | 4.8500 | 4.8500 |
| Fe | 0.0000 | 0.0001 | 0.0003 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| K | 0.0715 | 0.0025 | 0.0429 | 0.0021 | 0.0024 | 0.0032 | 0.0026 |
| Mg | 0.1944 | 0.6575 | 0.0095 | 0.6034 | 0.6515 | 0.7572 | 0.6675 |
| Na | 4.2580 | 4.2580 | 4.2580 | 4.2580 | 4.2580 | 4.2580 | 4.2580 |
| S | 0.0032 | 0.0543 | 0.0037 | 0.0459 | 0.0533 | 0.0695 | 0.0558 |
| Si | 0.0009 | 0.0009 | 0.0009 | 0.0008 | 0.0009 | 0.0011 | 0.0009 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1.510 | 27.610 | 8.027 | 1.186 | 0.418 | 4.180 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 13.070 | 2.095 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 1.388 | 17.560 | 0.000 | 2.483 | 30.230 | 15.960 | 13.090 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 1.299 | 10.720 | 38.950 | 57.860 | 16.740 | 25.960 | 24.940 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.852 | 0.000 | 5.484 | 1.060 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.131 | 44.270 | 18.260 | 16.480 | 2.107 | 11.410 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 2.912 | 13.880 | 13.960 | 6.022 | 3.926 | 6.423 |
| Quartz | 244.200 | 288.200 | 286.500 | 350.300 | 195.000 | 367.400 | 287.800 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 17.810 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | 298.800 | 296.500 | 289.400 | 290.200 | 296.800 | 297.100 | 293.700 |
| Dolomite | 1.563 | 19.320 | 9.772 | 10.770 | 31.670 | 16.640 | 17.520 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.432 | 2.785 | 9.801 | 17.190 | 4.902 | 4.968 | 6.294 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.708 | 6.461 | 67.590 | 51.100 | 25.810 | 24.690 | 27.370 |
| Phlogopite | 0.000 | 0.101 | 0.000 | 1.875 | 0.713 | 6.058 | 1.091 |
| Pyrite | 0.000 | 2.886 | 13.880 | 13.930 | 5.997 | 3.893 | 6.396 |
| Quartz | 245.800 | 300.900 | 333.200 | 416.000 | 213.600 | 425.700 | 321.800 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.025 | 0.000 | 0.021 | 0.025 | 0.033 | 0.026 |
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | −1.510 | −9.801 | −8.027 | −1.186 | −0.418 | −4.180 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −13.070 | −2.095 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | −1.249 | −3.535 | −10.570 | −9.793 | −3.178 | −2.924 | −6.251 |
| Dolomite | 0.175 | 1.765 | 9.772 | 8.282 | 1.441 | 0.673 | 4.435 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Illite | −1.299 | −10.720 | −38.950 | −57.860 | −16.740 | −25.960 | −24.940 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.432 | 2.785 | 9.801 | 16.340 | 4.902 | −0.517 | 5.233 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.708 | 6.330 | 23.320 | 32.840 | 9.331 | 22.590 | 15.960 |
| Phlogopite | 0.000 | 0.101 | 0.000 | 1.875 | 0.713 | 6.058 | 1.091 |
| Pyrite | 0.000 | −0.026 | 0.000 | −0.021 | −0.025 | −0.033 | −0.026 |
| Quartz | 1.558 | 12.660 | 46.730 | 65.680 | 18.670 | 58.250 | 34.030 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.025 | 0.000 | 0.021 | 0.025 | 0.033 | 0.026 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | 7.30E-07 | 5.47E-10 | 6.25E-06 | 5.33E-10 | 5.35E-10 | 5.42E-10 | 5.41E-10 |
| $CaHCO_3^+$ | 2.13E-03 | 5.83E-08 | 1.17E-02 | 5.62E-08 | 5.68E-08 | 5.81E-08 | 5.76E-08 |
| $CO_2$ | 8.85E-01 | 8.52E-01 | 8.65E-01 | 8.15E-01 | 8.59E-01 | 9.31E-01 | 8.66E-01 |
| $CO_3^{2-}$ | 6.22E-08 | 4.37E-05 | 1.44E-07 | 4.08E-05 | 4.38E-05 | 4.88E-05 | 4.45E-05 |
| $FeCO_3$ | 0.00E+00 | 7.23E-08 | 1.73E-09 | 7.23E-08 | 7.23E-08 | 7.23E-08 | 7.23E-08 |
| $FeCO_3^+$ | 0.00E+00 | 3.73E-18 | 2.18E-18 | 3.73E-18 | 3.73E-18 | 3.73E-18 | 3.73E-18 |
| $FeHCO_3^+$ | 0.00E+00 | 6.87E-05 | 2.90E-05 | 6.80E-05 | 6.86E-05 | 6.92E-05 | 6.87E-05 |
| $HCO_3^-$ | 9.00E-03 | 2.32E-01 | 1.35E-02 | 2.17E-01 | 2.33E-01 | 2.60E-01 | 2.36E-01 |
| $MgCO_3$ | 4.68E-07 | 6.25E-04 | 5.47E-08 | 6.42E-04 | 6.40E-04 | 6.31E-04 | 6.32E-04 |
| $MgHCO_3^+$ | 5.74E-03 | 2.80E-01 | 4.31E-04 | 2.85E-01 | 2.86E-01 | 2.85E-01 | 2.84E-01 |
| $NaCO_3^-$ | 4.11E-09 | 2.83E-06 | 9.98E-09 | 2.97E-06 | 2.91E-06 | 2.72E-06 | 2.85E-06 |
| $NaHCO_3$ | 4.62E-03 | 1.22E-01 | 7.48E-03 | 1.35E-01 | 1.27E-01 | 1.10E-01 | 1.23E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | −1.510E+00 | −9.801E+00 | −8.027E+00 | −1.186E+00 | −4.182E-01 | −4.180E+00 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 3.504E-01 | 3.530E+00 | 1.954E+01 | 1.656E+01 | 2.882E+00 | 1.346E+00 | 8.870E+00 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 2.543E-02 | 0.000E+00 | 2.124E-02 | 2.495E-02 | 3.306E-02 | 2.619E-02 |
| Mineral $CO_2$, moles/kg $H_2O$ | 3.504E-01 | 2.045E+00 | 9.743E+00 | 8.558E+00 | 1.721E+00 | 9.613E-01 | 4.716E+00 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 8.851E-01 | 8.516E-01 | 8.645E-01 | 8.154E-01 | 8.585E-01 | 9.314E-01 | 8.661E-01 |
| Solution $CO_2$, moles/kg $H_2O$ | 2.149E-02 | 6.352E-01 | 3.314E-02 | 6.380E-01 | 6.469E-01 | 6.566E-01 | 6.435E-01 |
| Total $CO_2$, moles/kg $H_2O$ | 1.257E+00 | 3.532E+00 | 1.064E+01 | 1.001E+01 | 3.226E+00 | 2.549E+00 | 6.226E+00 |
| Water, $g/cm^3$ | 0.146 | 0.097 | 0.049 | 0.049 | 0.082 | 0.059 | 0.071 |
| Water, $kg/m^3$ | 145.539 | 96.810 | 49.068 | 49.200 | 82.103 | 59.497 | 70.751 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Total |
| Mineral $CO_2$, moles/$m^3$ | 50.997 | 198.018 | 478.068 | 421.063 | 141.294 | 57.192 | 333.675 |
| Dissolved $CO_2$, moles/$m^3$ | 128.817 | 82.443 | 42.419 | 40.117 | 70.485 | 55.415 | 61.277 |
| Solution $CO_2$, moles/$m^3$ | 3.127 | 61.497 | 1.626 | 31.387 | 53.108 | 39.063 | 45.532 |
| Total $CO_2$, moles/$m^3$ | 182.941 | 341.958 | 522.113 | 492.567 | 264.888 | 151.670 | 440.484 |
| Mineral $CO_2$, moles/$ft^3$ | 1.444 | 5.607 | 13.537 | 11.923 | 4.001 | 1.620 | 9.449 |
| Dissolved $CO_2$, moles/$ft^3$ | 3.648 | 2.335 | 1.201 | 1.136 | 1.996 | 1.569 | 1.735 |
| Solution $CO_2$, moles/$ft^3$ | 0.089 | 1.741 | 0.046 | 0.889 | 1.504 | 1.106 | 1.289 |
| Total $CO_2$, moles/$ft^3$ | 5.180 | 9.683 | 14.785 | 13.948 | 7.501 | 4.295 | 12.473 |
| Mineral $CO_2$, kg/$m^3$ | 2.244 | 8.715 | 21.040 | 18.531 | 6.218 | 2.517 | 14.685 |
| Dissolved $CO_2$, kg/$m^3$ | 5.669 | 3.628 | 1.867 | 1.766 | 3.102 | 2.439 | 2.697 |
| Solution $CO_2$, kg/$m^3$ | 0.138 | 2.707 | 0.072 | 1.381 | 2.337 | 1.719 | 2.004 |
| Total $CO_2$, kg/$m^3$ | 8.051 | 15.050 | 22.978 | 21.678 | 11.658 | 6.675 | 19.386 |
| Mineral $CO_2$, lb/$ft^3$ | 0.140 | 0.544 | 1.313 | 1.157 | 0.388 | 0.157 | 0.917 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.354 | 0.227 | 0.117 | 0.110 | 0.194 | 0.152 | 0.168 |
| Solution $CO_2$, lb/$ft^3$ | 0.009 | 0.169 | 0.004 | 0.086 | 0.146 | 0.107 | 0.125 |
| Total $CO_2$, lb/$ft^3$ | 0.503 | 0.940 | 1.434 | 1.353 | 0.728 | 0.417 | 1.210 |
| Weighted Average of Zones | | | | | | | |
| Total Thickness, m | 262.4 | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 10.808 | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.692 | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 1.524 | | | | | | |
| Total $CO_2$, kg/$m^3$ | 15.024 | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.675 | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.168 | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.095 | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.938 | | | | | | |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | |
| pH | −1.863 | −0.769 | −1.999 | −0.759 | −0.769 | −0.781 | −0.767 |
| pE | 1.867 | 1.064 | 2.433 | 1.054 | 1.064 | 1.074 | 1.061 |
| Activity | −0.016 | −0.023 | 0.001 | −0.006 | −0.023 | −0.027 | −0.018 |
| Ionic Strength | −0.039 | 0.145 | −0.319 | −0.136 | 0.154 | 0.213 | 0.069 |
| Total Solution $CO_2$, moles | 0.906 | 1.487 | 0.897 | 1.453 | 1.505 | 1.588 | 1.510 |
| Solution, moles | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 0.901 | 1.493 | 0.833 | 1.238 | 1.461 | 1.966 | 1.538 |
| Ca | −0.174 | −0.290 | −0.006 | −0.290 | −0.290 | −0.290 | −0.290 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.070 | 0.002 | 0.042 | 0.002 | 0.002 | 0.003 | 0.002 |
| Mg | 0.149 | 0.648 | 0.000 | 0.594 | 0.642 | 0.747 | 0.658 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.051 | 0.000 | 0.043 | 0.050 | 0.066 | 0.053 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | −1.437 | −9.720 | −7.954 | −1.113 | −0.346 | −4.108 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | 298.800 | 296.500 | 289.400 | 290.200 | 296.800 | 297.100 | 293.700 |
| Dolomite | 0.174 | 1.720 | 9.735 | 8.249 | 1.400 | 0.640 | 4.400 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.002 | −0.789 | −3.179 | −2.950 | −0.679 | −0.457 | −1.682 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.037 | 0.790 | 3.200 | 2.950 | 0.680 | 0.460 | 1.680 |
| Phlogopite | −0.108 | −0.792 | −3.245 | −2.946 | −0.681 | −0.461 | −1.685 |
| Pyrite | 0.000 | −0.026 | 0.000 | −0.030 | −0.025 | −0.033 | −0.027 |
| Quartz | 0.200 | 1.600 | 6.500 | 5.900 | 1.300 | 0.900 | 3.300 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.025 | 0.000 | 0.021 | 0.025 | 0.033 | 0.026 |
| Change (initial – final), moles | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | −1.438 | −9.730 | −7.954 | −1.113 | −0.346 | −4.108 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21748 | 1.249 | 3.535 | 10.570 | 9.793 | 3.178 | 2.924 | 6.251 |
| Dolomite | 0.174 | 1.727 | 9.735 | 8.244 | 1.403 | 0.636 | 4.397 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Total |
|---|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.002 | −0.789 | −3.179 | −2.950 | −0.679 | −0.457 | −1.682 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.037 | 0.790 | 3.200 | 2.940 | 0.680 | 0.460 | 1.680 |
| Phlogopite | −0.108 | −0.792 | −3.245 | −2.946 | −0.681 | −0.461 | −1.685 |
| Pyrite | 0.000 | −0.026 | 0.000 | −0.021 | −0.025 | −0.033 | −0.026 |
| Quartz | 0.215 | 1.580 | 6.490 | 5.890 | 1.370 | 0.930 | 3.370 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.025 | 0.000 | 0.021 | 0.025 | 0.033 | 0.026 |
| Final Solution, moles | | | | | | | |
| $CaCO_3$ | −1.96E-06 | −6.25E-06 | 0.00E+00 | −6.25E-06 | −6.25E-06 | −6.25E-06 | −6.25E-06 |
| $CaHCO_3^+$ | 2.02E-03 | −1.15E-04 | 1.16E-02 | −1.14E-04 | −1.15E-04 | −1.13E-04 | −1.15E-04 |
| $CO_2$ | 8.85E-01 | 8.52E-01 | 8.64E-01 | 8.15E-01 | 8.58E-01 | 9.31E-01 | 8.66E-01 |
| $CO_3^{2-}$ | −7.98E-09 | 4.35E-05 | 2.00E-08 | 4.07E-05 | 4.36E-05 | 4.86E-05 | 4.43E-05 |
| $FeCO_3$ | 0.00E+00 | 7.22E-08 | 1.72E-09 | 7.22E-08 | 7.22E-08 | 7.22E-08 | 7.22E-08 |
| $FeCO_3^+$ | 0.00E+00 | 3.73E-18 | 2.18E-18 | 3.73E-18 | 3.73E-18 | 3.73E-18 | 3.73E-18 |
| $FeHCO_3^+$ | 0.00E+00 | 6.87E-05 | 2.90E-05 | 6.80E-05 | 6.86E-05 | 6.92E-05 | 6.87E-05 |
| $HCO_3^-$ | 8.87E-03 | 2.32E-01 | 1.34E-02 | 2.16E-01 | 2.33E-01 | 2.60E-01 | 2.36E-01 |
| $MgCO_3$ | 3.41E-07 | 6.25E-04 | 0.00E+00 | 6.42E-04 | 6.39E-04 | 6.31E-04 | 6.32E-04 |
| $MgHCO_3^+$ | 5.71E-03 | 2.80E-01 | 4.27E-04 | 2.85E-01 | 2.86E-01 | 2.85E-01 | 2.84E-01 |
| $NaCO_3^-$ | −5.32E-10 | 2.82E-06 | 5.39E-10 | 2.96E-06 | 2.90E-06 | 2.71E-06 | 2.84E-06 |
| $NaHCO_3$ | 4.55E-03 | 1.22E-01 | 7.40E-03 | 1.35E-01 | 1.27E-01 | 1.10E-01 | 1.23E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | −1.438E+00 | −9.730E+00 | −7.954E+00 | −1.113E+00 | −3.461E-01 | −4.108E+00 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 3.473E-01 | 3.454E+00 | 1.947E+01 | 1.649E+01 | 2.806E+00 | 1.271E+00 | 8.794E+00 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 2.543E-02 | 0.000E+00 | 2.124E-02 | 2.495E-02 | 3.306E-02 | 2.619E-02 |
| Mineral $CO_2$, moles/kg $H_2O$ | 3.473E-01 | 2.042E+00 | 9.741E+00 | 8.555E+00 | 1.718E+00 | 9.582E-01 | 4.713E+00 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 8.849E-01 | 8.515E-01 | 8.644E-01 | 8.153E-01 | 8.584E-01 | 9.313E-01 | 8.660E-01 |
| Solution $CO_2$, moles/kg $H_2O$ | 2.114E-02 | 6.349E-01 | 3.283E-02 | 6.376E-01 | 6.465E-01 | 6.562E-01 | 6.432E-01 |
| Total $CO_2$, moles/kg $H_2O$ | 1.253E+00 | 3.529E+00 | 1.064E+01 | 1.001E+01 | 3.223E+00 | 2.546E+00 | 6.222E+00 |
| Water, $g/cm^3$ | 0.146 | 0.097 | 0.049 | 0.049 | 0.082 | 0.059 | 0.071 |
| Water, $kg/m^3$ | 145.539 | 96.810 | 49.068 | 49.200 | 82.103 | 59.497 | 70.751 |

Continued…

**Table B-47. Summary of MT API 21748 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Total |
| Mineral $CO_2$, moles/$m^3$ | 50.544 | 197.702 | 477.974 | 420.899 | 141.027 | 57.007 | 333.447 |
| Dissolved $CO_2$, moles/$m^3$ | 128.790 | 82.436 | 42.416 | 40.114 | 70.479 | 55.410 | 61.272 |
| Solution $CO_2$, moles/$m^3$ | 3.077 | 61.466 | 1.611 | 31.372 | 53.082 | 39.043 | 45.509 |
| Total $CO_2$, moles/$m^3$ | 182.412 | 341.604 | 522.000 | 492.386 | 264.588 | 151.460 | 440.228 |
| Mineral $CO_2$, moles/$ft^3$ | 1.431 | 5.598 | 13.535 | 11.919 | 3.993 | 1.614 | 9.442 |
| Dissolved $CO_2$, moles/$ft^3$ | 3.647 | 2.334 | 1.201 | 1.136 | 1.996 | 1.569 | 1.735 |
| Solution $CO_2$, moles/$ft^3$ | 0.087 | 1.741 | 0.046 | 0.888 | 1.503 | 1.106 | 1.289 |
| Total $CO_2$, moles/$ft^3$ | 5.165 | 9.673 | 14.781 | 13.943 | 7.492 | 4.289 | 12.466 |
| Mineral $CO_2$, kg/$m^3$ | 2.224 | 8.701 | 21.036 | 18.524 | 6.207 | 2.509 | 14.675 |
| Dissolved $CO_2$, kg/$m^3$ | 5.668 | 3.628 | 1.867 | 1.765 | 3.102 | 2.439 | 2.697 |
| Solution $CO_2$, kg/$m^3$ | 0.135 | 2.705 | 0.071 | 1.381 | 2.336 | 1.718 | 2.003 |
| Total $CO_2$, kg/$m^3$ | 8.028 | 15.034 | 22.973 | 21.670 | 11.645 | 6.666 | 19.374 |
| Mineral $CO_2$, lb/$ft^3$ | 0.139 | 0.543 | 1.313 | 1.156 | 0.387 | 0.157 | 0.916 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.354 | 0.226 | 0.117 | 0.110 | 0.194 | 0.152 | 0.168 |
| Solution $CO_2$, lb/$ft^3$ | 0.008 | 0.169 | 0.004 | 0.086 | 0.146 | 0.107 | 0.125 |
| Total $CO_2$, lb/$ft^3$ | 0.501 | 0.939 | 1.434 | 1.353 | 0.727 | 0.416 | 1.209 |
| Weighted Average of Zones | | | | | | | |
| Total Thickness, m | 262.4 | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 10.799 | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.691 | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 1.523 | | | | | | |
| Total $CO_2$, kg/$m^3$ | 15.013 | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.674 | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.168 | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.095 | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.937 | | | | | | |

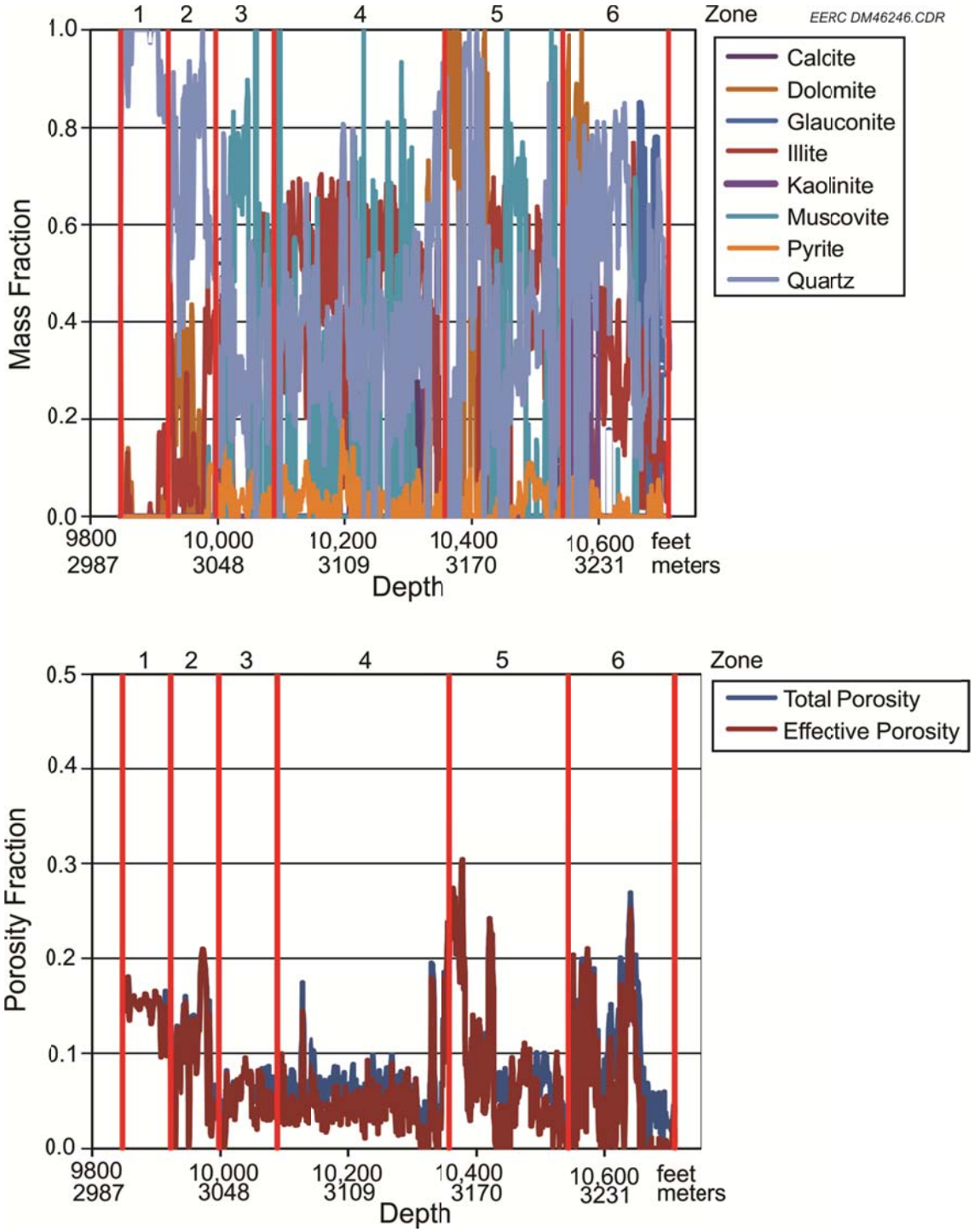



Figure B-13. MT API 21748 mineral composition and porosity as a function of depth.

**MT API 21112**

The water composition was available along with the mineral composition for the MT API 21112 well. Mineral data were available for 74% of COSS represented in this well. The total COSS thickness is not known, as the well did not penetrate into the Precambrian.

Zone 1 is primarily quartz, with a moderate amount of glauconite present, while Zone 2 is almost exclusively quartz. Zone 3 primarily comprises illite and muscovite in roughly equal amounts with a minor amount of quartz. The porosities of Zone 1, 2, and 3 are 0.101, 0.123, and 0.044, respectively.

Additional amounts of kaolinite, calcite, and phlogopite dissolve, with corresponding increases in dolomite, quartz, and muscovite. Zone 3 is especially high in conversion of calcite to dolomite. Small amounts of pyrite also dissolve with the formation of siderite.

The amount of $CO_2$ dissolved in the formation water is highest at 0.85 moles/kg (37.4 g/kg) for Zone 1 and lower at approximately 0.5 moles/kg (22 g/kg) for Zones 2 and 3. The total average amount of $CO_2$ reacting with the minerals and formation water is 12.8 kg/$m^3$ (0.8 lb/$ft^3$) of formation rock.

## Table B-48. Average Mineral and Porosity for the MT API 21112 Aquifer Zones

Well Name: MT API 21112
API Identification: 25-069-21112-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 6782.0 | 2067.2 | Average | 0.111 | 0.101 | 0.000 | 0.000 | 0.002 | 0.000 | 0.108 | 0.015 | 0.000 | 0.000 | 0.000 | 0.040 | 0.789 | 0.045 |
| End | 6796.0 | 2071.4 | Minimum | 0.068 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.214 | 0.000 |
| Thickness | 14.0 | 4.3 | Maximum | 0.164 | 0.146 | 0.000 | 0.000 | 0.072 | 0.000 | 0.281 | 0.209 | 0.000 | 0.000 | 0.000 | 0.236 | 1.000 | 0.538 |
| Number of Values | 29 | | Standard deviation | 0.028 | 0.033 | 0.000 | 0.000 | 0.013 | 0.000 | 0.089 | 0.048 | 0.000 | 0.000 | 0.000 | 0.078 | 0.168 | 0.114 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 6796.0 | 2071.4 | Average | 0.123 | 0.123 | 0.000 | 0.000 | 0.000 | 0.000 | 0.017 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.979 | 0.000 |
| End | 6895.0 | 2101.6 | Minimum | 0.043 | 0.043 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.681 | 0.000 |
| Thickness | 99.0 | 30.2 | Maximum | 0.171 | 0.171 | 0.000 | 0.000 | 0.000 | 0.000 | 0.319 | 0.223 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 198 | | Standard deviation | 0.034 | 0.035 | 0.000 | 0.000 | 0.000 | 0.000 | 0.049 | 0.022 | 0.000 | 0.000 | 0.000 | 0.000 | 0.053 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 6895.0 | 2101.6 | Average | 0.145 | 0.044 | 0.000 | 0.017 | 0.000 | 0.000 | 0.004 | 0.457 | 0.000 | 0.000 | 0.332 | 0.071 | 0.119 | 0.000 |
| End | 6927.5 | 2111.5 | Minimum | 0.077 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 32.5 | 9.9 | Maximum | 0.223 | 0.169 | 0.000 | 0.319 | 0.000 | 0.000 | 0.154 | 0.804 | 0.000 | 0.000 | 0.851 | 0.247 | 1.000 | 0.000 |
| Number of Values | 65 | | Standard deviation | 0.038 | 0.058 | 0.000 | 0.069 | 0.000 | 0.000 | 0.021 | 0.264 | 0.000 | 0.000 | 0.255 | 0.079 | 0.266 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 6782.0 | 2067.2 | Average | 0.127 | 0.103 | 0.000 | 0.004 | 0.000 | 0.000 | 0.023 | 0.106 | 0.000 | 0.000 | 0.074 | 0.020 | 0.769 | 0.005 |
| End | 6927.5 | 2111.5 | Minimum | 0.043 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 145.5 | 44.3 | Maximum | 0.223 | 0.171 | 0.000 | 0.319 | 0.072 | 0.000 | 0.319 | 0.804 | 0.000 | 0.000 | 0.851 | 0.247 | 1.000 | 0.538 |
| Number of Values | 292 | | Standard deviation | 0.036 | 0.052 | 0.000 | 0.033 | 0.004 | 0.000 | 0.058 | 0.227 | 0.000 | 0.000 | 0.183 | 0.053 | 0.380 | 0.038 |

**Table B-49. Summary of MT API 21112 and Cap Rock Minerals and Conditions**

Well Name: MT API 21112
API Identification: 25-069-21112-0000

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Total | Caprock Total |
|---|---|---|---|---|---|
| Start, ft | 6782 | 6796 | 6895 | 6782 | 6744 |
| End, ft | 6796 | 6895 | 6927.5 | 6927.5 | 6781.5 |
| Thickness, ft | 14.0 | 99.0 | 32.5 | 145.5 | 37.5 |
| Start, m | 2067.2 | 2071.4 | 2101.6 | 2067.2 | 2055.6 |
| End, m | 2071.4 | 2101.6 | 2111.5 | 2111.5 | 2067.0 |
| Thickness, m | 4.3 | 30.2 | 9.9 | 44.3 | 11.4 |
| Temperature, °F | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 |
| Temperature, °C | 77.8 | 77.8 | 77.8 | 77.8 | 77.8 |
| Pressure, psi | 4044 | 4044 | 4044 | 4044 | 4044 |
| Pressure, kPa | 27,882 | 27,882 | 27,882 | 27,882 | 27,882 |
| Effective Porosity, fraction | 0.101 | 0.123 | 0.044 | 0.103 | 0.001 |
| Mass Fraction | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.017 | 0.004 | 0.000 |
| Chlorite | 0.002 | 0.000 | 0.000 | 0.000 | 0.001 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Glauconite | 0.108 | 0.017 | 0.004 | 0.023 | 0.000 |
| Illite | 0.015 | 0.004 | 0.457 | 0.106 | 0.088 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.332 | 0.074 | 0.000 |
| Pyrite | 0.040 | 0.000 | 0.071 | 0.020 | 0.185 |
| Quartz | 0.789 | 0.979 | 0.119 | 0.769 | 0.001 |
| Shale | 0.045 | 0.000 | 0.000 | 0.005 | 0.725 |

## Table B-50. Summary of MT API 21112 Aquifer Calculation Results

Well Name: MT API 21112
API Identification: 25-069-21112-0000

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Total |
| Start, m | 2067.2 | 2071.4 | 2101.6 | 2067.2 |
| End, m | 2071.4 | 2101.6 | 2111.5 | 2111.5 |
| Thickness, m | 4.3 | 30.2 | 9.9 | 44.3 |
| Start, ft | 6782.0 | 6796.0 | 6895.0 | 6782.0 |
| End, ft | 6796.0 | 6895.0 | 6927.5 | 6927.5 |
| Thickness, ft | 14.0 | 99.0 | 32.5 | 145.5 |
| **Minerals Without $CO_2$** | | | | |
| pH | 6.482 | 5.658 | 6.456 | 6.480 |
| pE | −2.811 | 10.560 | −2.985 | −3.014 |
| Activity | 0.980 | 0.844 | 0.782 | 0.846 |
| Ionic Strength | 0.613 | 4.400 | 5.578 | 4.417 |
| Total Solution $CO_2$, moles | 8.388E-04 | 2.600E-04 | 2.200E-04 | 2.316E-04 |
| Solution, moles | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0009 | 0.0003 | 0.0002 | 0.0003 |
| Ca | 0.0131 | 0.5320 | 0.7493 | 0.7470 |
| Cl | 0.6278 | 5.9200 | 5.9200 | 5.9200 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0014 | 0.1083 | 0.0002 | 0.0004 |
| Mg | 0.0139 | 0.1875 | 0.0242 | 0.0266 |
| Na | 0.6123 | 4.3740 | 4.3740 | 4.3740 |
| S | 0.0196 | 0.0008 | 0.0008 | 0.0008 |
| Si | 0.0006 | 0.0005 | 0.0004 | 0.0006 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 11.030 | 0.912 |
| Celadonite | 6.200 | 0.742 | 0.564 | 1.266 |
| Clinochlore-7A | 0.103 | 0.000 | 0.000 | 0.010 |
| $CO_2$ MT API 21112 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 1.432 | 0.182 | 75.400 | 6.526 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Total |
|---|---|---|---|---|
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 1.269 | 0.000 | 0.000 | 0.120 |
| Maximum Microcline | 0.252 | 0.000 | 0.000 | 0.024 |
| Muscovite | 0.403 | 0.000 | 52.780 | 4.403 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 8.188 | 0.000 | 37.300 | 3.862 |
| Quartz | 329.100 | 305.700 | 125.200 | 301.600 |
| Rutile | 0.240 | 0.000 | 0.000 | 0.023 |
| Sanidine High | 0.072 | 0.000 | 0.000 | 0.007 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 10.600 | 0.483 |
| Celadonite | 3.665 | 0.744 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21112 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.217 | 0.215 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 24.430 | 1.123 |
| Maximum Microcline | 0.000 | 0.082 | 0.000 | 0.000 |
| Muscovite | 2.990 | 0.112 | 92.340 | 8.860 |
| Phlogopite | 1.135 | 0.000 | 6.439 | 0.950 |
| Pyrite | 8.188 | 0.000 | 37.300 | 3.862 |
| Quartz | 336.900 | 305.800 | 204.500 | 311.400 |
| Rutile | 0.240 | 0.000 | 0.000 | 0.023 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Total |
|---|---|---|---|---|
| Change (initial – final), moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | −0.435 | −0.430 |
| Celadonite | −2.534 | 0.002 | −0.564 | −1.266 |
| Clinochlore-7A | −0.103 | 0.000 | 0.000 | −0.010 |
| $CO_2$ MT API 21112 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.217 | 0.215 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −1.432 | −0.182 | −75.400 | −6.526 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −1.269 | 0.000 | 24.430 | 1.003 |
| Maximum Microcline | −0.252 | 0.082 | 0.000 | −0.024 |
| Muscovite | 2.587 | 0.112 | 39.560 | 4.457 |
| Phlogopite | 1.135 | 0.000 | 6.439 | 0.950 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 7.800 | 0.048 | 79.290 | 9.800 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | −0.072 | 0.000 | 0.000 | −0.007 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | |
| $CaCO_3$ | 1.49E-06 | 6.40E-07 | 7.19E-06 | 7.19E-06 |
| $CaHCO_3^+$ | 2.30E-05 | 5.56E-05 | 8.99E-05 | 9.38E-05 |
| $CO_2$ | 1.98E-04 | 8.84E-05 | 1.27E-05 | 1.59E-05 |
| $CO_3^{2-}$ | 5.15E-07 | 1.18E-08 | 7.02E-08 | 9.41E-08 |
| $FeCO_3$ | 2.13E-10 | 0.00E+00 | 2.78E-11 | 9.89E-11 |
| $FeCO_3^+$ | 1.44E-21 | 0.00E+00 | 9.60E-23 | 3.52E-22 |
| $FeHCO_3^+$ | 2.26E-08 | 0.00E+00 | 2.39E-09 | 8.87E-09 |
| $HCO_3^-$ | 5.25E-04 | 4.70E-05 | 4.25E-05 | 5.65E-05 |
| $MgCO_3$ | 4.27E-07 | 7.81E-08 | 8.84E-08 | 8.84E-08 |
| $MgHCO_3^+$ | 2.28E-05 | 2.34E-05 | 3.82E-06 | 3.99E-06 |
| $NaCO_3^-$ | 2.79E-08 | 2.34E-09 | 1.88E-08 | 1.86E-08 |
| $NaHCO_3$ | 6.76E-05 | 4.49E-05 | 6.37E-05 | 5.40E-05 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Total |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | −4.345E-01 | −4.298E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 6.642E-04 | 0.000E+00 | 4.346E-01 | 4.296E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 6.642E-04 | 0.000E+00 | 1.000E-04 | −2.000E-04 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.977E-04 | 8.840E-05 | 1.270E-05 | 1.594E-05 |
| Solution $CO_2$, moles/kg $H_2O$ | 6.412E-04 | 1.716E-04 | 2.073E-04 | 2.157E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 1.503E-03 | 2.600E-04 | 3.200E-04 | 3.162E-05 |
| Water, g/cm$^3$ | 0.101 | 0.123 | 0.044 | 0.103 |
| Water, kg/m$^3$ | 100.833 | 122.842 | 44.039 | 103.114 |
| Mineral $CO_2$, moles/m$^3$ | 6.697E-02 | 0.000E+00 | 4.404E-03 | −2.062E-02 |
| Dissolved $CO_2$, moles/m$^3$ | 1.993E-02 | 1.086E-02 | 5.593E-04 | 1.644E-03 |
| Solution $CO_2$, moles/m$^3$ | 6.465E-02 | 2.108E-02 | 9.130E-03 | 2.224E-02 |
| Total $CO_2$, moles/m$^3$ | 1.516E-01 | 3.194E-02 | 1.409E-02 | 3.260E-03 |
| Mineral $CO_2$, moles/ft$^3$ | 1.896E-03 | 0.000E+00 | 1.247E-04 | −5.840E-04 |
| Dissolved $CO_2$, moles/ft$^3$ | 5.645E-04 | 3.075E-04 | 1.584E-05 | 4.654E-05 |
| Solution $CO_2$, moles/ft$^3$ | 1.831E-03 | 5.970E-04 | 2.585E-04 | 6.297E-04 |
| Total $CO_2$, moles/ft$^3$ | 4.292E-03 | 9.045E-04 | 3.991E-04 | 9.231E-05 |
| Mineral $CO_2$, kg/m$^3$ | 2.947E-03 | 0.000E+00 | 1.938E-04 | −9.076E-04 |
| Dissolved $CO_2$, kg/m$^3$ | 8.773E-04 | 4.779E-04 | 2.461E-05 | 7.234E-05 |
| Solution $CO_2$, kg/m$^3$ | 2.845E-03 | 9.279E-04 | 4.018E-04 | 9.787E-04 |
| Total $CO_2$, kg/m$^3$ | 6.670E-03 | 1.406E-03 | 6.202E-04 | 1.435E-04 |
| Mineral $CO_2$, lb/ft$^3$ | 1.840E-04 | 0.000E+00 | 1.210E-05 | −5.666E-05 |
| Dissolved $CO_2$, lb/ft$^3$ | 5.477E-05 | 2.983E-05 | 1.537E-06 | 4.516E-06 |
| Solution $CO_2$, lb/ft$^3$ | 1.776E-04 | 5.793E-05 | 2.508E-05 | 6.110E-05 |
| Total $CO_2$, lb/ft$^3$ | 4.164E-04 | 8.776E-05 | 3.872E-05 | 8.956E-06 |
| Weighted Average of Zones | | | | |
| Total Thickness, m | 44.3 | | | |
| Mineral $CO_2$, kg/m$^3$ | 3.269E-04 | | | |
| Dissolved $CO_2$, kg/m$^3$ | 4.151E-04 | | | |
| Solution $CO_2$, kg/m$^3$ | 9.949E-04 | | | |
| Total $CO_2$, kg/m$^3$ | 1.737E-03 | | | |
| Mineral $CO_2$, lb/ft$^3$ | 2.041E-05 | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 2.591E-05 | | | |
| Solution $CO_2$, lb/ft$^3$ | 6.211E-05 | | | |
| Total $CO_2$, lb/ft$^3$ | 1.084E-04 | | | |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Total |
| **Minerals with $CO_2$** | | | | |
| pH | 5.885 | 4.276 | 5.741 | 5.762 |
| pE | −2.052 | 11.943 | −1.889 | −1.917 |
| Activity | 0.941 | 0.829 | 0.783 | 0.818 |
| Ionic Strength | 1.420 | 4.278 | 5.412 | 4.708 |
| Total Solution $CO_2$, moles | 2.02E+00 | 5.79E-01 | 1.80E+00 | 1.85E+00 |
| Solution, moles | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 2.2270 | 0.5841 | 1.5420 | 2.0310 |
| Ca | 0.0000 | 0.0312 | 0.0000 | 0.0000 |
| Cl | 0.6278 | 5.9200 | 5.9200 | 5.9200 |
| Fe | 0.0001 | 0.0000 | 0.0001 | 0.0001 |
| K | 0.0062 | 0.6590 | 0.0015 | 0.0019 |
| Mg | 0.7543 | 0.4309 | 1.4130 | 1.5960 |
| Na | 0.6123 | 4.3740 | 4.3740 | 4.3740 |
| S | 0.1370 | 0.0008 | 0.1024 | 0.1356 |
| Si | 0.0006 | 0.0005 | 0.0004 | 0.0006 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 11.030 | 0.912 |
| Celadonite | 6.200 | 0.742 | 0.564 | 1.266 |
| Clinochlore-7A | 0.103 | 0.000 | 0.000 | 0.010 |
| $CO_2$ MT API 21112 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 1.432 | 0.182 | 75.400 | 6.526 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 1.269 | 0.000 | 0.000 | 0.120 |
| Maximum Microcline | 0.252 | 0.000 | 0.000 | 0.024 |
| Muscovite | 0.403 | 0.000 | 52.780 | 4.403 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 8.188 | 0.000 | 37.300 | 3.862 |
| Quartz | 329.100 | 305.700 | 125.200 | 301.600 |
| Rutile | 0.240 | 0.000 | 0.000 | 0.023 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Total |
|---|---|---|---|---|
| Sanidine High | 0.072 | 0.000 | 0.000 | 0.007 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 4.031 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21112 | 297.700 | 298.400 | 286.300 | 295.900 |
| Dolomite | 0.013 | 0.501 | 11.570 | 1.444 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 20.190 | 0.192 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 2.992 | 0.387 | 96.590 | 9.792 |
| Phlogopite | 0.762 | 0.000 | 2.193 | 0.017 |
| Pyrite | 8.129 | 0.000 | 37.250 | 3.794 |
| Quartz | 336.500 | 308.200 | 213.000 | 313.300 |
| Rutile | 0.240 | 0.000 | 0.000 | 0.023 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.059 | 0.000 | 0.051 | 0.067 |
| Change (initial – final), moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | −11.030 | −0.912 |
| Celadonite | −2.168 | −0.742 | −0.564 | −1.266 |
| Clinochlore-7A | −0.103 | 0.000 | 0.000 | −0.010 |
| $CO_2$ MT API 21112 | −2.311 | −1.586 | −13.690 | −4.074 |
| Dolomite | 0.013 | 0.501 | 11.570 | 1.444 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −1.432 | −0.182 | −75.400 | −6.526 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −1.269 | 0.000 | 20.190 | 0.072 |
| Maximum Microcline | −0.252 | 0.000 | 0.000 | −0.024 |
| Muscovite | 2.589 | 0.387 | 43.800 | 5.388 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Total |
| Phlogopite | 0.762 | 0.000 | 2.193 | 0.017 |
| Pyrite | −0.059 | 0.000 | −0.051 | −0.067 |
| Quartz | 7.448 | 2.444 | 87.780 | 11.670 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | −0.072 | 0.000 | 0.000 | −0.007 |
| Siderite | 0.059 | 0.000 | 0.051 | 0.067 |
| Final Solution, moles | | | | |
| $CaCO_3$ | 3.00E-10 | 3.66E-07 | 2.05E-10 | 2.11E-10 |
| $CaHCO_3^+$ | 1.86E-08 | 7.73E-04 | 1.35E-08 | 1.40E-08 |
| $CO_2$ | 8.50E-01 | 5.43E-01 | 4.57E-01 | 5.09E-01 |
| $CO_3^{2-}$ | 2.05E-04 | 1.21E-07 | 9.27E-05 | 1.10E-04 |
| $FeCO_3$ | 1.85E-07 | 0.00E+00 | 1.85E-07 | 1.85E-07 |
| $FeCO_3^+$ | 7.31E-18 | 0.00E+00 | 8.09E-18 | 8.06E-18 |
| $FeHCO_3^+$ | 7.90E-05 | 0.00E+00 | 8.38E-05 | 8.47E-05 |
| $HCO_3^-$ | 6.44E-01 | 1.17E-02 | 2.92E-01 | 3.40E-01 |
| $MgCO_3$ | 2.12E-03 | 1.74E-06 | 3.10E-03 | 3.02E-03 |
| $MgHCO_3^+$ | 4.54E-01 | 1.27E-02 | 7.05E-01 | 6.93E-01 |
| $NaCO_3^-$ | 7.56E-06 | 2.36E-08 | 1.98E-05 | 1.96E-05 |
| $NaHCO_3$ | 7.13E-02 | 1.08E-02 | 3.42E-01 | 3.04E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | −11.030 | −0.912 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.027 | 1.002 | 23.140 | 2.888 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.059 | 0.000 | 0.051 | 0.067 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.086 | 1.002 | 12.161 | 2.043 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.850 | 0.543 | 0.457 | 0.509 |
| Solution $CO_2$, moles/kg $H_2O$ | 1.172 | 0.036 | 1.343 | 1.341 |
| Total $CO_2$, moles/kg $H_2O$ | 2.107 | 1.580 | 13.961 | 3.892 |
| Water, $g/cm^3$ | 0.101 | 0.123 | 0.044 | 0.103 |
| Water, $kg/m^3$ | 100.833 | 122.842 | 44.039 | 103.114 |
| Mineral $CO_2$, $moles/m^3$ | 8.622 | 123.038 | 535.550 | 210.654 |
| Dissolved $CO_2$, $moles/m^3$ | 85.667 | 66.678 | 20.144 | 52.444 |
| Solution $CO_2$, $moles/m^3$ | 118.174 | 4.413 | 59.154 | 138.248 |
| Total $CO_2$, $moles/m^3$ | 212.463 | 194.130 | 614.848 | 401.346 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Total |
| Mineral $CO_2$, moles/$ft^3$ | 0.244 | 3.484 | 15.165 | 5.965 |
| Dissolved $CO_2$, moles/$ft^3$ | 2.426 | 1.888 | 0.570 | 1.485 |
| Solution $CO_2$, moles/$ft^3$ | 3.346 | 0.125 | 1.675 | 3.915 |
| Total $CO_2$, moles/$ft^3$ | 6.016 | 5.497 | 17.411 | 11.365 |
| Mineral $CO_2$, kg/$m^3$ | 0.379 | 5.415 | 23.570 | 9.271 |
| Dissolved $CO_2$, kg/$m^3$ | 3.770 | 2.935 | 0.887 | 2.308 |
| Solution $CO_2$, kg/$m^3$ | 5.201 | 0.194 | 2.603 | 6.084 |
| Total $CO_2$, kg/$m^3$ | 9.351 | 8.544 | 27.059 | 17.663 |
| Mineral $CO_2$, lb/$ft^3$ | 0.024 | 0.338 | 1.471 | 0.579 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.235 | 0.183 | 0.055 | 0.144 |
| Solution $CO_2$, lb/$ft^3$ | 0.325 | 0.012 | 0.163 | 0.380 |
| Total $CO_2$, lb/$ft^3$ | 0.584 | 0.533 | 1.689 | 1.103 |
| Weighted Average of Zones | | | | |
| Total Thickness, m | 44.3 | | | |
| Mineral $CO_2$, kg/$m^3$ | 8.986 | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.557 | | | |
| Solution $CO_2$, kg/$m^3$ | 1.214 | | | |
| Total $CO_2$, kg/$m^3$ | 12.757 | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.561 | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.160 | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.076 | | | |
| Total $CO_2$, lb/$ft^3$ | 0.796 | | | |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | |
| pH | −0.597 | −1.382 | −0.715 | −0.718 |
| pE | 0.759 | 1.383 | 1.096 | 1.097 |
| Activity | −0.039 | −0.015 | 0.001 | −0.028 |
| Ionic Strength | 0.807 | −0.122 | −0.166 | 0.291 |
| Total Solution $CO_2$, moles | 2.021 | 0.578 | 1.801 | 1.849 |
| Solution, moles | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 2.226 | 0.584 | 1.542 | 2.031 |
| Ca | −0.013 | −0.501 | −0.749 | −0.747 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.005 | 0.551 | 0.001 | 0.002 |
| Mg | 0.740 | 0.243 | 1.389 | 1.569 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.117 | 0.000 | 0.102 | 0.135 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21112 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Total |
|---|---|---|---|---|
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | −10.600 | −0.483 |
| Celadonite | 0.366 | −0.744 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21112 | 297.700 | 298.400 | 286.300 | 295.900 |
| Dolomite | 0.013 | 0.501 | 11.353 | 1.229 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | -4.240 | −0.931 |
| Maximum Microcline | 0.000 | −0.082 | 0.000 | 0.000 |
| Muscovite | 0.002 | 0.275 | 4.250 | 0.932 |
| Phlogopite | −0.373 | 0.000 | −4.246 | −0.933 |
| Pyrite | −0.059 | 0.000 | −0.050 | −0.068 |
| Quartz | −0.400 | 2.400 | 8.500 | 1.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine high | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.059 | 0.000 | 0.051 | 0.067 |
| Change (initial – final), moles | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | −10.596 | −0.483 |
| Celadonite | 0.366 | −0.744 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21112 | 2.311 | 1.586 | 13.690 | 4.074 |
| Dolomite | 0.013 | 0.501 | 11.353 | 1.229 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | −4.240 | −0.931 |
| Maximum Microcline | 0.000 | −0.082 | 0.000 | 0.000 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Total |
|---|---|---|---|---|
| Muscovite | 0.002 | 0.275 | 4.240 | 0.931 |
| Phlogopite | −0.373 | 0.000 | −4.246 | −0.933 |
| Pyrite | −0.059 | 0.000 | −0.051 | −0.067 |
| Quartz | −0.352 | 2.396 | 8.490 | 1.870 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.059 | 0.000 | 0.051 | 0.067 |
| Final Solution, moles | | | | |
| $CaCO_3$ | −1.49E-06 | −2.74E-07 | −7.19E-06 | −7.19E-06 |
| $CaHCO_3^+$ | −2.30E-05 | 7.17E-04 | −8.99E-05 | −9.38E-05 |
| $CO_2$ | 8.49E-01 | 5.43E-01 | 4.57E-01 | 5.09E-01 |
| $CO_3^{2-}$ | 2.04E-04 | 1.09E-07 | 9.26E-05 | 1.10E-04 |
| $FeCO_3$ | 1.85E-07 | 0.00E+00 | 1.85E-07 | 1.85E-07 |
| $FeCO_3^+$ | 7.31E-18 | 0.00E+00 | 8.09E-18 | 8.06E-18 |
| $FeHCO_3^+$ | 7.90E-05 | 0.00E+00 | 8.38E-05 | 8.47E-05 |
| $HCO_3^-$ | 6.44E-01 | 1.16E-02 | 2.92E-01 | 3.40E-01 |
| $MgCO_3$ | 2.12E-03 | 1.66E-06 | 3.10E-03 | 3.01E-03 |
| $MgHCO_3^+$ | 4.54E-01 | 1.26E-02 | 7.05E-01 | 6.93E-01 |
| $NaCO_3^-$ | 7.53E-06 | 2.12E-08 | 1.98E-05 | 1.96E-05 |
| $NaHCO_3$ | 7.12E-02 | 1.08E-02 | 3.42E-01 | 3.04E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | −10.596 | −0.483 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.026 | 1.002 | 22.705 | 2.458 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.059 | 0.000 | 0.051 | 0.067 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.085 | 1.002 | 12.161 | 2.043 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.849 | 0.543 | 0.457 | 0.509 |
| Solution $CO_2$, moles/kg $H_2O$ | 1.171 | 0.036 | 1.343 | 1.341 |
| Total $CO_2$, moles/kg $H_2O$ | 2.106 | 1.580 | 13.961 | 3.892 |
| Water, g/$cm^3$ | 0.101 | 0.123 | 0.044 | 0.103 |
| Water, kg/$m^3$ | 100.833 | 122.842 | 44.039 | 103.114 |
| Mineral $CO_2$, moles/$m^3$ | 8.555 | 123.038 | 535.546 | 210.675 |
| Dissolved $CO_2$, moles/$m^3$ | 85.647 | 66.668 | 20.143 | 52.442 |
| Solution $CO_2$, moles/$m^3$ | 118.109 | 4.392 | 59.145 | 138.226 |
| Total $CO_2$, moles/$m^3$ | 212.312 | 194.098 | 614.834 | 401.343 |

Continued…

**Table B-50. Summary of MT API 21112 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Total |
| Mineral $CO_2$, moles/$ft^3$ | 0.242 | 3.484 | 15.165 | 5.966 |
| Dissolved $CO_2$, moles/$ft^3$ | 2.425 | 1.888 | 0.570 | 1.485 |
| Solution $CO_2$, moles/$ft^3$ | 3.344 | 0.124 | 1.675 | 3.914 |
| Total $CO_2$, moles/$ft^3$ | 6.012 | 5.496 | 17.410 | 11.365 |
| Mineral $CO_2$, kg/$m^3$ | 0.377 | 5.415 | 23.569 | 9.272 |
| Dissolved $CO_2$, kg/$m^3$ | 3.769 | 2.934 | 0.886 | 2.308 |
| Solution $CO_2$, kg/$m^3$ | 5.198 | 0.193 | 2.603 | 6.083 |
| Total $CO_2$, kg/$m^3$ | 9.344 | 8.542 | 27.059 | 17.663 |
| Mineral $CO_2$, lb/$ft^3$ | 0.024 | 0.338 | 1.471 | 0.579 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.235 | 0.183 | 0.055 | 0.144 |
| Solution $CO_2$, lb/$ft^3$ | 0.324 | 0.012 | 0.162 | 0.380 |
| Total $CO_2$, lb/$ft^3$ | 0.583 | 0.533 | 1.689 | 1.103 |
| Weighted Average of Zones | | | | |
| Total Thickness, m | 44.3 | | | |
| Mineral $CO_2$, kg/$m^3$ | 8.985 | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.557 | | | |
| Solution $CO_2$, kg/$m^3$ | 1.213 | | | |
| Total $CO_2$, kg/$m^3$ | 12.755 | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.561 | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.160 | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.076 | | | |
| Total $CO_2$, lb/$ft^3$ | 0.796 | | | |

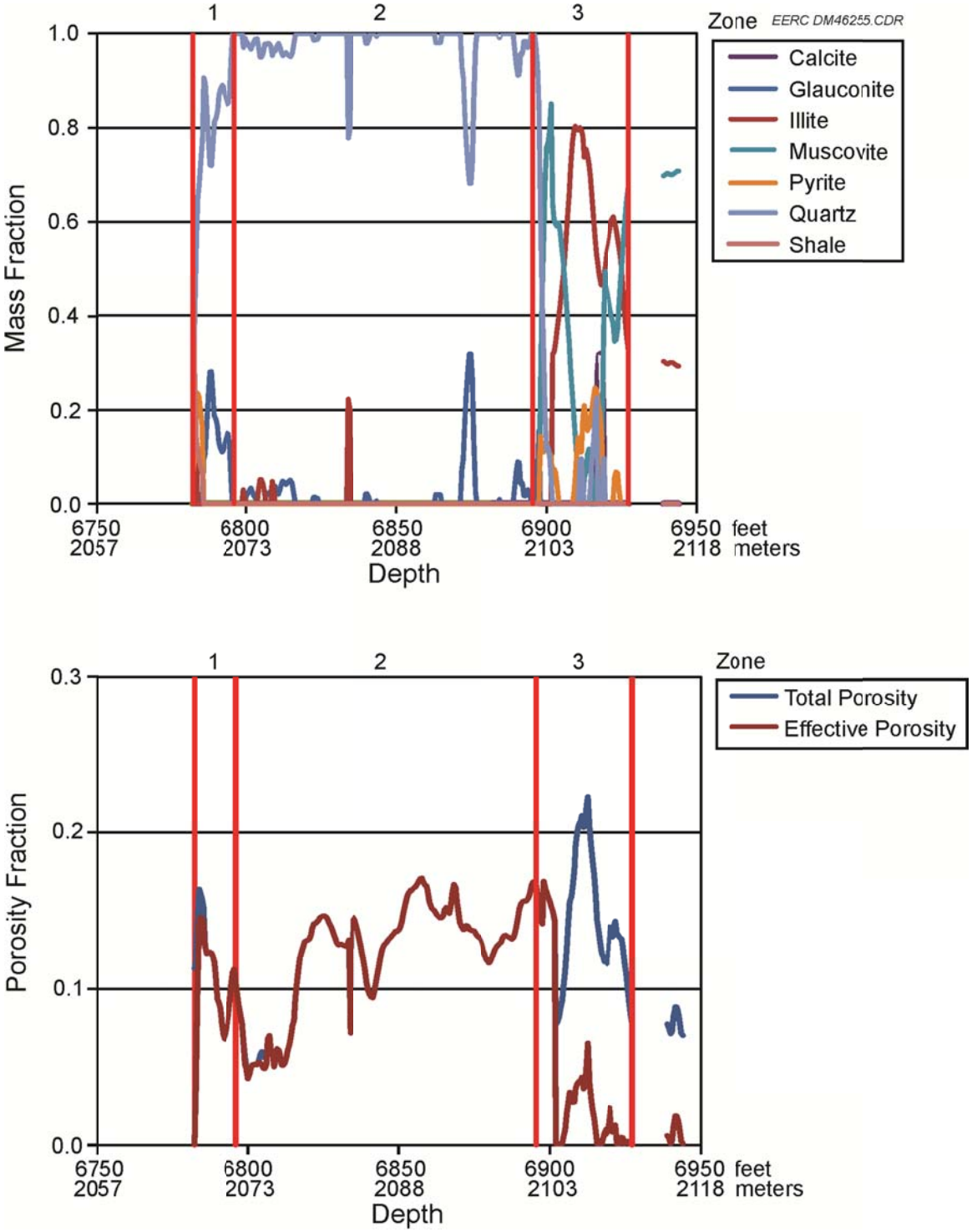



Figure B-14. MT API 21112 mineral composition and porosity as a function of depth.

**MT API 21112 CAP ROCK**

For the MT API 21112 well, 37.5 feet (11.4 meters) of cap rock data was available from the top of the COSS zone upward. The same formation water composition was used in the cap rock calculations.

The cap rock was adjudged to be a single, rather homogeneous, zone comprising mainly shale, with 18% pyrite and 9% illite present. The porosity was very low (0.001).

Small additional amounts of kaolinite dissolve, and less phlogopite forms, with corresponding increases in dolomite, quartz, and muscovite. An amount of pyrite also dissolves with the formation of siderite in approximately equal amounts as the dolomite.

The amount of $CO_2$ dissolved in the formation water is 0.865 moles/kg (38.1 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 0.2 kg/$m^3$ (0.01 lb/$ft^3$) of formation rock. The low amount reacting per unit rock volume is due to the very low porosity of the cap rock.

## Table B-51. Average Mineral and Porosity Values for the MT API 21112 Cap Rock Zones

Well Name: MT API 21112
API Identification: 25-069-21112-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 6744 | 2055.6 | Average | 0.137 | 0.001 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.088 | 0.000 | 0.000 | 0.000 | 0.185 | 0.001 | 0.725 |
| End | 6781.5 | 2067.0 | Minimum | 0.131 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.048 | 0.000 | 0.000 | 0.000 | 0.107 | 0.000 | 0.640 |
| Thickness | 37.5 | 11.4 | Maximum | 0.141 | 0.007 | 0.000 | 0.000 | 0.056 | 0.000 | 0.000 | 0.157 | 0.000 | 0.000 | 0.000 | 0.214 | 0.069 | 0.787 |
| Number of Values | 76 | | Standard deviation | 0.002 | 0.001 | 0.000 | 0.000 | 0.006 | 0.000 | 0.000 | 0.026 | 0.000 | 0.000 | 0.000 | 0.019 | 0.008 | 0.031 |

## Table B-52. Summary of MT API 21112 Cap Rock Calculation Results

Well Name: MT API 21112
API Identification: 25-069-21112-0000

| Formation: | Cap Rock | | |
|---|---|---|---|
| Zone: | Total | | |
| Start, m | 2055.6 | | |
| End, m | 2067.0 | | |
| Thickness, m | 11.4 | | |
| Start, ft | 6744.0 | | |
| End, ft | 6781.5 | | |
| Thickness, ft | 37.5 | | |
| | **Minerals Without $CO_2$** | **Minerals with $CO_2$** | **Difference (minerals with $CO_2$ – minerals without $CO_2$)** |
| pH | 6.213 | 5.878 | −0.335 |
| pE | −2.776 | −2.049 | 0.727 |
| Activity | 0.961 | 0.923 | −0.038 |
| Ionic Strength | 1.312 | 2.024 | 0.712 |
| Total Solution $CO_2$, moles | 4.870E-05 | 2.08E+00 | 2.082 |
| Solution, moles | | | |
| Al | 0.0000 | 0.0000 | 0.000 |
| C | 0.0003 | 10.2200 | 10.220 |
| Ca | 0.5320 | 0.0000 | −0.532 |
| Cl | 5.9200 | 5.9200 | 0.000 |
| Fe | 0.0000 | 0.0004 | 0.000 |
| K | 0.0041 | 0.0084 | 0.004 |
| Mg | 0.2396 | 4.4480 | 4.208 |
| Na | 4.3740 | 4.3740 | 0.000 |
| S | 0.0008 | 0.6603 | 0.659 |
| Si | 0.0025 | 0.0025 | 0.000 |
| Ti | 0.0000 | 0.0000 | 0.000 |
| Initial Minerals, moles | | | |
| Annite | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 3.596 | 3.596 | 0.000 |
| $CO_2$ MT API 21112 | 0.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-52. Summary of MT API 21112 Cap Rock Calculation Results (continued)**

| Formation : Zone: | | Cap Rock Total | |
|---|---|---|---|
| Illite | 1501.000 | 1501.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 |
| Kaolinite | 2374.000 | 2374.000 | 0.000 |
| Maximum Microcline | 470.500 | 470.500 | 0.000 |
| Muscovite | 754.200 | 754.200 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 |
| Pyrite | 4467.000 | 4467.000 | 0.000 |
| Quartz | 10990.000 | 10990.000 | 0.000 |
| Rutile | 449.000 | 449.000 | 0.000 |
| Sanidine High | 134.300 | 134.300 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | |
| Annite | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21112 | 0.000 | 288.400 | 288.400 |
| Dolomite | 0.000 | 0.532 | 0.532 |
| Goethite | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 |
| Kaolinite | 2279.000 | 2277.000 | −2.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 |
| Muscovite | 2129.000 | 2130.000 | 1.000 |
| Phlogopite | 131.000 | 129.500 | −1.500 |
| Pyrite | 4467.000 | 4466.000 | −1.000 |
| Quartz | 13,740.000 | 13,740.000 | 0.000 |
| Rutile | 449.000 | 449.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.329 | 0.329 |

Continued…

**Table B-52. Summary of MT API 21112 Cap Rock Calculation Results (continued)**

| Formation: | | Cap Rock | |
|---|---|---|---|
| Zone: | | Total | |
| Change (initial – final), moles | | | |
| Annite | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | −3.596 | −3.596 | 0.000 |
| $CO_2$ MT API 21112 | 0.000 | −11.610 | 11.610 |
| Dolomite | 0.000 | 0.532 | 0.532 |
| Goethite | 0.000 | 0.000 | 0.000 |
| Illite | −1501.000 | −1501.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 |
| Kaolinite | −95.250 | −96.820 | −1.570 |
| Maximum Microcline | −470.500 | −470.500 | 0.000 |
| Muscovite | 1375.000 | 1376.000 | 1.000 |
| Phlogopite | 131.000 | 129.500 | −1.500 |
| Pyrite | 0.000 | −0.330 | −0.330 |
| Quartz | 2752.000 | 2755.000 | 3.000 |
| Rutile | 0.000 | 0.000 | 0.000 |
| Sanidine High | −134.300 | −134.300 | 0.000 |
| Siderite | 0.000 | 0.329 | 0.329 |
| Final Solution, moles | | | |
| $CaCO_3$ | 2.52E-07 | 2.28E-10 | −2.52E-07 |
| $CaHCO_3^+$ | 7.37E-06 | 1.41E-08 | −7.35E-06 |
| $CO_2$ | 1.26E-05 | 7.70E-01 | 7.70E-01 |
| $CO_3^{2-}$ | 1.35E-08 | 2.09E-04 | 2.09E-04 |
| $FeCO_3$ | 3.20E-11 | 1.85E-07 | 1.85E-07 |
| $FeCO_3^+$ | 2.39E-22 | 7.19E-18 | 7.19E-18 |
| $FeHCO_3^+$ | 6.44E-09 | 7.86E-05 | 7.86E-05 |
| $HCO_3^-$ | 2.04E-05 | 6.07E-01 | 6.07E-01 |
| $MgCO_3$ | 3.95E-08 | 2.78E-03 | 2.78E-03 |
| $MgHCO_3^+$ | 3.99E-06 | 5.94E-01 | 5.94E-01 |
| $NaCO_3^-$ | 9.00E-10 | 1.11E-05 | 1.11E-05 |
| $NaHCO_3$ | 3.99E-06 | 1.09E-01 | 1.09E-01 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000 | 0.000 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.000E+00 | 1.064 | 1.064 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.329 | 0.329 |

Continued…

**Table B-52. Summary of MT API 21112 Cap Rock Calculation Results (continued)**

| Formation: | | Cap Rock | |
|---|---|---|---|
| Zone: | | Total | |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.000E+00 | 1.393 | 1.393 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.262E-05 | 0.770 | 0.770 |
| Solution $CO_2$, moles/kg $H_2O$ | 3.609E-05 | 1.312 | 1.312 |
| Total $CO_2$, moles/kg $H_2O$ | 4.871E-05 | 3.475 | 3.475 |
| Water, g/cm$^3$ | 0.001 | 0.001 | 0.001 |
| Water, kg/m$^3$ | 1.077 | 1.077 | 1.077 |
| Mineral $CO_2$, moles/m$^3$ | 0.000E+00 | 1.500 | 1.500 |
| Dissolved $CO_2$, moles/m$^3$ | 1.359E-05 | 0.829 | 0.829 |
| Solution $CO_2$, moles/m$^3$ | 3.886E-05 | 1.413 | 1.413 |
| Total $CO_2$, moles/m$^3$ | 5.245E-05 | 3.742 | 3.742 |
| Mineral $CO_2$, moles/ft$^3$ | 0.000E+00 | 0.042 | 0.042 |
| Dissolved $CO_2$, moles/ft$^3$ | 3.848E-07 | 0.023 | 0.023 |
| Solution $CO_2$, moles/ft$^3$ | 1.100E-06 | 0.040 | 0.040 |
| Total $CO_2$, moles/ft$^3$ | 1.485E-06 | 0.106 | 0.106 |
| Mineral $CO_2$, kg/m$^3$ | 0.000E+00 | 0.066 | 0.066 |
| Dissolved $CO_2$, kg/m$^3$ | 5.981E-07 | 0.036 | 0.036 |
| Solution $CO_2$, kg/m$^3$ | 1.710E-06 | 0.062 | 0.062 |
| Total $CO_2$, kg/m$^3$ | 2.308E-06 | 0.165 | 0.165 |
| Mineral $CO_2$, lb/ft$^3$ | 0.000E+00 | 0.004 | 0.004 |
| Dissolved $CO_2$, lb/ft$^3$ | 3.734E-08 | 0.002 | 0.002 |
| Solution $CO_2$, lb/ft$^3$ | 1.068E-07 | 0.004 | 0.004 |
| Total $CO_2$, lb/ft$^3$ | 1.441E-07 | 0.010 | 0.010 |
| Weighted Average of Zones | | | |
| Total Thickness, m | 11.4 | 11.4 | 11.4 |
| Mineral $CO_2$, kg/m$^3$ | 0.000E+00 | 0.066 | 0.066 |
| Dissolved $CO_2$, kg/m$^3$ | 5.981E-07 | 0.036 | 0.036 |
| Solution $CO_2$, kg/m$^3$ | 1.710E-06 | 0.062 | 0.062 |
| Total $CO_2$, kg/m$^3$ | 2.308E-06 | 0.165 | 0.165 |
| Mineral $CO_2$, lb/ft$^3$ | 0.000E+00 | 0.004 | 0.004 |
| Dissolved $CO_2$, lb/ft$^3$ | 3.734E-08 | 0.002 | 0.002 |
| Solution $CO_2$, lb/ft$^3$ | 1.068E-07 | 0.004 | 0.004 |
| Total $CO_2$, lb/ft$^3$ | 1.441E-07 | 0.010 | 0.010 |

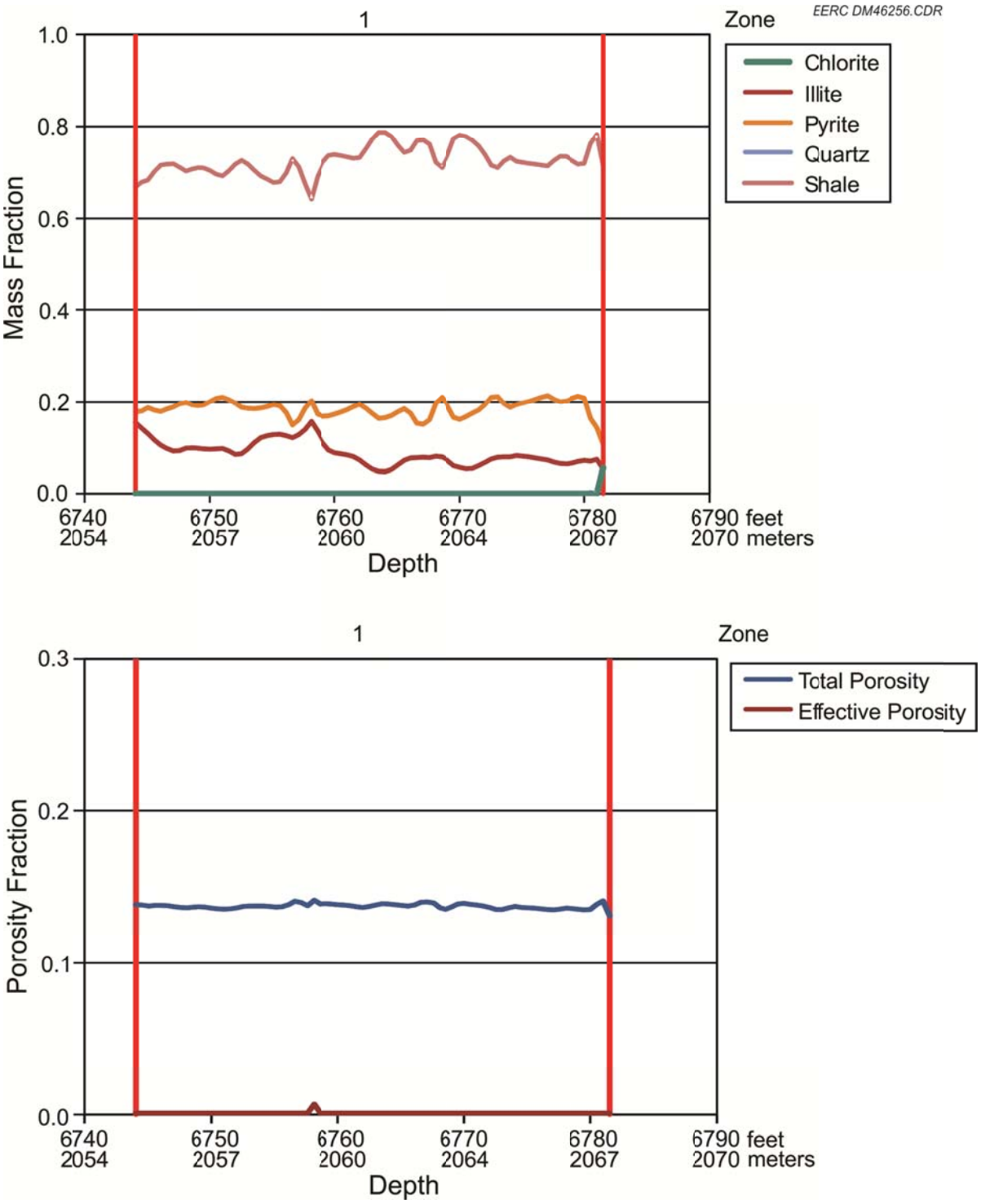



Figure B-15. MT API 21112 mineral composition and porosity as a function of depth.

**ND 9800**

The water composition used for ND 9800 is from the ND 1636 well 17 miles (27 km) to the southeast. Mineral data were available for 35% of the COSS represented in this well. The total COSS thickness is 413 feet (126 meters), as the well penetrated into the Precambrian.

Zones 1 and 7 contain primarily quartz and illite in a 2:1 ratio. The other zones contain roughly equal amounts of calcite and pyrite, with a moderate amount of illite. All of the zones contain pyrite, between 3% and 8%. The porosity is relatively constant, being between 0.014 and 0.024.

Lower amounts of kaolinite and phlogopite form, with corresponding increases in quartz and muscovite. The dissolution of calcite and the concurrent formation of dolomite comprise the greatest contribution to the $CO_2$ interaction with the minerals. Here, no pyrite dissolves and no siderite forms.

The amount of $CO_2$ dissolved in the formation water is approximately 1.1 moles/kg (48.4 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 15.6 $kg/m^3$ (1.0 $lb/ft^3$) of formation rock.

## Table B-53. Average Mineral and Porosity for the ND 9800 Aquifer Zones

Well Name: ND 9800
API Identification: 33-105-01044-0000
State Identification: ND 9800

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankertite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 14,214 | 4332.4 | Average | 0.042 | 0.022 | 0.000 | 0.043 | 0.000 | 0.000 | 0.000 | 0.251 | 0.000 | 0.000 | 0.000 | 0.037 | 0.669 | 0.000 |
| End | 14,218 | 4333.7 | Minimum | 0.037 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.138 | 0.000 | 0.000 | 0.000 | 0.000 | 0.167 | 0.000 |
| Thickness | 4.0 | 1.2 | Maximum | 0.047 | 0.031 | 0.000 | 0.468 | 0.000 | 0.000 | 0.000 | 0.335 | 0.000 | 0.000 | 0.000 | 0.096 | 0.862 | 0.000 |
| Number of Values | 11 | | Standard deviation | 0.003 | 0.005 | 0.000 | 0.141 | 0.000 | 0.000 | 0.000 | 0.069 | 0.000 | 0.000 | 0.000 | 0.040 | 0.195 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 14,218 | 4333.7 | Average | 0.031 | 0.015 | 0.000 | 0.478 | 0.000 | 0.000 | 0.000 | 0.188 | 0.000 | 0.000 | 0.000 | 0.085 | 0.250 | 0.000 |
| End | 14,228 | 4336.7 | Minimum | 0.020 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.070 | 0.000 | 0.000 | 0.000 | 0.025 | 0.000 | 0.000 |
| Thickness | 10.0 | 3.0 | Maximum | 0.041 | 0.016 | 0.000 | 0.707 | 0.000 | 0.000 | 0.000 | 0.311 | 0.000 | 0.000 | 0.000 | 0.165 | 0.742 | 0.000 |
| Number of Values | 20 | | Standard deviation | 0.008 | 0.001 | 0.000 | 0.204 | 0.000 | 0.000 | 0.000 | 0.091 | 0.000 | 0.000 | 0.000 | 0.050 | 0.229 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 14,228 | 4336.7 | Average | 0.028 | 0.014 | 0.000 | 0.352 | 0.000 | 0.000 | 0.000 | 0.166 | 0.000 | 0.000 | 0.000 | 0.080 | 0.402 | 0.000 |
| End | 14,251 | 4343.7 | Minimum | 0.020 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.092 | 0.000 | 0.000 | 0.000 | 0.036 | 0.000 | 0.000 |
| Thickness | 23.0 | 7.0 | Maximum | 0.038 | 0.017 | 0.000 | 0.734 | 0.000 | 0.000 | 0.000 | 0.268 | 0.000 | 0.000 | 0.000 | 0.140 | 0.757 | 0.000 |
| Number of Values | 45 | | Standard deviation | 0.006 | 0.002 | 0.000 | 0.182 | 0.000 | 0.000 | 0.000 | 0.052 | 0.000 | 0.000 | 0.000 | 0.024 | 0.173 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 14,251 | 4343.7 | Average | 0.027 | 0.015 | 0.000 | 0.250 | 0.000 | 0.000 | 0.000 | 0.150 | 0.000 | 0.000 | 0.000 | 0.068 | 0.532 | 0.000 |
| End | 14,310 | 4361.7 | Minimum | 0.017 | 0.009 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.085 | 0.000 | 0.000 | 0.000 | 0.033 | 0.000 | 0.000 |
| Thickness | 59.0 | 18.0 | Maximum | 0.051 | 0.024 | 0.000 | 0.767 | 0.000 | 0.000 | 0.000 | 0.338 | 0.000 | 0.000 | 0.000 | 0.098 | 0.829 | 0.000 |
| Number of Values | 119 | | Standard deviation | 0.006 | 0.003 | 0.000 | 0.189 | 0.000 | 0.000 | 0.000 | 0.047 | 0.000 | 0.000 | 0.000 | 0.015 | 0.188 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 14,310 | 4361.7 | Average | 0.042 | 0.022 | 0.000 | 0.052 | 0.000 | 0.000 | 0.000 | 0.241 | 0.000 | 0.000 | 0.000 | 0.066 | 0.641 | 0.000 |
| End | 14,330 | 4367.8 | Minimum | 0.031 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.150 | 0.000 | 0.000 | 0.000 | 0.035 | 0.190 | 0.000 |
| Thickness | 20.0 | 6.1 | Maximum | 0.052 | 0.026 | 0.000 | 0.498 | 0.000 | 0.000 | 0.000 | 0.339 | 0.000 | 0.000 | 0.000 | 0.089 | 0.783 | 0.000 |
| Number of Values | 40 | | Standard deviation | 0.007 | 0.003 | 0.000 | 0.123 | 0.000 | 0.000 | 0.000 | 0.056 | 0.000 | 0.000 | 0.000 | 0.012 | 0.149 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 14,330 | 4367.8 | Average | 0.047 | 0.024 | 0.000 | 0.324 | 0.000 | 0.000 | 0.000 | 0.286 | 0.000 | 0.000 | 0.000 | 0.033 | 0.357 | 0.000 |
| End | 14,338 | 4370.2 | Minimum | 0.038 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.211 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 8.0 | 2.4 | Maximum | 0.052 | 0.029 | 0.000 | 0.668 | 0.000 | 0.000 | 0.000 | 0.318 | 0.000 | 0.000 | 0.000 | 0.080 | 0.712 | 0.000 |
| Number of Values | 16 | | Standard deviation | 0.004 | 0.003 | 0.000 | 0.205 | 0.000 | 0.000 | 0.000 | 0.029 | 0.000 | 0.000 | 0.000 | 0.026 | 0.219 | 0.000 |

Continued…

**Table B-53. Average Mineral and Porosity for the ND 9800 Aquifer Zones (continued)**

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankertite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 14,338 | 4370.2 | Average | 0.039 | 0.023 | 0.000 | 0.091 | 0.000 | 0.000 | 0.000 | 0.200 | 0.000 | 0.000 | 0.000 | 0.051 | 0.658 | 0.000 |
| End | 14,359 | 4376.6 | Minimum | 0.016 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.048 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 21.0 | 6.4 | Maximum | 0.063 | 0.035 | 0.000 | 0.630 | 0.000 | 0.000 | 0.000 | 0.372 | 0.000 | 0.000 | 0.000 | 0.089 | 0.872 | 0.000 |
| Number of Values | 41 | | Standard deviation | 0.016 | 0.008 | 0.000 | 0.193 | 0.000 | 0.000 | 0.000 | 0.120 | 0.000 | 0.000 | 0.000 | 0.030 | 0.242 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 14,214 | 4332.4 | Average | 0.033 | 0.017 | 0.000 | 0.228 | 0.000 | 0.000 | 0.000 | 0.186 | 0.000 | 0.000 | 0.000 | 0.065 | 0.521 | 0.000 |
| End | 14,359 | 4376.6 | Minimum | 0.016 | 0.009 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.048 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 145.0 | 44.2 | Maximum | 0.063 | 0.035 | 0.000 | 0.767 | 0.000 | 0.000 | 0.000 | 0.372 | 0.000 | 0.000 | 0.000 | 0.165 | 0.872 | 0.000 |
| Number of Values | 292 | | Standard deviation | 0.011 | 0.005 | 0.000 | 0.219 | 0.000 | 0.000 | 0.000 | 0.079 | 0.000 | 0.000 | 0.000 | 0.027 | 0.227 | 0.000 |

**Table B-54. Summary of ND 9800 Aquifer Minerals and Conditions**

Well Name: ND 9800
API Identification: 33-105-01044-0000
State Identification: ND 9800

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Start, ft | 14,214 | 14,218 | 14,228 | 14,251 | 14,310 | 14,330 | 14,338 | 14,214 |
| End, ft | 14,218 | 14,228 | 14,251 | 14,310 | 14,330 | 14,338 | 14,359 | 14,359 |
| Thickness, ft | 4.0 | 10.0 | 23.0 | 59.0 | 20.0 | 8.0 | 21.0 | 145.0 |
| Start, m | 4332.4 | 4333.7 | 4336.7 | 4343.7 | 4361.7 | 4367.8 | 4370.2 | 4332.4 |
| End, m | 4333.7 | 4336.7 | 4343.7 | 4361.7 | 4367.8 | 4370.2 | 4376.6 | 4376.6 |
| Thickness, m | 1.2 | 3.0 | 7.0 | 18.0 | 6.1 | 2.4 | 6.4 | 44.2 |
| Temperature, °F | 318.0 | 318.0 | 318.0 | 318.0 | 318.0 | 318.0 | 318.0 | 318.0 |
| Temperature, °C | 158.9 | 158.9 | 158.9 | 158.9 | 158.9 | 158.9 | 158.9 | 158.9 |
| Pressure, psi | 8600 | 8601 | 8604 | 8611 | 8618 | 8621 | 8623 | 8612 |
| Pressure, kPa | 59,294 | 59,303 | 59,323 | 59,373 | 59,421 | 59,438 | 59,456 | 59,380 |
| Effective Porosity, fraction | 0.022 | 0.015 | 0.014 | 0.015 | 0.022 | 0.024 | 0.023 | 0.017 |
| Mass Fraction | | | | | | | | |
| Ankerite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.043 | 0.478 | 0.352 | 0.250 | 0.052 | 0.324 | 0.091 | 0.228 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Glauconite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.251 | 0.188 | 0.166 | 0.150 | 0.241 | 0.286 | 0.200 | 0.186 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.037 | 0.085 | 0.080 | 0.068 | 0.066 | 0.033 | 0.051 | 0.065 |
| Quartz | 0.669 | 0.250 | 0.402 | 0.532 | 0.641 | 0.357 | 0.658 | 0.521 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-55. Summary of ND 9800 Aquifer Calculation Results

Well Name: ND 9800
API Identification: 33-105-01044-0000
State Identification: ND 9800

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Start, m | 4332.4 | 4333.7 | 4336.7 | 4343.7 | 4361.7 | 4367.8 | 4370.2 | 4332.4 |
| End, m | 4333.7 | 4336.7 | 4343.7 | 4361.7 | 4367.8 | 4370.2 | 4376.6 | 4376.6 |
| Thickness, m | 1.2 | 3.0 | 7.0 | 18.0 | 6.1 | 2.4 | 6.4 | 44.2 |
| Start, ft | 14,214.0 | 14,218.0 | 14,228.0 | 14,251.0 | 14,310.0 | 14,330.0 | 14,338.0 | 14,214.0 |
| End, ft | 14,218.0 | 14,228.0 | 14,251.0 | 14,310.0 | 14,330.0 | 14,338.0 | 14,359.0 | 14,359.0 |
| Thickness, ft | 4.0 | 10.0 | 23.0 | 59.0 | 20.0 | 8.0 | 21.0 | 145.0 |
| **Minerals Without $CO_2$** | | | | | | | | |
| pH | 5.537 | 5.542 | 5.539 | 5.535 | 5.537 | 5.538 | 5.534 | 5.536 |
| pE | −2.351 | −2.351 | −2.351 | −2.352 | −2.351 | −2.351 | −2.353 | −2.351 |
| Activity | 0.752 | 0.728 | 0.741 | 0.762 | 0.754 | 0.748 | 0.779 | 0.758 |
| Ionic Strength | 4.944 | 5.195 | 5.067 | 4.830 | 4.917 | 4.985 | 4.631 | 4.874 |
| Total Solution $CO_2$, moles | 1.331E-03 | 1.271E-03 | 1.302E-03 | 1.358E-03 | 1.337E-03 | 1.321E-03 | 1.404E-03 | 1.347E-03 |
| Solution, moles | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0008 | 0.0007 | 0.0008 | 0.0009 | 0.0008 | 0.0008 | 0.0010 | 0.0009 |
| Ca | 0.5668 | 0.5675 | 0.5671 | 0.5666 | 0.5668 | 0.5669 | 0.5661 | 0.5667 |
| Cl | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0007 | 0.0006 | 0.0006 | 0.0007 | 0.0007 | 0.0007 | 0.0008 | 0.0007 |
| Mg | 0.0144 | 0.0138 | 0.0141 | 0.0147 | 0.0145 | 0.0143 | 0.0151 | 0.0146 |
| Na | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 |
| S | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 |
| Si | 0.0014 | 0.0012 | 0.0013 | 0.0014 | 0.0014 | 0.0013 | 0.0016 | 0.0014 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 52.800 | 923.200 | 714.500 | 479.300 | 66.490 | 363.700 | 109.100 | 364.600 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 9800 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Illite | 81.360 | 94.460 | 87.990 | 74.870 | 79.880 | 83.610 | 62.680 | 77.410 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 38.270 | 136.300 | 134.700 | 109.400 | 69.470 | 30.710 | 51.350 | 87.070 |
| Quartz | 1384.000 | 803.200 | 1359.000 | 1698.000 | 1357.000 | 668.300 | 1317.000 | 1387.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 52.590 | 922.900 | 714.300 | 479.100 | 66.280 | 363.500 | 108.900 | 364.400 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 9800 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.103 | 0.105 | 0.104 | 0.104 | 0.104 | 0.104 | 0.103 | 0.104 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 27.120 | 31.490 | 29.330 | 24.960 | 26.630 | 27.870 | 20.890 | 25.800 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 42.030 | 48.800 | 45.460 | 38.680 | 41.270 | 43.200 | 32.380 | 39.990 |
| Phlogopite | 6.780 | 7.872 | 7.333 | 6.239 | 6.657 | 6.967 | 5.223 | 6.451 |
| Pyrite | 38.270 | 136.300 | 134.700 | 109.400 | 69.470 | 30.710 | 51.350 | 87.070 |
| Quartz | 1468.000 | 900.800 | 1450.000 | 1776.000 | 1439.000 | 754.700 | 1382.000 | 1467.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.207 | −0.209 | −0.208 | −0.207 | −0.207 | −0.208 | −0.206 | −0.207 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| $CO_2$ ND 9800 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.103 | 0.105 | 0.104 | 0.104 | 0.104 | 0.104 | 0.103 | 0.104 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −81.360 | −94.460 | −87.990 | −74.870 | −79.880 | −83.610 | −62.680 | −77.410 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 27.120 | 31.490 | 29.330 | 24.960 | 26.630 | 27.870 | 20.890 | 25.800 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 42.030 | 48.800 | 45.460 | 38.680 | 41.270 | 43.200 | 32.380 | 39.990 |
| Phlogopite | 6.780 | 7.872 | 7.333 | 6.239 | 6.657 | 6.967 | 5.223 | 6.451 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 84.070 | 97.610 | 90.920 | 77.360 | 82.540 | 86.390 | 64.760 | 79.990 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 |
| $CaHCO_3^+$ | 3.42E-04 | 3.31E-04 | 3.37E-04 | 3.47E-04 | 3.44E-04 | 3.41E-04 | 3.55E-04 | 3.45E-04 |
| $CO_2$ | 8.37E-04 | 7.95E-04 | 8.16E-04 | 8.56E-04 | 8.41E-04 | 8.30E-04 | 8.90E-04 | 8.49E-04 |
| $CO_3^{2-}$ | 2.25E-08 | 2.16E-08 | 2.20E-08 | 2.29E-08 | 2.26E-08 | 2.23E-08 | 2.37E-08 | 2.28E-08 |
| $FeCO_3$ | 5.65E-13 | 4.41E-13 | 5.00E-13 | 6.35E-13 | 5.81E-13 | 5.42E-13 | 7.79E-13 | 6.07E-13 |
| $FeCO_3^+$ | 1.17E-23 | 8.89E-24 | 1.02E-23 | 1.32E-23 | 1.20E-23 | 1.12E-23 | 1.65E-23 | 1.26E-23 |
| $FeHCO_3^+$ | 4.78E-10 | 3.60E-10 | 4.16E-10 | 5.44E-10 | 4.93E-10 | 4.56E-10 | 6.83E-10 | 5.18E-10 |
| $HCO_3^-$ | 1.08E-04 | 1.01E-04 | 1.05E-04 | 1.11E-04 | 1.09E-04 | 1.07E-04 | 1.17E-04 | 1.10E-04 |
| $MgCO_3$ | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 |
| $MgHCO_3^+$ | 1.01E-05 | 9.80E-06 | 9.98E-06 | 1.03E-05 | 1.02E-05 | 1.01E-05 | 1.05E-05 | 1.02E-05 |
| $NaCO_3^-$ | 1.82E-10 | 1.87E-10 | 1.84E-10 | 1.80E-10 | 1.82E-10 | 1.83E-10 | 1.77E-10 | 1.81E-10 |
| $NaHCO_3$ | 2.95E-05 | 3.06E-05 | 3.00E-05 | 2.90E-05 | 2.94E-05 | 2.97E-05 | 2.81E-05 | 2.92E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −2.065E-01 | −2.088E-01 | −2.081E-01 | −2.068E-01 | −2.073E-01 | −2.076E-01 | −2.057E-01 | −2.070E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 2.062E-01 | 2.096E-01 | 2.088E-01 | 2.074E-01 | 2.080E-01 | 2.084E-01 | 2.062E-01 | 2.076E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | -3.000E-04 | 8.000E-04 | 7.000E-04 | 6.000E-04 | 7.000E-04 | 8.000E-04 | 5.000E-04 | 6.000E-04 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 8.369E-04 | 7.947E-04 | 8.161E-04 | 8.562E-04 | 8.413E-04 | 8.300E-04 | 8.899E-04 | 8.487E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 4.940E-04 | 4.768E-04 | 4.857E-04 | 5.014E-04 | 4.957E-04 | 4.912E-04 | 5.139E-04 | 4.986E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 1.031E-03 | 2.071E-03 | 2.002E-03 | 1.958E-03 | 2.037E-03 | 2.121E-03 | 1.904E-03 | 1.947E-03 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Water, g/cm$^3$ | 0.022 | 0.015 | 0.014 | 0.015 | 0.022 | 0.024 | 0.023 | 0.017 |
| Water, kg/m$^3$ | 21.610 | 14.731 | 13.901 | 14.511 | 21.637 | 24.020 | 22.564 | 17.327 |
| Mineral $CO_2$, moles/m$^3$ | −6.483E-03 | 1.178E-02 | 9.731E-03 | 8.706E-03 | 1.515E-02 | 1.922E-02 | 1.128E-02 | 1.040E-02 |
| Dissolved $CO_2$, moles/m$^3$ | 1.809E-02 | 1.171E-02 | 1.134E-02 | 1.242E-02 | 1.820E-02 | 1.994E-02 | 2.008E-02 | 1.471E-02 |
| Solution $CO_2$, moles/m$^3$ | 1.068E-02 | 7.023E-03 | 6.751E-03 | 7.276E-03 | 1.073E-02 | 1.180E-02 | 1.159E-02 | 8.639E-03 |
| Total $CO_2$, moles/m$^3$ | 2.228E-02 | 3.051E-02 | 2.783E-02 | 2.841E-02 | 4.408E-02 | 5.095E-02 | 4.296E-02 | 3.374E-02 |
| Mineral $CO_2$, moles/ft$^3$ | −1.836E-04 | 3.337E-04 | 2.755E-04 | 2.465E-04 | 4.289E-04 | 5.441E-04 | 3.195E-04 | 2.944E-04 |
| Dissolved $CO_2$, moles/ft$^3$ | 5.121E-04 | 3.315E-04 | 3.212E-04 | 3.518E-04 | 5.155E-04 | 5.645E-04 | 5.686E-04 | 4.164E-04 |
| Solution $CO_2$, moles/ft$^3$ | 3.023E-04 | 1.989E-04 | 1.912E-04 | 2.060E-04 | 3.037E-04 | 3.341E-04 | 3.283E-04 | 2.446E-04 |
| Total $CO_2$, moles/ft$^3$ | 6.308E-04 | 8.641E-04 | 7.880E-04 | 8.044E-04 | 1.248E-03 | 1.443E-03 | 1.216E-03 | 9.554E-04 |
| Mineral $CO_2$, kg/m$^3$ | −2.853E-04 | 5.186E-04 | 4.282E-04 | 3.832E-04 | 6.666E-04 | 8.457E-04 | 4.965E-04 | 4.575E-04 |
| Dissolved $CO_2$, kg/m$^3$ | 7.959E-04 | 5.152E-04 | 4.993E-04 | 5.468E-04 | 8.011E-04 | 8.774E-04 | 8.837E-04 | 6.472E-04 |
| Solution $CO_2$, kg/m$^3$ | 4.698E-04 | 3.091E-04 | 2.971E-04 | 3.202E-04 | 4.720E-04 | 5.193E-04 | 5.103E-04 | 3.802E-04 |
| Total $CO_2$, kg/m$^3$ | 9.804E-04 | 1.343E-03 | 1.225E-03 | 1.250E-03 | 1.940E-03 | 2.242E-03 | 1.891E-03 | 1.485E-03 |
| Mineral $CO_2$, lb/ft$^3$ | −1.781E-05 | 3.238E-05 | 2.673E-05 | 2.392E-05 | 4.161E-05 | 5.279E-05 | 3.100E-05 | 2.856E-05 |
| Dissolved $CO_2$, lb/ft$^3$ | 4.969E-05 | 3.216E-05 | 3.117E-05 | 3.413E-05 | 5.001E-05 | 5.477E-05 | 5.517E-05 | 4.040E-05 |
| Solution $CO_2$, lb/ft$^3$ | 2.933E-05 | 1.929E-05 | 1.855E-05 | 1.999E-05 | 2.947E-05 | 3.242E-05 | 3.186E-05 | 2.374E-05 |
| Total $CO_2$, lb/ft$^3$ | 6.121E-05 | 8.383E-05 | 7.645E-05 | 7.804E-05 | 1.211E-04 | 1.400E-04 | 1.180E-04 | 9.270E-05 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 44.2 | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 4.622E-04 | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 6.461E-04 | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 3.794E-04 | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 1.488E-03 | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 2.886E-05 | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 4.033E-05 | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 2.368E-05 | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 9.287E-05 | | | | | | | |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| **Minerals with $CO_2$** | | | | | | | | |
| pH | 4.018 | 4.016 | 4.017 | 4.018 | 4.017 | 4.016 | 4.018 | 4.017 |
| pE | −0.517 | −0.515 | −0.516 | −0.517 | −0.516 | −0.516 | −0.518 | −0.517 |
| Activity | 0.793 | 0.789 | 0.791 | 0.795 | 0.794 | 0.792 | 0.799 | 0.794 |
| Ionic Strength | 4.194 | 4.255 | 4.225 | 4.164 | 4.187 | 4.204 | 4.109 | 4.175 |
| Total Solution $CO_2$, moles | 1.12E+00 | 1.11E+00 | 1.12E+00 | 1.13E+00 | 1.13E+00 | 1.12E+00 | 1.14E+00 | 1.13E+00 |
| Solution, moles | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.9553 | 0.9221 | 0.9392 | 0.9744 | 0.9630 | 0.9540 | 1.0090 | 0.9681 |
| Ca | 0.5564 | 0.5568 | 0.5566 | 0.5562 | 0.5563 | 0.5564 | 0.5558 | 0.5562 |
| Cl | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 | 6.6230 |
| Fe | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |
| K | 0.0338 | 0.0327 | 0.0333 | 0.0343 | 0.0340 | 0.0337 | 0.0353 | 0.0341 |
| Mg | 0.0159 | 0.0158 | 0.0158 | 0.0159 | 0.0159 | 0.0159 | 0.0160 | 0.0159 |
| Na | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 | 5.4630 |
| S | 0.0017 | 0.0017 | 0.0017 | 0.0017 | 0.0017 | 0.0017 | 0.0017 | 0.0017 |
| Si | 0.0019 | 0.0018 | 0.0018 | 0.0019 | 0.0019 | 0.0019 | 0.0019 | 0.0019 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 52.800 | 923.200 | 714.500 | 479.300 | 66.490 | 363.700 | 109.100 | 364.600 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 9800 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 81.360 | 94.460 | 87.990 | 74.870 | 79.880 | 83.610 | 62.680 | 77.410 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 38.270 | 136.300 | 134.700 | 109.400 | 69.470 | 30.710 | 51.350 | 87.070 |
| Quartz | 1384.000 | 803.200 | 1359.000 | 1698.000 | 1357.000 | 668.300 | 1317.000 | 1387.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 32.270 | 899.300 | 692.300 | 460.400 | 46.330 | 342.600 | 93.210 | 345.100 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 9800 | 278.700 | 275.500 | 277.100 | 280.300 | 279.100 | 278.100 | 283.300 | 279.700 |
| Dolomite | 20.440 | 23.720 | 22.100 | 18.820 | 20.070 | 21.000 | 15.770 | 19.450 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 20.390 | 23.660 | 22.050 | 18.770 | 20.020 | 20.950 | 15.720 | 19.400 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 48.780 | 56.640 | 52.760 | 44.890 | 47.900 | 50.130 | 37.570 | 46.410 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 38.270 | 136.300 | 134.700 | 109.400 | 69.470 | 30.710 | 51.350 | 87.070 |
| Quartz | 1482.000 | 916.600 | 1465.000 | 1788.000 | 1453.000 | 768.600 | 1392.000 | 1479.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −20.540 | −23.810 | −22.190 | −18.910 | −20.170 | −21.100 | −15.860 | −19.550 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 9800 | −21.300 | −24.540 | −22.950 | −19.700 | −20.940 | −21.860 | −16.690 | −20.330 |
| Dolomite | 20.440 | 23.720 | 22.100 | 18.820 | 20.070 | 21.000 | 15.770 | 19.450 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Illite | −81.360 | −94.460 | −87.990 | −74.870 | −79.880 | −83.610 | −62.680 | −77.410 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 20.390 | 23.660 | 22.050 | 18.770 | 20.020 | 20.950 | 15.720 | 19.400 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 48.780 | 56.640 | 52.760 | 44.890 | 47.900 | 50.130 | 37.570 | 46.410 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 97.630 | 113.300 | 105.600 | 89.840 | 95.860 | 100.300 | 75.210 | 92.890 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 | 3.86E-06 |
| $CaHCO_3^+$ | 1.21E-02 | 1.20E-02 | 1.21E-02 | 1.21E-02 | 1.21E-02 | 1.21E-02 | 1.21E-02 | 1.21E-02 |
| $CO_2$ | 1.10E+00 | 1.10E+00 | 1.10E+00 | 1.11E+00 | 1.11E+00 | 1.11E+00 | 1.12E+00 | 1.11E+00 |
| $CO_3^{2-}$ | 2.67E-08 | 2.63E-08 | 2.65E-08 | 2.68E-08 | 2.67E-08 | 2.66E-08 | 2.71E-08 | 2.68E-08 |
| $FeCO_3$ | 1.66E-11 | 1.55E-11 | 1.60E-11 | 1.73E-11 | 1.68E-11 | 1.65E-11 | 1.85E-11 | 1.70E-11 |
| $FeCO_3^+$ | 2.50E-20 | 2.32E-20 | 2.41E-20 | 2.59E-20 | 2.53E-20 | 2.48E-20 | 2.78E-20 | 2.56E-20 |
| $FeHCO_3^+$ | 4.96E-07 | 4.60E-07 | 4.78E-07 | 5.15E-07 | 5.02E-07 | 4.91E-07 | 5.53E-07 | 5.08E-07 |
| $HCO_3^-$ | 4.42E-03 | 4.36E-03 | 4.39E-03 | 4.45E-03 | 4.43E-03 | 4.42E-03 | 4.51E-03 | 4.44E-03 |
| $MgCO_3$ | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 | 1.92E-08 |
| $MgHCO_3^+$ | 3.57E-04 | 3.57E-04 | 3.57E-04 | 3.58E-04 | 3.58E-04 | 3.58E-04 | 3.59E-04 | 3.58E-04 |
| $NaCO_3^-$ | 1.76E-10 | 1.77E-10 | 1.76E-10 | 1.75E-10 | 1.76E-10 | 1.76E-10 | 1.75E-10 | 1.76E-10 |
| $NaHCO_3$ | 8.82E-04 | 8.94E-04 | 8.88E-04 | 8.78E-04 | 8.83E-04 | 8.86E-04 | 8.69E-04 | 8.80E-04 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −20.540 | −23.810 | −22.190 | −18.910 | −20.170 | −21.100 | −15.860 | −19.550 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 40.880 | 47.440 | 44.200 | 37.640 | 40.140 | 42.000 | 31.540 | 38.900 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 20.340 | 23.630 | 22.010 | 18.730 | 19.970 | 20.900 | 15.680 | 19.350 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.103 | 1.095 | 1.100 | 1.110 | 1.108 | 1.107 | 1.120 | 1.108 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 | 0.018 |
| Total $CO_2$, moles/kg $H_2O$ | 21.461 | 24.743 | 23.128 | 19.858 | 21.096 | 22.025 | 16.818 | 20.476 |
| Water, $g/cm^3$ | 0.022 | 0.015 | 0.014 | 0.015 | 0.022 | 0.024 | 0.023 | 0.017 |
| Water, $kg/m^3$ | 21.610 | 14.731 | 13.901 | 14.511 | 21.637 | 24.020 | 22.564 | 17.327 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$m^3$ | 439.542 | 348.083 | 305.958 | 271.783 | 432.091 | 502.009 | 353.807 | 335.281 |
| Dissolved $CO_2$, moles/$m^3$ | 23.836 | 16.130 | 15.291 | 16.107 | 23.974 | 26.590 | 25.272 | 19.199 |
| Solution $CO_2$, moles/$m^3$ | 0.383 | 0.260 | 0.246 | 0.258 | 0.384 | 0.426 | 0.403 | 0.308 |
| Total $CO_2$, moles/$m^3$ | 463.761 | 364.473 | 321.495 | 288.148 | 456.449 | 529.025 | 379.482 | 354.788 |
| Mineral $CO_2$, moles/$ft^3$ | 12.447 | 9.857 | 8.664 | 7.696 | 12.236 | 14.215 | 10.019 | 9.494 |
| Dissolved $CO_2$, moles/$ft^3$ | 0.675 | 0.457 | 0.433 | 0.456 | 0.679 | 0.753 | 0.716 | 0.544 |
| Solution $CO_2$, moles/$ft^3$ | 0.011 | 0.007 | 0.007 | 0.007 | 0.011 | 0.012 | 0.011 | 0.009 |
| Total $CO_2$, moles/$ft^3$ | 13.132 | 10.321 | 9.104 | 8.159 | 12.925 | 14.980 | 10.746 | 10.047 |
| Mineral $CO_2$, kg/$m^3$ | 19.344 | 15.319 | 13.465 | 11.961 | 19.016 | 22.093 | 15.571 | 14.756 |
| Dissolved $CO_2$, kg/$m^3$ | 1.049 | 0.710 | 0.673 | 0.709 | 1.055 | 1.170 | 1.112 | 0.845 |
| Solution $CO_2$, kg/$m^3$ | 0.017 | 0.011 | 0.011 | 0.011 | 0.017 | 0.019 | 0.018 | 0.014 |
| Total $CO_2$, kg/$m^3$ | 20.410 | 16.040 | 14.149 | 12.681 | 20.088 | 23.282 | 16.701 | 15.614 |
| Mineral $CO_2$, lb/$ft^3$ | 1.208 | 0.956 | 0.841 | 0.747 | 1.187 | 1.379 | 0.972 | 0.921 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.065 | 0.044 | 0.042 | 0.044 | 0.066 | 0.073 | 0.069 | 0.053 |
| Solution $CO_2$, lb/$ft^3$ | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Total $CO_2$, lb/$ft^3$ | 1.274 | 1.001 | 0.883 | 0.792 | 1.254 | 1.453 | 1.043 | 0.975 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 44.196 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 14.690 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 0.844 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.014 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 15.548 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.917 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.053 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.001 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.971 | | | | | | | |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | |
| pH | −1.519 | −1.526 | −1.522 | −1.517 | −1.520 | −1.522 | −1.516 | −1.519 |
| pE | 1.834 | 1.836 | 1.835 | 1.835 | 1.835 | 1.835 | 1.835 | 1.834 |
| Activity | 0.041 | 0.061 | 0.050 | 0.033 | 0.040 | 0.044 | 0.020 | 0.036 |
| Ionic Strength | −0.750 | −0.940 | −0.842 | −0.666 | −0.730 | −0.781 | −0.522 | −0.699 |
| Total Solution $CO_2$, moles | 1.119 | 1.111 | 1.116 | 1.126 | 1.125 | 1.123 | 1.137 | 1.125 |
| Solution, moles | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 0.954 | 0.921 | 0.938 | 0.974 | 0.962 | 0.953 | 1.008 | 0.967 |
| Ca | −0.010 | −0.011 | −0.011 | −0.010 | −0.011 | −0.011 | −0.010 | −0.011 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.033 | 0.032 | 0.033 | 0.034 | 0.033 | 0.033 | 0.034 | 0.033 |
| Mg | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Si | 0.001 | 0.001 | 0.001 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 9800 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −20.320 | −23.600 | −22.000 | −18.700 | −19.950 | −20.900 | −15.690 | −19.300 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 9800 | 278.700 | 275.500 | 277.100 | 280.300 | 279.100 | 278.100 | 283.300 | 279.700 |
| Dolomite | 20.337 | 23.615 | 21.996 | 18.716 | 19.966 | 20.896 | 15.667 | 19.346 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −6.730 | −7.830 | −7.280 | −6.190 | −6.610 | −6.920 | −5.170 | −6.400 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 6.750 | 7.840 | 7.300 | 6.210 | 6.630 | 6.930 | 5.190 | 6.420 |
| Phlogopite | −6.780 | −7.872 | −7.333 | −6.239 | −6.657 | −6.967 | −5.223 | −6.451 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 14.000 | 15.800 | 15.000 | 12.000 | 14.000 | 13.900 | 10.000 | 12.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −20.334 | −23.601 | −21.982 | −18.703 | −19.963 | −20.892 | −15.654 | −19.343 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 9800 | 21.300 | 24.540 | 22.950 | 19.700 | 20.940 | 21.860 | 16.690 | 20.330 |
| Dolomite | 20.337 | 23.615 | 21.996 | 18.716 | 19.966 | 20.896 | 15.667 | 19.346 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −6.730 | −7.830 | −7.280 | −6.190 | −6.610 | −6.920 | −5.170 | −6.400 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Muscovite | 6.750 | 7.840 | 7.300 | 6.210 | 6.630 | 6.930 | 5.190 | 6.420 |
| Phlogopite | −6.780 | −7.872 | −7.333 | −6.239 | −6.657 | −6.967 | −5.223 | −6.451 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 13.560 | 15.690 | 14.680 | 12.480 | 13.320 | 13.910 | 10.450 | 12.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $CaHCO_3^+$ | 1.17E-02 | 1.17E-02 | 1.17E-02 | 1.17E-02 | 1.17E-02 | 1.17E-02 | 1.18E-02 | 1.17E-02 |
| $CO_2$ | 1.10E+00 | 1.09E+00 | 1.10E+00 | 1.11E+00 | 1.11E+00 | 1.11E+00 | 1.12E+00 | 1.11E+00 |
| $CO_3^{2-}$ | 4.17E-09 | 4.71E-09 | 4.45E-09 | 3.91E-09 | 4.11E-09 | 4.26E-09 | 3.43E-09 | 4.01E-09 |
| $FeCO_3$ | 1.61E-11 | 1.50E-11 | 1.55E-11 | 1.66E-11 | 1.62E-11 | 1.59E-11 | 1.77E-11 | 1.64E-11 |
| $FeCO_3^+$ | 2.49E-20 | 2.32E-20 | 2.40E-20 | 2.59E-20 | 2.52E-20 | 2.47E-20 | 2.78E-20 | 2.56E-20 |
| $FeHCO_3^+$ | 4.95E-07 | 4.59E-07 | 4.77E-07 | 5.15E-07 | 5.01E-07 | 4.91E-07 | 5.52E-07 | 5.08E-07 |
| $HCO_3^-$ | 4.31E-03 | 4.26E-03 | 4.28E-03 | 4.34E-03 | 4.32E-03 | 4.31E-03 | 4.40E-03 | 4.33E-03 |
| $MgCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $MgHCO_3^+$ | 3.47E-04 | 3.47E-04 | 3.47E-04 | 3.48E-04 | 3.48E-04 | 3.48E-04 | 3.49E-04 | 3.48E-04 |
| $NaCO_3^-$ | −6.40E-12 | −1.03E-11 | −8.30E-12 | −4.80E-12 | −6.00E-12 | −7.10E-12 | −2.10E-12 | −5.30E-12 |
| $NaHCO_3$ | 8.53E-04 | 8.63E-04 | 8.58E-04 | 8.49E-04 | 8.53E-04 | 8.57E-04 | 8.41E-04 | 8.51E-04 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −20.334 | −23.601 | −21.982 | −18.703 | −19.963 | −20.892 | −15.654 | −19.343 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 40.674 | 47.230 | 43.991 | 37.433 | 39.932 | 41.792 | 31.334 | 38.692 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 20.340 | 23.629 | 22.009 | 18.729 | 19.969 | 20.899 | 15.680 | 19.349 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.102 | 1.094 | 1.099 | 1.109 | 1.107 | 1.106 | 1.119 | 1.107 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 | 0.017 |
| Total $CO_2$, moles/kg $H_2O$ | 21.460 | 24.741 | 23.126 | 19.856 | 21.094 | 22.023 | 16.816 | 20.474 |
| Water, $g/cm^3$ | 0.022 | 0.015 | 0.014 | 0.015 | 0.022 | 0.024 | 0.023 | 0.017 |
| Water, $kg/m^3$ | 21.610 | 14.731 | 13.901 | 14.511 | 21.637 | 24.020 | 22.564 | 17.327 |

Continued…

**Table B-55. Summary of ND 9800 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, moles/$m^3$ | 439.548 | 348.071 | 305.948 | 271.774 | 432.076 | 501.990 | 353.796 | 335.271 |
| Dissolved $CO_2$, moles/$m^3$ | 23.817 | 16.118 | 15.280 | 16.094 | 23.956 | 26.570 | 25.252 | 19.184 |
| Solution $CO_2$, moles/$m^3$ | 0.372 | 0.253 | 0.239 | 0.251 | 0.374 | 0.415 | 0.392 | 0.299 |
| Total $CO_2$, moles/$m^3$ | 463.738 | 364.442 | 321.467 | 288.119 | 456.405 | 528.974 | 379.439 | 354.754 |
| Mineral $CO_2$, moles/$ft^3$ | 12.447 | 9.856 | 8.664 | 7.696 | 12.235 | 14.215 | 10.018 | 9.494 |
| Dissolved $CO_2$, moles/$ft^3$ | 0.674 | 0.456 | 0.433 | 0.456 | 0.678 | 0.752 | 0.715 | 0.543 |
| Solution $CO_2$, moles/$ft^3$ | 0.011 | 0.007 | 0.007 | 0.007 | 0.011 | 0.012 | 0.011 | 0.008 |
| Total $CO_2$, moles/$ft^3$ | 13.132 | 10.320 | 9.103 | 8.159 | 12.924 | 14.979 | 10.745 | 10.046 |
| Mineral $CO_2$, kg/$m^3$ | 19.345 | 15.319 | 13.465 | 11.961 | 19.016 | 22.093 | 15.571 | 14.755 |
| Dissolved $CO_2$, kg/$m^3$ | 1.048 | 0.709 | 0.672 | 0.708 | 1.054 | 1.169 | 1.111 | 0.844 |
| Solution $CO_2$, kg/$m^3$ | 0.016 | 0.011 | 0.011 | 0.011 | 0.016 | 0.018 | 0.017 | 0.013 |
| Total $CO_2$, kg/$m^3$ | 20.409 | 16.039 | 14.148 | 12.680 | 20.086 | 23.280 | 16.699 | 15.613 |
| Mineral $CO_2$, lb/$ft^3$ | 1.208 | 0.956 | 0.841 | 0.747 | 1.187 | 1.379 | 0.972 | 0.921 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.065 | 0.044 | 0.042 | 0.044 | 0.066 | 0.073 | 0.069 | 0.053 |
| Solution $CO_2$, lb/$ft^3$ | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Total $CO_2$, lb/$ft^3$ | 1.274 | 1.001 | 0.883 | 0.792 | 1.254 | 1.453 | 1.042 | 0.975 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 44.196 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 14.689 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 0.844 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.013 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 15.546 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.917 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.053 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.001 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.971 | | | | | | | |

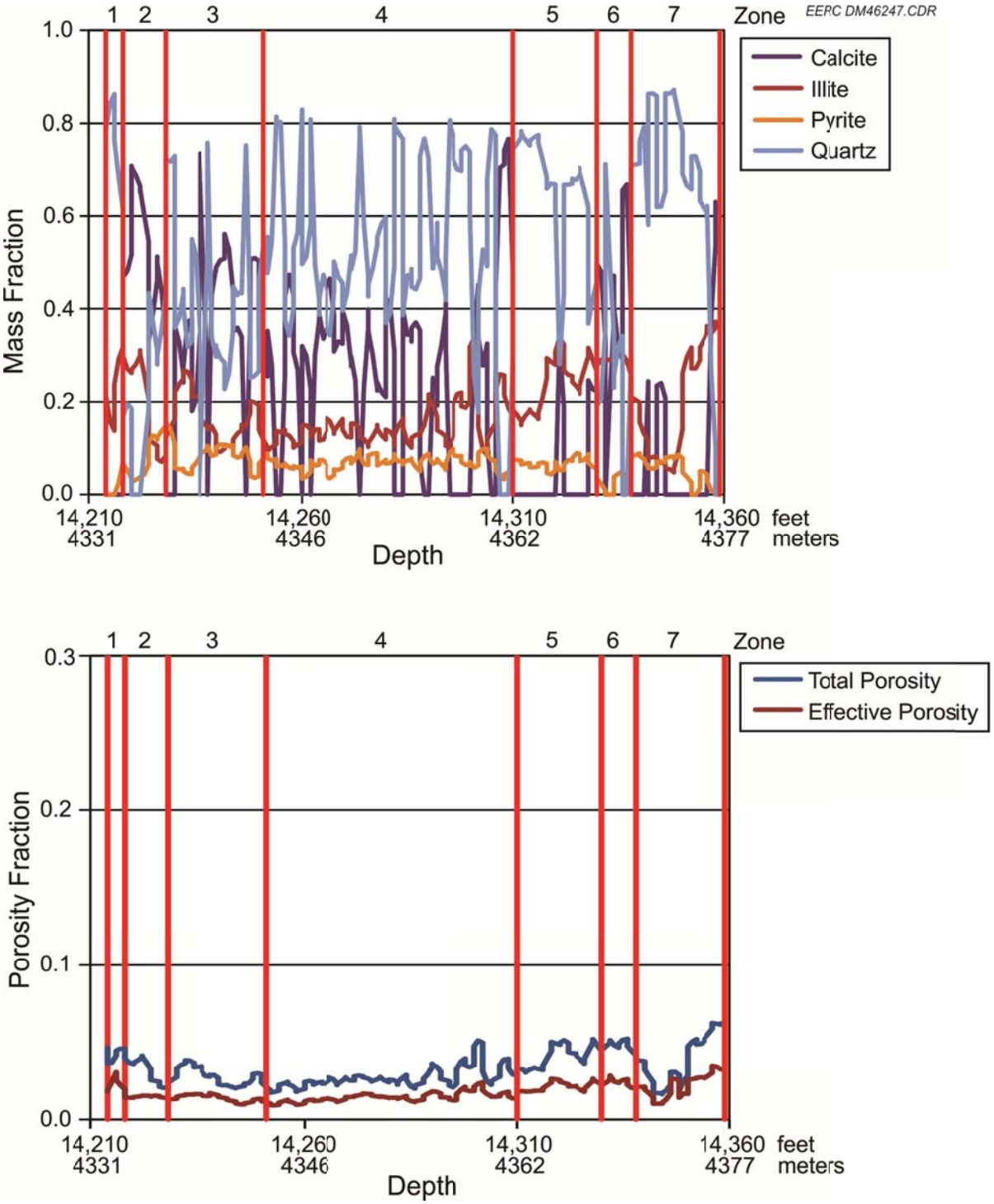



Figure B-16. ND 9800 mineral composition and porosity as a function of depth.

**MT API 21279**

The water composition used for MT API 21279 is from the MT API 05083 well 11 miles (18 km) to the southeast. Mineral data were available for 99% of the COSS represented in this well. The total COSS thickness is 747 feet (228 meters), as the well penetrated into the Precambrian.

The geology of the COSS penetrated by the well is somewhat complex, resulting in the assignment of 13 zones. Zones 1 and 2 contain mainly dolomite and quartz in a 2:1 ratio. Zones 3, 9, and 13 contain primarily quartz with a moderate amount of calcite. Zones 2, 4, 6, 8, and 10 mostly comprise calcite, with lesser amounts of illite and a modest amount of quartz. Zone 7 contains mostly quartz along with dolomite and illite, while Zone 8 contains mostly illite, with moderate amounts of calcite and quartz. Finally, Zone 12 comprises mainly dolomite, with moderate amounts of illite and quartz. Porosities range from 0.016 to 0.059.

Less kaolinite and phlogopite form, with corresponding increases in quartz and muscovite. The dissolution of calcite and the concurrent formation of dolomite makes up the greatest contribution to the $CO_2$ interaction with the minerals when calcite is present. A small amount of pyrite dissolves, and a corresponding amount of siderite forms.

The amount of $CO_2$ dissolved in the formation water ranges from 1.18 to1.36 moles/kg (51.9 to 59.8 g/kg) and is the dominant component of the $CO_2$ interaction with the formation water. The total average amount of $CO_2$ reacting with the minerals and formation water is 14.2 kg/m$^3$ (0.9 lb/ft$^3$) of formation rock.

## Table B-56. Average Mineral and Porosity Values for the MT API 21279 Aquifer Zones

Well Name: MT API 21279
API Identification: 25-011-21279-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 9516.5 | 2900.6 | Average | 0.030 | 0.026 | 0.000 | 0.000 | 0.000 | 0.370 | 0.000 | 0.077 | 0.000 | 0.000 | 0.000 | 0.002 | 0.551 | 0.000 |
| End | 9575 | 2918.5 | Minimum | 0.015 | 0.011 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 58.5 | 17.8 | Maximum | 0.090 | 0.085 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 | 0.252 | 0.000 | 0.000 | 0.000 | 0.096 | 0.829 | 0.000 |
| Number of Values | 118 | | Standard deviation | 0.015 | 0.016 | 0.000 | 0.000 | 0.000 | 0.176 | 0.000 | 0.040 | 0.000 | 0.000 | 0.000 | 0.010 | 0.160 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 9575 | 2918.5 | Average | 0.022 | 0.017 | 0.000 | 0.677 | 0.000 | 0.031 | 0.000 | 0.106 | 0.000 | 0.000 | 0.000 | 0.006 | 0.181 | 0.000 |
| End | 9660.5 | 2944.5 | Minimum | 0.010 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 85.5 | 26.1 | Maximum | 0.047 | 0.041 | 0.000 | 1.000 | 0.000 | 0.502 | 0.000 | 0.280 | 0.000 | 0.000 | 0.000 | 0.079 | 0.698 | 0.000 |
| Number of Values | 171 | | Standard deviation | 0.008 | 0.008 | 0.000 | 0.267 | 0.000 | 0.104 | 0.000 | 0.048 | 0.000 | 0.000 | 0.000 | 0.014 | 0.208 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 9660.5 | 2944.5 | Average | 0.025 | 0.021 | 0.000 | 0.389 | 0.000 | 0.009 | 0.000 | 0.089 | 0.000 | 0.000 | 0.000 | 0.001 | 0.512 | 0.000 |
| End | 9695 | 2955.0 | Minimum | 0.014 | 0.011 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 34.5 | 10.5 | Maximum | 0.043 | 0.037 | 0.000 | 0.922 | 0.000 | 0.151 | 0.000 | 0.122 | 0.000 | 0.000 | 0.000 | 0.013 | 0.945 | 0.000 |
| Number of Values | 69 | | Standard deviation | 0.006 | 0.006 | 0.000 | 0.292 | 0.000 | 0.032 | 0.000 | 0.021 | 0.000 | 0.000 | 0.000 | 0.003 | 0.286 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 9695 | 2955.0 | Average | 0.030 | 0.022 | 0.000 | 0.725 | 0.000 | 0.008 | 0.000 | 0.161 | 0.000 | 0.000 | 0.000 | 0.005 | 0.102 | 0.000 |
| End | 9795 | 2985.5 | Minimum | 0.013 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.063 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 100 | 30.5 | Maximum | 0.116 | 0.095 | 0.000 | 0.909 | 0.000 | 0.344 | 0.000 | 0.522 | 0.000 | 0.000 | 0.000 | 0.106 | 0.937 | 0.000 |
| Number of Values | 200 | | Standard deviation | 0.015 | 0.013 | 0.000 | 0.220 | 0.000 | 0.042 | 0.000 | 0.076 | 0.000 | 0.000 | 0.000 | 0.017 | 0.207 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 9795 | 2985.5 | Average | 0.024 | 0.017 | 0.000 | 0.000 | 0.000 | 0.264 | 0.000 | 0.138 | 0.000 | 0.000 | 0.000 | 0.000 | 0.598 | 0.000 |
| End | 9828 | 2995.6 | Minimum | 0.017 | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.088 | 0.000 | 0.000 | 0.000 | 0.000 | 0.406 | 0.000 |
| Thickness | 33 | 10.1 | Maximum | 0.036 | 0.028 | 0.000 | 0.000 | 0.000 | 0.486 | 0.000 | 0.202 | 0.000 | 0.000 | 0.000 | 0.007 | 0.851 | 0.000 |
| Number of Values | 66 | | Standard deviation | 0.005 | 0.005 | 0.000 | 0.000 | 0.000 | 0.117 | 0.000 | 0.028 | 0.000 | 0.000 | 0.000 | 0.001 | 0.115 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 9828 | 2995.6 | Average | 0.047 | 0.032 | 0.000 | 0.549 | 0.000 | 0.030 | 0.001 | 0.305 | 0.000 | 0.000 | 0.000 | 0.001 | 0.115 | 0.000 |
| End | 9894 | 3015.7 | Minimum | 0.020 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.142 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 66 | 20.1 | Maximum | 0.142 | 0.120 | 0.000 | 0.826 | 0.000 | 0.626 | 0.085 | 0.611 | 0.000 | 0.000 | 0.000 | 0.031 | 0.740 | 0.000 |
| Number of Values | 132 | | Standard deviation | 0.026 | 0.023 | 0.000 | 0.276 | 0.000 | 0.103 | 0.007 | 0.109 | 0.000 | 0.000 | 0.000 | 0.004 | 0.205 | 0.000 |
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 9894 | 3015.7 | Average | 0.028 | 0.016 | 0.000 | 0.000 | 0.000 | 0.193 | 0.000 | 0.237 | 0.000 | 0.000 | 0.000 | 0.000 | 0.570 | 0.000 |
| End | 9917 | 3022.7 | Minimum | 0.019 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.108 | 0.000 | 0.000 | 0.000 | 0.000 | 0.360 | 0.000 |
| Thickness | 23 | 7.0 | Maximum | 0.043 | 0.031 | 0.000 | 0.000 | 0.000 | 0.437 | 0.000 | 0.378 | 0.000 | 0.000 | 0.000 | 0.000 | 0.725 | 0.000 |
| Number of Values | 46 | | Standard deviation | 0.006 | 0.006 | 0.000 | 0.000 | 0.000 | 0.144 | 0.000 | 0.071 | 0.000 | 0.000 | 0.000 | 0.000 | 0.094 | 0.000 |

Continued…

## Table B-56. Average Mineral and Porosity Values for the MT API 21279 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 8 | | | | | | | | | | | | | | | | | |
| Start | 9917 | 3022.7 | Average | 0.048 | 0.036 | 0.000 | 0.601 | 0.000 | 0.011 | 0.000 | 0.246 | 0.000 | 0.000 | 0.000 | 0.021 | 0.122 | 0.000 |
| End | 10,018 | 3053.5 | Minimum | 0.017 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 101 | 30.8 | Maximum | 0.127 | 0.127 | 0.000 | 0.976 | 0.000 | 0.256 | 0.000 | 0.552 | 0.000 | 0.000 | 0.000 | 0.125 | 0.822 | 0.000 |
| Number of Values | 203 | | Standard deviation | 0.026 | 0.032 | 0.000 | 0.221 | 0.000 | 0.042 | 0.000 | 0.152 | 0.000 | 0.000 | 0.000 | 0.033 | 0.215 | 0.000 |
| Zone 9 | | | | | | | | | | | | | | | | | |
| Start | 10,018 | 3053.5 | Average | 0.084 | 0.083 | 0.000 | 0.102 | 0.000 | 0.026 | 0.000 | 0.018 | 0.000 | 0.000 | 0.000 | 0.021 | 0.833 | 0.000 |
| End | 10,068 | 3068.7 | Minimum | 0.029 | 0.025 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.279 | 0.000 |
| Thickness | 50 | 15.2 | Maximum | 0.143 | 0.143 | 0.000 | 0.703 | 0.000 | 0.318 | 0.000 | 0.134 | 0.000 | 0.000 | 0.000 | 0.076 | 1.000 | 0.000 |
| Number of Values | 100 | | Standard deviation | 0.033 | 0.034 | 0.000 | 0.143 | 0.000 | 0.065 | 0.000 | 0.035 | 0.000 | 0.000 | 0.000 | 0.021 | 0.138 | 0.000 |
| Zone 10 | | | | | | | | | | | | | | | | | |
| Start | 10,068 | 3068.7 | Average | 0.065 | 0.048 | 0.000 | 0.402 | 0.000 | 0.000 | 0.007 | 0.354 | 0.000 | 0.000 | 0.000 | 0.005 | 0.232 | 0.000 |
| End | 10,112 | 3082.1 | Minimum | 0.039 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.090 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 44 | 13.4 | Maximum | 0.094 | 0.077 | 0.000 | 0.816 | 0.000 | 0.000 | 0.161 | 0.615 | 0.000 | 0.000 | 0.000 | 0.087 | 0.910 | 0.000 |
| Number of Values | 88 | | Standard deviation | 0.014 | 0.016 | 0.000 | 0.327 | 0.000 | 0.000 | 0.029 | 0.158 | 0.000 | 0.000 | 0.000 | 0.017 | 0.249 | 0.000 |
| Zone 11 | | | | | | | | | | | | | | | | | |
| Start | 10,112 | 3082.1 | Average | 0.057 | 0.032 | 0.000 | 0.102 | 0.000 | 0.020 | 0.025 | 0.500 | 0.000 | 0.000 | 0.000 | 0.030 | 0.323 | 0.000 |
| End | 10,136 | 3089.5 | Minimum | 0.018 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.332 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 24 | 7.3 | Maximum | 0.096 | 0.066 | 0.000 | 0.632 | 0.000 | 0.240 | 0.116 | 0.639 | 0.000 | 0.000 | 0.000 | 0.093 | 0.655 | 0.000 |
| Number of Values | | | Standard deviation | 0.029 | 0.025 | 0.000 | 0.216 | 0.000 | 0.054 | 0.040 | 0.108 | 0.000 | 0.000 | 0.000 | 0.031 | 0.181 | 0.000 |
| Zone 12 | | | | | | | | | | | | | | | | | |
| Start | 10,136 | 3089.5 | Average | 0.070 | 0.059 | 0.000 | 0.006 | 0.000 | 0.453 | 0.029 | 0.209 | 0.000 | 0.000 | 0.000 | 0.121 | 0.183 | 0.000 |
| End | 10,172 | 3100.4 | Minimum | 0.013 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.052 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 36 | 11.0 | Maximum | 0.140 | 0.132 | 0.000 | 0.422 | 0.000 | 0.792 | 0.731 | 0.471 | 0.000 | 0.000 | 0.000 | 0.337 | 0.673 | 0.000 |
| Number of Values | 72 | | Standard deviation | 0.045 | 0.048 | 0.000 | 0.050 | 0.000 | 0.228 | 0.112 | 0.109 | 0.000 | 0.000 | 0.000 | 0.127 | 0.220 | 0.000 |
| Zone 13 | | | | | | | | | | | | | | | | | |
| Start | 10,172 | 3100.4 | Average | 0.055 | 0.050 | 0.000 | 0.105 | 0.000 | 0.023 | 0.000 | 0.094 | 0.000 | 0.000 | 0.000 | 0.007 | 0.771 | 0.000 |
| End | 10,262 | 3127.9 | Minimum | 0.011 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.375 | 0.000 |
| Thickness | 90 | 27.4 | Maximum | 0.134 | 0.131 | 0.000 | 0.549 | 0.000 | 0.247 | 0.000 | 0.391 | 0.000 | 0.000 | 0.000 | 0.088 | 1.000 | 0.000 |
| Number of Values | 180 | | Standard deviation | 0.030 | 0.032 | 0.000 | 0.148 | 0.000 | 0.053 | 0.000 | 0.103 | 0.000 | 0.000 | 0.000 | 0.015 | 0.153 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 9516.5 | 2900.6 | Average | 0.044 | 0.035 | 0.000 | 0.369 | 0.000 | 0.083 | 0.003 | 0.177 | 0.000 | 0.000 | 0.000 | 0.014 | 0.354 | 0.000 |
| End | 10,262 | 3127.9 | Minimum | 0.010 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 745.5 | 227.2 | Maximum | 0.143 | 0.143 | 0.000 | 1.000 | 0.000 | 1.000 | 0.731 | 0.639 | 0.000 | 0.000 | 0.000 | 0.337 | 1.000 | 0.000 |
| Number of Values | 1493 | | Standard deviation | 0.029 | 0.030 | 0.000 | 0.353 | 0.000 | 0.167 | 0.028 | 0.145 | 0.000 | 0.000 | 0.000 | 0.042 | 0.331 | 0.000 |

## Table B-57. Summary of MT API 21279 Aquifer Minerals and Conditions

Well Name: MT API 21279
API Identification: 25-011-21279-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, ft | 9516.5 | 9575 | 9660.5 | 9695 | 9795 | 9828 | 9894 | 9917 | 10018 | 10068 | 10112 | 10136 | 10172 | 9516.5 |
| End, ft | 9575 | 9660.5 | 9695 | 9795 | 9828 | 9894 | 9917 | 10018 | 10068 | 10112 | 10136 | 10172 | 10262 | 10262 |
| Thickness, ft | 58.5 | 85.5 | 34.5 | 100.0 | 33.0 | 66.0 | 23.0 | 101.0 | 50.0 | 44.0 | 24.0 | 36.0 | 90.0 | 745.5 |
| Start, m | 2900.6 | 2918.5 | 2944.5 | 2955.0 | 2985.5 | 2995.6 | 3015.7 | 3022.7 | 3053.5 | 3068.7 | 3082.1 | 3089.5 | 3100.4 | 2900.6 |
| End, m | 2918.5 | 2944.5 | 2955.0 | 2985.5 | 2995.6 | 3015.7 | 3022.7 | 3053.5 | 3068.7 | 3082.1 | 3089.5 | 3100.4 | 3127.9 | 3127.9 |
| Thickness, m | 17.8 | 26.1 | 10.5 | 30.5 | 10.1 | 20.1 | 7.0 | 30.8 | 15.2 | 13.4 | 7.3 | 11.0 | 27.4 | 227.2 |
| Temperature, °F | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 | 214.0 |
| Temperature, °C | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 | 101.1 |
| Pressure, psi | 6188 | 6201 | 6211 | 6223 | 6235 | 6244 | 6252 | 6262 | 6276 | 6284 | 6290 | 6295 | 6307 | 6249 |
| Pressure, kPa | 42,664 | 42,752 | 42,825 | 42,907 | 42,988 | 43,049 | 43,103 | 43,178 | 43,270 | 43,328 | 43,369 | 43,406 | 43,483 | 43,083 |
| Effective Porosity, fraction | 0.026 | 0.017 | 0.021 | 0.022 | 0.017 | 0.032 | 0.016 | 0.036 | 0.083 | 0.048 | 0.032 | 0.059 | 0.050 | 0.035 |
| Mass Fraction | | | | | | | | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.677 | 0.389 | 0.725 | 0.000 | 0.549 | 0.000 | 0.601 | 0.102 | 0.402 | 0.102 | 0.006 | 0.105 | 0.369 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.370 | 0.031 | 0.009 | 0.008 | 0.264 | 0.030 | 0.193 | 0.011 | 0.026 | 0.000 | 0.020 | 0.453 | 0.023 | 0.083 |
| Glauconite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.007 | 0.025 | 0.029 | 0.000 | 0.003 |
| Illite | 0.077 | 0.106 | 0.089 | 0.161 | 0.138 | 0.305 | 0.237 | 0.246 | 0.018 | 0.354 | 0.500 | 0.209 | 0.094 | 0.177 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.002 | 0.006 | 0.001 | 0.005 | 0.000 | 0.001 | 0.000 | 0.021 | 0.021 | 0.005 | 0.030 | 0.121 | 0.007 | 0.014 |
| Quartz | 0.551 | 0.181 | 0.512 | 0.102 | 0.598 | 0.115 | 0.570 | 0.122 | 0.833 | 0.232 | 0.323 | 0.183 | 0.771 | 0.354 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-58. Summary of MT API 21279 Aquifer Calculation Results

Well Name: MT API 21279
API Identification: 25-011-21279-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, m | 2900.6 | 2918.5 | 2944.5 | 2955.0 | 2985.5 | 2995.6 | 3015.7 | 3022.7 | 3053.5 | 3068.7 | 3082.1 | 3089.5 | 3100.4 | 2900.6 |
| End, m | 2918.5 | 2944.5 | 2955.0 | 2985.5 | 2995.6 | 3015.7 | 3022.7 | 3053.5 | 3068.7 | 3082.1 | 3089.5 | 3100.4 | 3127.9 | 3127.9 |
| Thickness, m | 17.8 | 26.1 | 10.5 | 30.5 | 10.1 | 20.1 | 7.0 | 30.8 | 15.2 | 13.4 | 7.3 | 11.0 | 27.4 | 227.2 |
| Start, ft | 9516.5 | 9575.0 | 9660.5 | 9695.0 | 9795.0 | 9828.0 | 9894.0 | 9917.0 | 10,018.0 | 10,068.0 | 10,112.0 | 10,136.0 | 10,172.0 | 9516.5 |
| End, ft | 9575.0 | 9660.5 | 9695.0 | 9795.0 | 9828.0 | 9894.0 | 9917.0 | 10,018.0 | 10,068.0 | 10,112.0 | 10,136.0 | 10,172.0 | 10,262.0 | 10,262.0 |
| Thickness, ft | 58.5 | 85.5 | 34.5 | 100.0 | 33.0 | 66.0 | 23.0 | 101.0 | 50.0 | 44.0 | 24.0 | 36.0 | 90.0 | 745.5 |
| **Minerals Without $CO_2$** | | | | | | | | | | | | | | |
| pH | 6.105 | 6.542 | 6.542 | 6.535 | 6.073 | 6.522 | 6.017 | 6.538 | 6.576 | 6.540 | 6.499 | 6.569 | 6.568 | 6.552 |
| pE | −2.584 | −3.076 | −3.076 | −3.068 | −2.547 | −3.052 | 9.089 | −3.071 | −3.117 | −3.074 | −3.023 | −3.109 | −3.107 | −3.088 |
| Activity | 0.985 | 0.983 | 0.983 | 0.982 | 0.982 | 0.981 | 0.974 | 0.983 | 0.987 | 0.983 | 0.978 | 0.986 | 0.986 | 0.984 |
| Ionic Strength | 0.482 | 0.553 | 0.553 | 0.578 | 0.583 | 0.628 | 0.825 | 0.567 | 0.444 | 0.559 | 0.728 | 0.463 | 0.468 | 0.519 |
| Total Solution $CO_2$, moles | 8.604E-04 | 5.155E-04 | 5.155E-04 | 5.125E-04 | 8.419E-04 | 5.067E-04 | 8.038E-04 | 5.138E-04 | 5.306E-04 | 5.147E-04 | 4.965E-04 | 5.278E-04 | 5.270E-04 | 5.199E-04 |
| Solution, moles | | | | | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0008 | 0.0004 | 0.0004 | 0.0004 | 0.0006 | 0.0004 | 0.0004 | 0.0004 | 0.0005 | 0.0004 | 0.0003 | 0.0005 | 0.0005 | 0.0004 |
| Ca | 0.0269 | 0.0365 | 0.0365 | 0.0365 | 0.0269 | 0.0365 | 0.0268 | 0.0365 | 0.0366 | 0.0365 | 0.0365 | 0.0366 | 0.0366 | 0.0365 |
| Cl | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0007 | 0.0002 | 0.0002 | 0.0002 | 0.0006 | 0.0002 | 0.0005 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| Mg | 0.0108 | 0.0014 | 0.0014 | 0.0014 | 0.0109 | 0.0014 | 0.0110 | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.0014 | 0.0014 |
| Na | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 |
| S | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 |
| Si | 0.0008 | 0.0007 | 0.0007 | 0.0007 | 0.0007 | 0.0006 | 0.0005 | 0.0007 | 0.0009 | 0.0007 | 0.0005 | 0.0009 | 0.0009 | 0.0008 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1071.000 | 494.000 | 880.700 | 0.000 | 448.700 | 0.000 | 448.800 | 30.050 | 218.200 | 85.610 | 2.840 | 52.930 | 276.800 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.122 | 0.000 | 0.000 | 0.000 | 0.915 | 4.913 | 3.266 | 0.000 | 0.468 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 204.500 | 26.350 | 6.424 | 5.137 | 217.700 | 13.520 | 172.400 | 4.563 | 4.188 | 0.000 | 9.264 | 119.300 | 6.279 | 33.780 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 20.460 | 43.680 | 29.420 | 51.040 | 54.590 | 64.920 | 101.900 | 47.830 | 1.380 | 50.150 | 109.500 | 26.400 | 12.310 | 34.590 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 1.350 | 7.664 | 1.067 | 5.037 | 0.143 | 0.436 | 0.000 | 12.990 | 5.088 | 2.400 | 21.280 | 48.780 | 2.954 | 8.579 |
| Quartz | 935.300 | 475.900 | 1084.000 | 205.700 | 1516.000 | 156.200 | 1562.000 | 151.500 | 409.600 | 209.800 | 452.000 | 147.900 | 648.300 | 441.600 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1071.000 | 494.000 | 880.700 | 0.000 | 448.600 | 0.000 | 448.800 | 30.030 | 218.100 | 85.590 | 2.820 | 52.920 | 276.700 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 204.500 | 26.360 | 6.437 | 5.150 | 217.700 | 13.530 | 172.500 | 4.576 | 4.201 | 0.013 | 9.277 | 119.300 | 6.292 | 33.790 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 6.820 | 14.560 | 9.806 | 17.010 | 18.190 | 21.560 | 33.960 | 15.940 | 0.458 | 16.110 | 33.230 | 6.620 | 4.103 | 11.220 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 10.570 | 22.570 | 15.200 | 26.370 | 28.200 | 33.620 | 52.650 | 24.720 | 0.715 | 26.520 | 59.870 | 15.820 | 6.364 | 18.190 |
| Phlogopite | 1.703 | 3.638 | 2.450 | 4.251 | 4.547 | 5.449 | 8.489 | 3.984 | 0.113 | 4.482 | 10.760 | 3.286 | 1.024 | 3.037 |
| Pyrite | 1.350 | 7.664 | 1.067 | 5.037 | 0.143 | 0.436 | 0.000 | 12.990 | 5.088 | 2.400 | 21.280 | 48.780 | 2.954 | 8.579 |
| Quartz | 956.400 | 521.000 | 1115.000 | 258.400 | 1572.000 | 223.600 | 1667.000 | 200.900 | 411.000 | 263.800 | 576.600 | 182.800 | 661.000 | 478.500 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | −0.020 | −0.020 | −0.020 | 0.000 | −0.020 | 0.000 | −0.020 | −0.019 | −0.020 | −0.020 | −0.020 | −0.020 | −0.020 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −0.122 | 0.000 | 0.000 | 0.000 | −0.915 | −4.913 | −3.266 | 0.000 | −0.468 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.003 | 0.013 | 0.013 | 0.013 | 0.003 | 0.013 | 0.003 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −20.460 | −43.680 | −29.420 | −51.040 | −54.590 | −64.920 | −101.900 | −47.830 | −1.380 | −50.150 | −109.500 | −26.400 | −12.310 | −34.590 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

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## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kaolinite | 6.820 | 14.560 | 9.806 | 17.010 | 18.190 | 21.560 | 33.960 | 15.940 | 0.458 | 16.110 | 33.230 | 6.620 | 4.103 | 11.220 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 10.570 | 22.570 | 15.200 | 26.370 | 28.200 | 33.620 | 52.650 | 24.720 | 0.715 | 26.520 | 59.870 | 15.820 | 6.364 | 18.190 |
| Phlogopite | 1.703 | 3.638 | 2.450 | 4.251 | 4.547 | 5.449 | 8.489 | 3.984 | 0.113 | 4.482 | 10.760 | 3.286 | 1.024 | 3.037 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 21.150 | 45.140 | 30.410 | 52.740 | 56.410 | 67.370 | 105.300 | 49.430 | 1.429 | 53.960 | 124.700 | 34.900 | 12.730 | 36.840 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | | | | | | |
| $CaCO_3$ | 1.92E-06 | 6.37E-06 | 6.37E-06 | 6.37E-06 | 1.91E-06 | 6.37E-06 | 1.90E-06 | 6.37E-06 | 6.37E-06 | 6.37E-06 | 6.37E-06 | 6.37E-06 | 6.37E-06 | 6.37E-06 |
| $CaHCO_3^+$ | 5.58E-05 | 6.83E-05 | 6.61E-05 | 6.96E-05 | 6.05E-05 | 7.21E-05 | 6.98E-05 | 6.90E-05 | 6.22E-05 | 6.86E-05 | 7.66E-05 | 6.33E-05 | 6.36E-05 | 6.65E-05 |
| $CO_2$ | 3.96E-04 | 1.18E-04 | 1.19E-04 | 1.17E-04 | 3.89E-04 | 1.16E-04 | 3.72E-04 | 1.17E-04 | 1.20E-04 | 1.17E-04 | 1.13E-04 | 1.20E-04 | 1.20E-04 | 1.18E-04 |
| $CO_3^{2-}$ | 1.54E-07 | 3.66E-07 | 3.76E-07 | 3.60E-07 | 1.44E-07 | 3.49E-07 | 1.25E-07 | 3.63E-07 | 3.94E-07 | 3.65E-07 | 3.30E-07 | 3.89E-07 | 3.87E-07 | 3.74E-07 |
| $FeCO_3$ | 1.03E-10 | 1.52E-10 | 1.69E-10 | 1.44E-10 | 7.95E-11 | 1.29E-10 | 0.00E+00 | 1.47E-10 | 2.03E-10 | 1.50E-10 | 1.07E-10 | 1.92E-10 | 1.90E-10 | 1.65E-10 |
| $FeCO_3^+$ | 9.82E-22 | 4.73E-22 | 5.04E-22 | 4.56E-22 | 8.38E-22 | 4.27E-22 | 0.00E+00 | 4.63E-22 | 5.66E-22 | 4.68E-22 | 3.81E-22 | 5.47E-22 | 5.42E-22 | 4.98E-22 |
| $FeHCO_3^+$ | 2.62E-08 | 1.43E-08 | 1.53E-08 | 1.38E-08 | 2.21E-08 | 1.28E-08 | 0.00E+00 | 1.40E-08 | 1.74E-08 | 1.42E-08 | 1.13E-08 | 1.68E-08 | 1.66E-08 | 1.51E-08 |
| $HCO_3^-$ | 3.62E-04 | 3.01E-04 | 3.09E-04 | 2.97E-04 | 3.42E-04 | 2.89E-04 | 3.03E-04 | 2.99E-04 | 3.22E-04 | 3.00E-04 | 2.75E-04 | 3.18E-04 | 3.17E-04 | 3.07E-04 |
| $MgCO_3$ | 1.91E-07 | 5.76E-08 | 5.76E-08 | 5.76E-08 | 1.92E-07 | 5.76E-08 | 1.93E-07 | 5.76E-08 | 5.76E-08 | 5.76E-08 | 5.76E-08 | 5.76E-08 | 5.76E-08 | 5.76E-08 |
| $MgHCO_3^+$ | 2.30E-05 | 2.55E-06 | 2.47E-06 | 2.60E-06 | 2.51E-05 | 2.69E-06 | 2.92E-05 | 2.58E-06 | 2.32E-06 | 2.56E-06 | 2.86E-06 | 2.36E-06 | 2.38E-06 | 2.48E-06 |
| $NaCO_3^-$ | 2.37E-09 | 6.05E-09 | 5.93E-09 | 6.12E-09 | 2.48E-09 | 6.25E-09 | 2.69E-09 | 6.09E-09 | 5.70E-09 | 6.07E-09 | 6.47E-09 | 5.77E-09 | 5.79E-09 | 5.95E-09 |
| $NaHCO_3$ | 2.09E-05 | 1.93E-05 | 1.85E-05 | 1.98E-05 | 2.33E-05 | 2.07E-05 | 2.82E-05 | 1.96E-05 | 1.72E-05 | 1.95E-05 | 2.25E-05 | 1.75E-05 | 1.76E-05 | 1.87E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | −1.955E-02 | −1.953E-02 | −1.955E-02 | 0.000E+00 | −1.957E-02 | 0.000E+00 | −1.955E-02 | −1.949E-02 | −1.955E-02 | −1.959E-02 | −1.951E-02 | −1.951E-02 | −1.953E-02 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 6.422E-03 | 2.634E-02 | 2.628E-02 | 2.636E-02 | 6.576E-03 | 2.642E-02 | 6.788E-03 | 2.636E-02 | 2.616E-02 | 2.634E-02 | 2.650E-02 | 2.620E-02 | 2.622E-02 | 2.630E-02 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 6.422E-03 | 6.790E-03 | 6.750E-03 | 6.810E-03 | 6.576E-03 | 6.850E-03 | 6.788E-03 | 6.810E-03 | 6.670E-03 | 6.790E-03 | 6.910E-03 | 6.690E-03 | 6.710E-03 | 6.770E-03 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 3.962E-04 | 1.175E-04 | 1.186E-04 | 1.169E-04 | 3.892E-04 | 1.156E-04 | 3.717E-04 | 1.172E-04 | 1.204E-04 | 1.174E-04 | 1.133E-04 | 1.199E-04 | 1.198E-04 | 1.184E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 4.642E-04 | 3.979E-04 | 4.024E-04 | 3.955E-04 | 4.527E-04 | 3.910E-04 | 4.321E-04 | 3.966E-04 | 4.103E-04 | 3.974E-04 | 3.832E-04 | 4.079E-04 | 4.073E-04 | 4.015E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 7.282E-03 | 7.305E-03 | 7.271E-03 | 7.322E-03 | 7.418E-03 | 7.357E-03 | 7.592E-03 | 7.324E-03 | 7.201E-03 | 7.305E-03 | 7.407E-03 | 7.218E-03 | 7.237E-03 | 7.290E-03 |
| Water, g/cm$^3$ | 0.026 | 0.017 | 0.021 | 0.022 | 0.017 | 0.032 | 0.016 | 0.036 | 0.083 | 0.048 | 0.032 | 0.059 | 0.050 | 0.035 |
| Water, kg/m$^3$ | 25.946 | 16.863 | 20.566 | 21.867 | 17.406 | 32.149 | 16.086 | 35.570 | 83.392 | 47.600 | 31.989 | 59.044 | 50.110 | 35.114 |

Continued…

## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$m^3$ | 1.666E-01 | 1.145E-01 | 1.388E-01 | 1.489E-01 | 1.145E-01 | 2.202E-01 | 1.092E-01 | 2.422E-01 | 5.562E-01 | 3.232E-01 | 2.210E-01 | 3.950E-01 | 3.362E-01 | 2.377E-01 |
| Dissolved $CO_2$, moles/$m^3$ | 1.028E-02 | 1.981E-03 | 2.439E-03 | 2.556E-03 | 6.774E-03 | 3.716E-03 | 5.979E-03 | 4.169E-03 | 1.004E-02 | 5.588E-03 | 3.624E-03 | 7.079E-03 | 6.003E-03 | 4.158E-03 |
| Solution $CO_2$, moles/$m^3$ | 1.204E-02 | 6.710E-03 | 8.275E-03 | 8.648E-03 | 7.879E-03 | 1.257E-02 | 6.951E-03 | 1.411E-02 | 3.421E-02 | 1.891E-02 | 1.226E-02 | 2.408E-02 | 2.041E-02 | 1.410E-02 |
| Total $CO_2$, moles/$m^3$ | 1.890E-01 | 1.232E-01 | 1.495E-01 | 1.601E-01 | 1.291E-01 | 2.365E-01 | 1.221E-01 | 2.605E-01 | 6.005E-01 | 3.477E-01 | 2.369E-01 | 4.262E-01 | 3.626E-01 | 2.560E-01 |
| Mineral $CO_2$, moles/$ft^3$ | 4.718E-03 | 3.242E-03 | 3.931E-03 | 4.217E-03 | 3.241E-03 | 6.236E-03 | 3.092E-03 | 6.859E-03 | 1.575E-02 | 9.152E-03 | 6.259E-03 | 1.119E-02 | 9.521E-03 | 6.732E-03 |
| Dissolved $CO_2$, moles/$ft^3$ | 2.911E-04 | 5.611E-05 | 6.907E-05 | 7.238E-05 | 1.918E-04 | 1.052E-04 | 1.693E-04 | 1.180E-04 | 2.843E-04 | 1.582E-04 | 1.026E-04 | 2.005E-04 | 1.700E-04 | 1.177E-04 |
| Solution $CO_2$, moles/$ft^3$ | 3.411E-04 | 1.900E-04 | 2.343E-04 | 2.449E-04 | 2.231E-04 | 3.559E-04 | 1.968E-04 | 3.995E-04 | 9.688E-04 | 5.356E-04 | 3.471E-04 | 6.820E-04 | 5.779E-04 | 3.992E-04 |
| Total $CO_2$, moles/$ft^3$ | 5.351E-03 | 3.488E-03 | 4.234E-03 | 4.534E-03 | 3.656E-03 | 6.697E-03 | 3.458E-03 | 7.377E-03 | 1.700E-02 | 9.846E-03 | 6.709E-03 | 1.207E-02 | 1.027E-02 | 7.248E-03 |
| Mineral $CO_2$, kg/$m^3$ | 7.333E-03 | 5.039E-03 | 6.110E-03 | 6.554E-03 | 5.037E-03 | 9.692E-03 | 4.806E-03 | 1.066E-02 | 2.448E-02 | 1.422E-02 | 9.728E-03 | 1.738E-02 | 1.480E-02 | 1.046E-02 |
| Dissolved $CO_2$, kg/$m^3$ | 4.524E-04 | 8.720E-05 | 1.073E-04 | 1.125E-04 | 2.981E-04 | 1.636E-04 | 2.631E-04 | 1.835E-04 | 4.419E-04 | 2.459E-04 | 1.595E-04 | 3.116E-04 | 2.642E-04 | 1.830E-04 |
| Solution $CO_2$, kg/$m^3$ | 5.301E-04 | 2.953E-04 | 3.642E-04 | 3.806E-04 | 3.467E-04 | 5.532E-04 | 3.059E-04 | 6.209E-04 | 1.506E-03 | 8.324E-04 | 5.395E-04 | 1.060E-03 | 8.982E-04 | 6.204E-04 |
| Total $CO_2$, kg/$m^3$ | 8.316E-03 | 5.422E-03 | 6.581E-03 | 7.047E-03 | 5.682E-03 | 1.041E-02 | 5.375E-03 | 1.146E-02 | 2.643E-02 | 1.530E-02 | 1.043E-02 | 1.876E-02 | 1.596E-02 | 1.127E-02 |
| Mineral $CO_2$, lb/$ft^3$ | 4.578E-04 | 3.146E-04 | 3.814E-04 | 4.091E-04 | 3.145E-04 | 6.050E-04 | 3.000E-04 | 6.655E-04 | 1.528E-03 | 8.880E-04 | 6.073E-04 | 1.085E-03 | 9.238E-04 | 6.531E-04 |
| Dissolved $CO_2$, lb/$ft^3$ | 2.824E-05 | 5.444E-06 | 6.701E-06 | 7.023E-06 | 1.861E-05 | 1.021E-05 | 1.643E-05 | 1.145E-05 | 2.759E-05 | 1.535E-05 | 9.958E-06 | 1.945E-05 | 1.649E-05 | 1.142E-05 |
| Solution $CO_2$, lb/$ft^3$ | 3.309E-05 | 1.844E-05 | 2.273E-05 | 2.376E-05 | 2.165E-05 | 3.454E-05 | 1.910E-05 | 3.876E-05 | 9.400E-05 | 5.197E-05 | 3.368E-05 | 6.617E-05 | 5.607E-05 | 3.873E-05 |
| Total $CO_2$, lb/$ft^3$ | 5.191E-04 | 3.385E-04 | 4.108E-04 | 4.399E-04 | 3.547E-04 | 6.498E-04 | 3.355E-04 | 7.157E-04 | 1.650E-03 | 9.553E-04 | 6.509E-04 | 1.171E-03 | 9.964E-04 | 7.033E-04 |
| Weighted Average of Zones | | | | | | | | | | | | | | |
| Total Thickness, m | 227.2 | | | | | | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 1.041E-02 | | | | | | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.224E-04 | | | | | | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 6.284E-04 | | | | | | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 1.126E-02 | | | | | | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 6.498E-04 | | | | | | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 1.389E-05 | | | | | | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 3.923E-05 | | | | | | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 7.029E-04 | | | | | | | | | | | | | |

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## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | | | | | | | | |
| pH | 5.602 | 4.546 | 4.548 | 4.543 | 5.597 | 4.540 | 5.594 | 4.542 | 4.551 | 4.544 | 4.548 | 5.602 | 4.547 | 4.547 |
| pE | −1.918 | −0.681 | −0.684 | −0.678 | −1.912 | −0.673 | 9.527 | −0.676 | −0.687 | −0.679 | −0.684 | −1.918 | −0.683 | −0.683 |
| Activity | 0.951 | 0.962 | 0.962 | 0.962 | 0.948 | 0.961 | 0.942 | 0.961 | 0.962 | 0.962 | 0.962 | 0.951 | 0.962 | 0.962 |
| Ionic Strength | 0.937 | 0.512 | 0.500 | 0.518 | 1.032 | 0.529 | 1.226 | 0.516 | 0.478 | 0.502 | 0.486 | 0.911 | 0.486 | 0.496 |
| Total Solution $CO_2$, moles | 1.88E+00 | 1.36E+00 | 1.37E+00 | 1.37E+00 | 1.88E+00 | 1.37E+00 | 1.86E+00 | 1.38E+00 | 1.40E+00 | 1.39E+00 | 1.40E+00 | 1.93E+00 | 1.40E+00 | 1.38E+00 |
| Solution, moles | | | | | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.7400 | 1.2540 | 1.2950 | 1.2410 | 1.4260 | 1.2160 | 0.9478 | 1.2600 | 1.3900 | 1.3100 | 1.3680 | 1.9530 | 1.3700 | 1.3180 |
| Ca | 0.0000 | 0.0434 | 0.0438 | 0.0432 | 0.0000 | 0.0430 | 0.0000 | 0.0434 | 0.0445 | 0.0438 | 0.0443 | 0.0000 | 0.0443 | 0.0439 |
| Cl | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 | 0.4148 |
| Fe | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| K | 0.0022 | 0.0243 | 0.0247 | 0.0241 | 0.0018 | 0.0238 | 0.0013 | 0.0243 | 0.0258 | 0.0249 | 0.0255 | 0.0024 | 0.0255 | 0.0250 |
| Mg | 0.3842 | 0.0016 | 0.0016 | 0.0016 | 0.3250 | 0.0016 | 0.2111 | 0.0016 | 0.0017 | 0.0016 | 0.0017 | 0.4252 | 0.0017 | 0.0016 |
| Na | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3499 |
| S | 0.0555 | 0.0056 | 0.0056 | 0.0056 | 0.0464 | 0.0056 | 0.0054 | 0.0056 | 0.0056 | 0.0056 | 0.0056 | 0.0618 | 0.0056 | 0.0056 |
| Si | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0007 | 0.0008 | 0.0005 | 0.0008 | 0.0009 | 0.0008 | 0.0009 | 0.0009 | 0.0009 | 0.0009 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1071.000 | 494.000 | 880.700 | 0.000 | 448.700 | 0.000 | 448.800 | 30.050 | 218.200 | 85.610 | 2.840 | 52.930 | 276.800 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.122 | 0.000 | 0.000 | 0.000 | 0.915 | 4.913 | 3.266 | 0.000 | 0.468 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 204.500 | 26.350 | 6.424 | 5.137 | 217.700 | 13.520 | 172.400 | 4.563 | 4.188 | 0.000 | 9.264 | 119.300 | 6.279 | 33.780 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 20.460 | 43.680 | 29.420 | 51.040 | 54.590 | 64.920 | 101.900 | 47.830 | 1.380 | 50.150 | 109.500 | 26.400 | 12.310 | 34.590 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 1.350 | 7.664 | 1.067 | 5.037 | 0.143 | 0.436 | 0.000 | 12.990 | 5.088 | 2.400 | 21.280 | 48.780 | 2.954 | 8.579 |
| Quartz | 935.300 | 475.900 | 1084.000 | 205.700 | 1516.000 | 156.200 | 1562.000 | 151.500 | 409.600 | 209.800 | 452.000 | 147.900 | 648.300 | 441.600 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

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## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Final Minerals, moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 1060.000 | 486.600 | 868.000 | 0.000 | 432.300 | 0.000 | 436.900 | 29.680 | 204.700 | 53.290 | 0.000 | 49.840 | 267.600 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | 298.200 | 287.800 | 291.400 | 286.000 | 298.500 | 282.400 | 299.000 | 286.800 | 298.300 | 285.300 | 266.300 | 295.100 | 295.600 | 289.600 |
| Dolomite | 204.600 | 37.270 | 13.790 | 17.900 | 217.800 | 29.880 | 172.500 | 16.530 | 4.540 | 13.460 | 41.570 | 122.100 | 9.365 | 42.900 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 6.689 | 10.960 | 7.393 | 12.800 | 18.080 | 16.140 | 33.890 | 11.990 | 0.384 | 11.660 | 22.510 | 5.530 | 3.117 | 8.217 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 10.710 | 26.180 | 17.630 | 30.600 | 28.320 | 39.050 | 52.720 | 28.680 | 0.802 | 30.980 | 70.610 | 16.910 | 7.363 | 21.200 |
| Phlogopite | 1.570 | 0.000 | 0.000 | 0.000 | 4.433 | 0.000 | 8.414 | 0.000 | 0.000 | 0.000 | 0.000 | 2.193 | 0.000 | 0.000 |
| Pyrite | 1.324 | 7.664 | 1.067 | 5.037 | 0.122 | 0.436 | 0.000 | 12.990 | 5.087 | 2.399 | 21.270 | 48.750 | 2.954 | 8.579 |
| Quartz | 956.700 | 528.300 | 1120.000 | 266.900 | 1573.000 | 234.500 | 1667.000 | 208.800 | 411.300 | 272.700 | 598.100 | 185.000 | 663.000 | 484.500 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.025 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.028 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | −10.940 | −7.376 | −12.780 | 0.000 | −16.370 | 0.000 | −11.980 | −0.366 | −13.470 | −32.320 | −2.840 | −3.100 | −9.136 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −0.122 | 0.000 | 0.000 | 0.000 | −0.915 | -4.913 | −3.266 | 0.000 | −0.468 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | −1.818 | −12.160 | −8.637 | −13.990 | −1.500 | −17.550 | −1.001 | −13.210 | −1.721 | −14.750 | −33.650 | −4.874 | −4.434 | −10.420 |
| Dolomite | 0.030 | 10.930 | 7.362 | 12.770 | 0.030 | 16.360 | 0.030 | 11.970 | 0.352 | 13.460 | 32.300 | 2.870 | 3.086 | 9.122 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −20.460 | −43.680 | −29.420 | −51.040 | −54.590 | −64.920 | −101.900 | −47.830 | −1.380 | −50.150 | −109.500 | −26.400 | −12.310 | −34.590 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 6.689 | 10.960 | 7.393 | 12.800 | 18.080 | 16.140 | 33.890 | 11.990 | 0.384 | 11.660 | 22.510 | 5.530 | 3.117 | 8.217 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 10.710 | 26.180 | 17.630 | 30.600 | 28.320 | 39.050 | 52.720 | 28.680 | 0.802 | 30.980 | 70.610 | 16.910 | 7.363 | 21.200 |
| Phlogopite | 1.570 | 0.000 | 0.000 | 0.000 | 4.433 | 0.000 | 8.414 | 0.000 | 0.000 | 0.000 | 0.000 | 2.193 | 0.000 | 0.000 |
| Pyrite | −0.025 | 0.000 | 0.000 | 0.000 | −0.021 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −0.028 | 0.000 | 0.000 |
| Quartz | 21.420 | 52.410 | 35.310 | 61.250 | 56.640 | 78.270 | 105.400 | 57.400 | 1.655 | 62.920 | 146.200 | 37.090 | 14.780 | 42.910 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.025 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.028 | 0.000 | 0.000 |

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## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Final Solution, moles | | | | | | | | | | | | | | |
| $CaCO_3$ | 5.61E-10 | 6.37E-06 | 6.37E-06 | 6.37E-06 | 5.53E-10 | 6.37E-06 | 5.49E-10 | 6.37E-06 | 6.37E-06 | 6.37E-06 | 6.37E-06 | 5.47E-10 | 6.37E-06 | 6.37E-06 |
| $CaHCO_3^+$ | 5.38E-08 | 6.74E-03 | 6.69E-03 | 6.79E-03 | 5.37E-08 | 6.85E-03 | 5.37E-08 | 6.80E-03 | 6.63E-03 | 6.75E-03 | 6.68E-03 | 5.24E-08 | 6.69E-03 | 6.70E-03 |
| $CO_2$ | 1.22E+00 | 1.32E+00 | 1.33E+00 | 1.33E+00 | 1.21E+00 | 1.33E+00 | 1.18E+00 | 1.34E+00 | 1.35E+00 | 1.35E+00 | 1.36E+00 | 1.25E+00 | 1.36E+00 | 1.34E+00 |
| $CO_3^{2-}$ | 6.27E-05 | 3.94E-07 | 3.96E-07 | 3.93E-07 | 6.39E-05 | 3.91E-07 | 6.62E-05 | 3.93E-07 | 3.99E-07 | 3.95E-07 | 3.98E-07 | 6.38E-05 | 3.98E-07 | 3.96E-07 |
| $FeCO_3$ | 7.98E-08 | 6.48E-09 | 6.70E-09 | 6.38E-09 | 7.98E-08 | 6.22E-09 | 0.00E+00 | 6.45E-09 | 7.14E-09 | 6.69E-09 | 7.00E-09 | 7.98E-08 | 6.99E-09 | 6.78E-09 |
| $FeCO_3^+$ | 3.66E-18 | 4.97E-18 | 5.10E-18 | 4.94E-18 | 3.71E-18 | 4.87E-18 | 0.00E+00 | 5.00E-18 | 5.38E-18 | 5.15E-18 | 5.32E-18 | 3.66E-18 | 5.33E-18 | 5.17E-18 |
| $FeHCO_3^+$ | 6.70E-05 | 6.00E-05 | 6.16E-05 | 5.95E-05 | 6.78E-05 | 5.86E-05 | 0.00E+00 | 6.03E-05 | 6.51E-05 | 6.21E-05 | 6.43E-05 | 6.69E-05 | 6.43E-05 | 6.24E-05 |
| $HCO_3^-$ | 3.81E-01 | 3.29E-02 | 3.31E-02 | 3.29E-02 | 3.80E-01 | 3.28E-02 | 3.77E-01 | 3.31E-02 | 3.37E-02 | 3.34E-02 | 3.37E-02 | 3.91E-01 | 3.37E-02 | 3.33E-02 |
| $MgCO_3$ | 6.54E-04 | 5.76E-08 | 5.76E-08 | 5.76E-08 | 6.63E-04 | 5.76E-08 | 6.68E-04 | 5.76E-08 | 5.76E-08 | 5.76E-08 | 5.76E-08 | 6.71E-04 | 5.76E-08 | 5.76E-08 |
| $MgHCO_3^+$ | 2.59E-01 | 2.51E-04 | 2.50E-04 | 2.53E-04 | 2.66E-01 | 2.56E-04 | 2.70E-01 | 2.54E-04 | 2.47E-04 | 2.52E-04 | 2.49E-04 | 2.65E-01 | 2.50E-04 | 2.50E-04 |
| $NaCO_3^-$ | 7.21E-07 | 5.78E-09 | 5.71E-09 | 5.82E-09 | 8.62E-07 | 5.88E-09 | 1.20E-06 | 5.80E-09 | 5.57E-09 | 5.72E-09 | 5.62E-09 | 6.79E-07 | 5.62E-09 | 5.69E-09 |
| $NaHCO_3$ | 1.96E-02 | 1.84E-03 | 1.81E-03 | 1.86E-03 | 2.36E-02 | 1.90E-03 | 3.32E-02 | 1.86E-03 | 1.76E-03 | 1.83E-03 | 1.79E-03 | 1.84E-02 | 1.79E-03 | 1.81E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | −10.940 | −7.376 | −12.780 | 0.000 | −16.370 | 0.000 | −11.980 | −0.366 | −13.470 | −32.320 | −2.840 | −3.100 | −9.136 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.060 | 21.860 | 14.724 | 25.540 | 0.060 | 32.720 | 0.060 | 23.940 | 0.704 | 26.920 | 64.600 | 5.740 | 6.172 | 18.244 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.025 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.028 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.085 | 10.920 | 7.348 | 12.760 | 0.081 | 16.350 | 0.060 | 11.960 | 0.338 | 13.450 | 32.280 | 2.928 | 3.072 | 9.108 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.218 | 1.321 | 1.328 | 1.326 | 1.211 | 1.330 | 1.177 | 1.339 | 1.353 | 1.349 | 1.355 | 1.253 | 1.360 | 1.340 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.660 | 0.042 | 0.042 | 0.042 | 0.670 | 0.042 | 0.681 | 0.042 | 0.042 | 0.042 | 0.042 | 0.675 | 0.043 | 0.042 |
| Total $CO_2$, moles/kg $H_2O$ | 1.964 | 12.283 | 8.718 | 14.128 | 1.962 | 17.722 | 1.918 | 13.341 | 1.733 | 14.841 | 33.677 | 4.856 | 4.475 | 10.490 |
| Water, g/cm$^3$ | 0.026 | 0.017 | 0.021 | 0.022 | 0.017 | 0.032 | 0.016 | 0.036 | 0.083 | 0.048 | 0.032 | 0.059 | 0.050 | 0.035 |
| Water, kg/m$^3$ | 25.946 | 16.863 | 20.566 | 21.867 | 17.406 | 32.149 | 16.086 | 35.570 | 83.392 | 47.600 | 31.989 | 59.044 | 50.110 | 35.114 |

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## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$m^3$ | 2.213 | 184.147 | 151.120 | 279.021 | 1.405 | 525.634 | 0.970 | 425.418 | 28.145 | 640.214 | 1032.595 | 172.890 | 153.937 | 319.819 |
| Dissolved $CO_2$, moles/$m^3$ | 31.603 | 22.276 | 27.312 | 28.995 | 21.078 | 42.758 | 18.933 | 47.628 | 112.830 | 64.212 | 43.345 | 73.983 | 68.149 | 47.053 |
| Solution $CO_2$, moles/$m^3$ | 17.131 | 0.705 | 0.863 | 0.916 | 11.670 | 1.347 | 10.951 | 1.497 | 3.538 | 2.013 | 1.357 | 39.839 | 2.130 | 1.480 |
| Total $CO_2$, moles/$m^3$ | 50.947 | 207.128 | 179.295 | 308.932 | 34.154 | 569.739 | 30.855 | 474.543 | 144.513 | 706.439 | 1077.297 | 286.711 | 224.217 | 368.352 |
| Mineral $CO_2$, moles/$ft^3$ | 0.063 | 5.214 | 4.279 | 7.901 | 0.040 | 14.884 | 0.027 | 12.047 | 0.797 | 18.129 | 29.240 | 4.896 | 4.359 | 9.056 |
| Dissolved $CO_2$, moles/$ft^3$ | 0.895 | 0.631 | 0.773 | 0.821 | 0.597 | 1.211 | 0.536 | 1.349 | 3.195 | 1.818 | 1.227 | 2.095 | 1.930 | 1.332 |
| Solution $CO_2$, moles/$ft^3$ | 0.485 | 0.020 | 0.024 | 0.026 | 0.330 | 0.038 | 0.310 | 0.042 | 0.100 | 0.057 | 0.038 | 1.128 | 0.060 | 0.042 |
| Total $CO_2$, moles/$ft^3$ | 1.443 | 5.865 | 5.077 | 8.748 | 0.967 | 16.133 | 0.874 | 13.438 | 4.092 | 20.004 | 30.506 | 8.119 | 6.349 | 10.431 |
| Mineral $CO_2$, kg/$m^3$ | 0.097 | 8.104 | 6.651 | 12.280 | 0.062 | 23.133 | 0.043 | 18.723 | 1.239 | 28.176 | 45.444 | 7.609 | 6.775 | 14.075 |
| Dissolved $CO_2$, kg/$m^3$ | 1.391 | 0.980 | 1.202 | 1.276 | 0.928 | 1.882 | 0.833 | 2.096 | 4.966 | 2.826 | 1.908 | 3.256 | 2.999 | 2.071 |
| Solution $CO_2$, kg/$m^3$ | 0.754 | 0.031 | 0.038 | 0.040 | 0.514 | 0.059 | 0.482 | 0.066 | 0.156 | 0.089 | 0.060 | 1.753 | 0.094 | 0.065 |
| Total $CO_2$, kg/$m^3$ | 2.242 | 9.116 | 7.891 | 13.596 | 1.503 | 25.074 | 1.358 | 20.885 | 6.360 | 31.090 | 47.412 | 12.618 | 9.868 | 16.211 |
| Mineral $CO_2$, lb/$ft^3$ | 0.006 | 0.506 | 0.415 | 0.767 | 0.004 | 1.444 | 0.003 | 1.169 | 0.077 | 1.759 | 2.837 | 0.475 | 0.423 | 0.879 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.087 | 0.061 | 0.075 | 0.080 | 0.058 | 0.117 | 0.052 | 0.131 | 0.310 | 0.176 | 0.119 | 0.203 | 0.187 | 0.129 |
| Solution $CO_2$, lb/$ft^3$ | 0.047 | 0.002 | 0.002 | 0.003 | 0.032 | 0.004 | 0.030 | 0.004 | 0.010 | 0.006 | 0.004 | 0.109 | 0.006 | 0.004 |
| Total $CO_2$, lb/$ft^3$ | 0.140 | 0.569 | 0.493 | 0.849 | 0.094 | 1.565 | 0.085 | 1.304 | 0.397 | 1.941 | 2.960 | 0.788 | 0.616 | 1.012 |
| Weighted Average of Zones | | | | | | | | | | | | | | |
| Total Thickness, m | 227.229 | | | | | | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 11.875 | | | | | | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.046 | | | | | | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.235 | | | | | | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 14.157 | | | | | | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.741 | | | | | | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.128 | | | | | | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.015 | | | | | | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.884 | | | | | | | | | | | | | |

Continued…

## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | | | | | | | |
| pH | −0.503 | −1.996 | −1.994 | −1.992 | −0.476 | −1.982 | −0.423 | −1.996 | −2.025 | −1.996 | −1.951 | −0.967 | −2.021 | −2.005 |
| pE | 0.666 | 2.395 | 2.392 | 2.390 | 0.635 | 2.379 | 0.438 | 2.395 | 2.430 | 2.395 | 2.339 | 1.191 | 2.424 | 2.405 |
| Activity | −0.034 | −0.021 | −0.021 | −0.020 | −0.034 | −0.020 | −0.032 | −0.022 | −0.025 | −0.021 | −0.016 | −0.035 | −0.024 | −0.022 |
| Ionic Strength | 0.455 | −0.041 | −0.053 | −0.060 | 0.449 | −0.099 | 0.401 | −0.051 | 0.034 | −0.057 | −0.242 | 0.448 | 0.018 | −0.022 |
| Total Solution $CO_2$, moles | 1.877 | 1.362 | 1.369 | 1.367 | 1.880 | 1.371 | 1.856 | 1.380 | 1.395 | 1.390 | 1.398 | 1.927 | 1.402 | 1.381 |
| Solution, moles | | | | | | | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.739 | 1.254 | 1.295 | 1.241 | 1.425 | 1.216 | 0.947 | 1.260 | 1.389 | 1.310 | 1.368 | 1.952 | 1.370 | 1.318 |
| Ca | -0.027 | 0.007 | 0.007 | 0.007 | −0.027 | 0.006 | −0.027 | 0.007 | 0.008 | 0.007 | 0.008 | −0.037 | 0.008 | 0.007 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K | 0.002 | 0.024 | 0.025 | 0.024 | 0.001 | 0.024 | 0.001 | 0.024 | 0.026 | 0.025 | 0.025 | 0.002 | 0.025 | 0.025 |
| Mg | 0.373 | 0.000 | 0.000 | 0.000 | 0.314 | 0.000 | 0.200 | 0.000 | 0.000 | 0.000 | 0.000 | 0.424 | 0.000 | 0.000 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.050 | 0.000 | 0.000 | 0.000 | 0.041 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.056 | 0.000 | 0.000 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Final Minerals, moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | −11.000 | −7.400 | −12.700 | 0.000 | −16.300 | 0.000 | −11.900 | −0.350 | −13.400 | −32.300 | −2.820 | −3.080 | −9.100 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | 298.200 | 287.800 | 291.400 | 286.000 | 298.500 | 282.400 | 299.000 | 286.800 | 298.300 | 285.300 | 266.300 | 295.100 | 295.600 | 289.600 |
| Dolomite | 0.100 | 10.910 | 7.353 | 12.750 | 0.100 | 16.350 | 0.000 | 11.954 | 0.339 | 13.447 | 32.293 | 2.800 | 3.073 | 9.110 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.131 | −3.600 | −2.413 | −4.210 | −0.110 | −5.420 | −0.070 | −3.950 | −0.075 | −4.450 | −10.720 | −1.090 | −0.986 | −3.003 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.140 | 3.610 | 2.430 | 4.230 | 0.120 | 5.430 | 0.070 | 3.960 | 0.088 | 4.460 | 10.740 | 1.090 | 0.999 | 3.010 |
| Phlogopite | −0.133 | −3.638 | −2.450 | −4.251 | −0.114 | −5.449 | −0.075 | −3.984 | −0.113 | −4.482 | −10.760 | −1.093 | −1.024 | −3.037 |
| Pyrite | −0.026 | 0.000 | 0.000 | 0.000 | −0.021 | 0.000 | 0.000 | 0.000 | −0.001 | −0.001 | −0.010 | −0.030 | 0.000 | 0.000 |
| Quartz | 0.300 | 7.300 | 5.000 | 8.500 | 1.000 | 10.900 | 0.000 | 7.900 | 0.300 | 8.900 | 21.500 | 2.200 | 2.000 | 6.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.025 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.028 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | −10.920 | −7.356 | −12.760 | 0.000 | −16.350 | 0.000 | −11.960 | −0.347 | −13.450 | −32.300 | −2.820 | −3.080 | −9.116 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21279 | 1.818 | 12.160 | 8.637 | 13.990 | 1.500 | 17.550 | 1.001 | 13.210 | 1.721 | 14.750 | 33.650 | 4.874 | 4.434 | 10.420 |
| Dolomite | 0.027 | 10.917 | 7.349 | 12.757 | 0.027 | 16.347 | 0.027 | 11.957 | 0.339 | 13.447 | 32.287 | 2.857 | 3.073 | 9.109 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.131 | −3.600 | −2.413 | −4.210 | −0.110 | −5.420 | −0.070 | −3.950 | −0.075 | −4.450 | −10.720 | −1.090 | −0.986 | −3.003 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.140 | 3.610 | 2.430 | 4.230 | 0.120 | 5.430 | 0.070 | 3.960 | 0.088 | 4.460 | 10.740 | 1.090 | 0.999 | 3.010 |
| Phlogopite | −0.133 | −3.638 | −2.450 | −4.251 | −0.114 | −5.449 | −0.075 | −3.984 | −0.113 | −4.482 | −10.760 | −1.093 | −1.024 | −3.037 |
| Pyrite | −0.025 | 0.000 | 0.000 | 0.000 | −0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −0.028 | 0.000 | 0.000 |
| Quartz | 0.270 | 7.270 | 4.900 | 8.510 | 0.230 | 10.900 | 0.100 | 7.970 | 0.226 | 8.960 | 21.500 | 2.190 | 2.050 | 6.070 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.025 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.028 | 0.000 | 0.000 |

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## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Final Solution, moles | | | | | | | | | | | | | | |
| $CaCO_3$ | −1.92E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | −1.91E-06 | 0.00E+00 | −1.90E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | −6.37E-06 | 0.00E+00 | 0.00E+00 |
| $CaHCO_3^+$ | −5.58E-05 | 6.67E-03 | 6.62E-03 | 6.72E-03 | −6.05E-05 | 6.78E-03 | −6.98E-05 | 6.73E-03 | 6.57E-03 | 6.68E-03 | 6.60E-03 | −6.33E-05 | 6.63E-03 | 6.63E-03 |
| $CO_2$ | 1.22E+00 | 1.32E+00 | 1.33E+00 | 1.33E+00 | 1.21E+00 | 1.33E+00 | 1.18E+00 | 1.34E+00 | 1.35E+00 | 1.35E+00 | 1.35E+00 | 1.25E+00 | 1.36E+00 | 1.34E+00 |
| $CO_3^{2-}$ | 6.26E-05 | 2.79E-08 | 1.96E-08 | 3.26E-08 | 6.37E-05 | 4.19E-08 | 6.61E-05 | 3.06E-08 | 5.00E-09 | 3.08E-08 | 6.77E-08 | 6.34E-05 | 1.04E-08 | 2.20E-08 |
| $FeCO_3$ | 7.96E-08 | 6.33E-09 | 6.53E-09 | 6.24E-09 | 7.97E-08 | 6.09E-09 | 0.00E+00 | 6.30E-09 | 6.94E-09 | 6.54E-09 | 6.89E-09 | 7.96E-08 | 6.80E-09 | 6.61E-09 |
| $FeCO_3^+$ | 3.66E-18 | 4.97E-18 | 5.09E-18 | 4.94E-18 | 3.71E-18 | 4.87E-18 | 0.00E+00 | 5.00E-18 | 5.38E-18 | 5.15E-18 | 5.32E-18 | 3.65E-18 | 5.32E-18 | 5.16E-18 |
| $FeHCO_3^+$ | 6.70E-05 | 6.00E-05 | 6.16E-05 | 5.95E-05 | 6.78E-05 | 5.85E-05 | 0.00E+00 | 6.02E-05 | 6.51E-05 | 6.21E-05 | 6.42E-05 | 6.68E-05 | 6.43E-05 | 6.24E-05 |
| $HCO_3^-$ | 3.80E-01 | 3.26E-02 | 3.28E-02 | 3.26E-02 | 3.80E-01 | 3.26E-02 | 3.77E-01 | 3.28E-02 | 3.34E-02 | 3.31E-02 | 3.34E-02 | 3.90E-01 | 3.34E-02 | 3.30E-02 |
| $MgCO_3$ | 6.54E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.63E-04 | 0.00E+00 | 6.68E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.70E-04 | 0.00E+00 | 0.00E+00 |
| $MgHCO_3^+$ | 2.59E-01 | 2.49E-04 | 2.47E-04 | 2.51E-04 | 2.66E-01 | 2.53E-04 | 2.70E-01 | 2.51E-04 | 2.45E-04 | 2.49E-04 | 2.46E-04 | 2.65E-01 | 2.47E-04 | 2.48E-04 |
| $NaCO_3^-$ | 7.18E-07 | −2.68E-10 | −2.15E-10 | −2.99E-10 | 8.59E-07 | −3.69E-10 | 1.20E-06 | −2.86E-10 | −1.32E-10 | −3.46E-10 | −8.49E-10 | 6.73E-07 | −1.62E-10 | −2.61E-10 |
| $NaHCO_3$ | 1.95E-02 | 1.82E-03 | 1.79E-03 | 1.84E-03 | 2.36E-02 | 1.87E-03 | 3.31E-02 | 1.84E-03 | 1.75E-03 | 1.81E-03 | 1.77E-03 | 1.84E-02 | 1.78E-03 | 1.79E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | −10.920 | −7.356 | −12.760 | 0.000 | −16.350 | 0.000 | −11.960 | −0.347 | −13.450 | −32.300 | −2.820 | −3.080 | −9.116 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.054 | 21.834 | 14.698 | 25.514 | 0.054 | 32.694 | 0.054 | 23.914 | 0.678 | 26.894 | 64.574 | 5.714 | 6.146 | 18.218 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.025 | 0.000 | 0.000 | 0.000 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.028 | 0.000 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.079 | 10.913 | 7.341 | 12.753 | 0.074 | 16.343 | 0.054 | 11.953 | 0.331 | 13.443 | 32.273 | 2.921 | 3.065 | 9.101 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.218 | 1.321 | 1.328 | 1.326 | 1.211 | 1.330 | 1.177 | 1.339 | 1.353 | 1.349 | 1.355 | 1.253 | 1.360 | 1.340 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.660 | 0.041 | 0.042 | 0.041 | 0.670 | 0.042 | 0.680 | 0.042 | 0.042 | 0.042 | 0.042 | 0.674 | 0.042 | 0.042 |
| Total $CO_2$, moles/kg $H_2O$ | 1.956 | 12.276 | 8.711 | 14.121 | 1.955 | 17.715 | 1.911 | 13.334 | 1.726 | 14.834 | 33.670 | 4.849 | 4.467 | 10.483 |
| Water, g/cm$^3$ | 0.026 | 0.017 | 0.021 | 0.022 | 0.017 | 0.032 | 0.016 | 0.036 | 0.083 | 0.048 | 0.032 | 0.059 | 0.050 | 0.035 |
| Water, kg/m$^3$ | 25.946 | 16.863 | 20.566 | 21.867 | 17.406 | 32.149 | 16.086 | 35.570 | 83.392 | 47.600 | 31.989 | 59.044 | 50.110 | 35.114 |

Continued…

## Table B-58. Summary of MT API 21279 Aquifer Calculation Results (continued)

| Formation Zone | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Zone 13 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$m^3$ | 2.047 | 184.032 | 150.981 | 278.872 | 1.291 | 525.414 | 0.861 | 425.175 | 27.589 | 639.891 | 1032.374 | 172.495 | 153.601 | 319.581 |
| Dissolved $CO_2$, moles/$m^3$ | 31.592 | 22.274 | 27.309 | 28.993 | 21.071 | 42.754 | 18.927 | 47.624 | 112.820 | 64.206 | 43.341 | 73.975 | 68.143 | 47.049 |
| Solution $CO_2$, moles/$m^3$ | 17.119 | 0.699 | 0.855 | 0.907 | 11.662 | 1.335 | 10.945 | 1.483 | 3.504 | 1.994 | 1.345 | 39.814 | 2.110 | 1.466 |
| Total $CO_2$, moles/$m^3$ | 50.758 | 207.005 | 179.145 | 308.772 | 34.025 | 569.502 | 30.733 | 474.282 | 143.912 | 706.091 | 1077.060 | 286.285 | 223.854 | 368.096 |
| Mineral $CO_2$, moles/$ft^3$ | 0.058 | 5.211 | 4.275 | 7.897 | 0.037 | 14.878 | 0.024 | 12.040 | 0.781 | 18.120 | 29.234 | 4.885 | 4.350 | 9.050 |
| Dissolved $CO_2$, moles/$ft^3$ | 0.895 | 0.631 | 0.773 | 0.821 | 0.597 | 1.211 | 0.536 | 1.349 | 3.195 | 1.818 | 1.227 | 2.095 | 1.930 | 1.332 |
| Solution $CO_2$, moles/$ft^3$ | 0.485 | 0.020 | 0.024 | 0.026 | 0.330 | 0.038 | 0.310 | 0.042 | 0.099 | 0.056 | 0.038 | 1.127 | 0.060 | 0.042 |
| Total $CO_2$, moles/$ft^3$ | 1.437 | 5.862 | 5.073 | 8.744 | 0.963 | 16.127 | 0.870 | 13.430 | 4.075 | 19.994 | 30.499 | 8.107 | 6.339 | 10.423 |
| Mineral $CO_2$, kg/$m^3$ | 0.090 | 8.099 | 6.645 | 12.273 | 0.057 | 23.123 | 0.038 | 18.712 | 1.214 | 28.162 | 45.435 | 7.592 | 6.760 | 14.065 |
| Dissolved $CO_2$, kg/$m^3$ | 1.390 | 0.980 | 1.202 | 1.276 | 0.927 | 1.882 | 0.833 | 2.096 | 4.965 | 2.826 | 1.907 | 3.256 | 2.999 | 2.071 |
| Solution $CO_2$, kg/$m^3$ | 0.753 | 0.031 | 0.038 | 0.040 | 0.513 | 0.059 | 0.482 | 0.065 | 0.154 | 0.088 | 0.059 | 1.752 | 0.093 | 0.065 |
| Total $CO_2$, kg/$m^3$ | 2.234 | 9.110 | 7.884 | 13.589 | 1.497 | 25.064 | 1.353 | 20.873 | 6.334 | 31.075 | 47.401 | 12.599 | 9.852 | 16.200 |
| Mineral $CO_2$, lb/$ft^3$ | 0.006 | 0.506 | 0.415 | 0.766 | 0.004 | 1.444 | 0.002 | 1.168 | 0.076 | 1.758 | 2.836 | 0.474 | 0.422 | 0.878 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.087 | 0.061 | 0.075 | 0.080 | 0.058 | 0.117 | 0.052 | 0.131 | 0.310 | 0.176 | 0.119 | 0.203 | 0.187 | 0.129 |
| Solution $CO_2$, lb/$ft^3$ | 0.047 | 0.002 | 0.002 | 0.002 | 0.032 | 0.004 | 0.030 | 0.004 | 0.010 | 0.005 | 0.004 | 0.109 | 0.006 | 0.004 |
| Total $CO_2$, lb/$ft^3$ | 0.139 | 0.569 | 0.492 | 0.848 | 0.093 | 1.565 | 0.084 | 1.303 | 0.395 | 1.940 | 2.959 | 0.787 | 0.615 | 1.011 |
| Weighted Average of Zones | | | | | | | | | | | | | | |
| Total Thickness, m | 227.229 | | | | | | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 11.865 | | | | | | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 2.046 | | | | | | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.235 | | | | | | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 14.145 | | | | | | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.741 | | | | | | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.128 | | | | | | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.015 | | | | | | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.883 | | | | | | | | | | | | | |

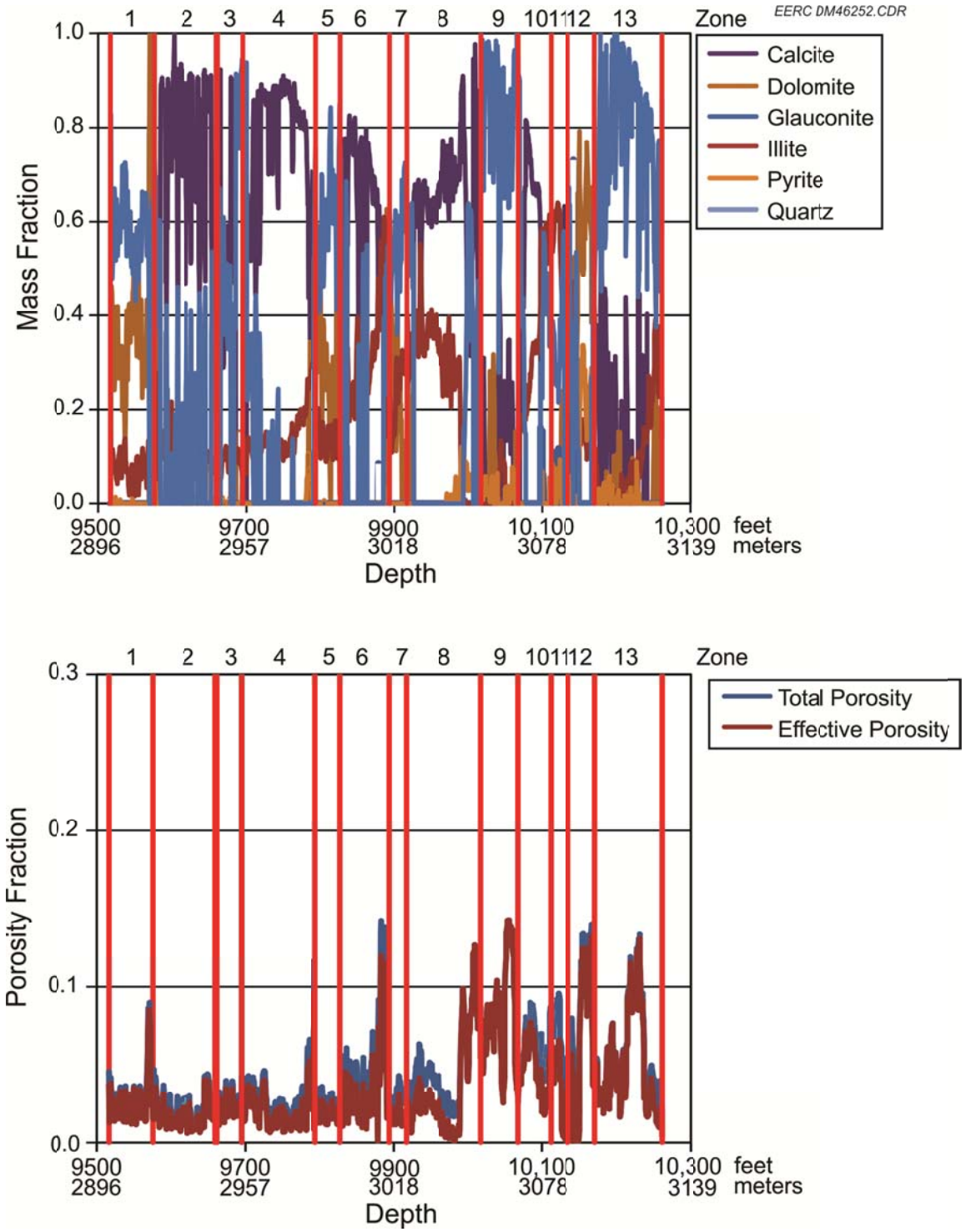



Figure B-17. MT API 21279 mineral composition and porosity as a function of depth.

**ND 7087**

The water composition used for ND 7087 is from the ND 6436 well 49 miles (79 km) to the east. Mineral data were available for 35% of the COSS represented in this well. The total COSS thickness is 738 feet (225 meters), as the well penetrated into the Precambrian.

Zones 1, 4, and 12 contain mainly quartz, illite, and glauconite. Zones 2, 3, 6, 7, 9, 11 comprise mainly quartz with moderate illite present. Zone 5 is predominantly quartz, and Zone 8 is roughly equal amounts of illite and calcite. Zone 10 comprises quartz and calcite in a 2:1 ratio. Zones 1, 6, and 8 have very low porosities of 0.006, 0.005, and 0.003, respectively. The other zones range in porosity from 0.012 to 0.108.

The PHREEQC calculations for Zones 6, 8, and 9 did not converge. These thicknesses have been omitted from the calculation of the weighted average for $CO_2$ interactions. Less kaolinite and phlogopite form, with corresponding increases in quartz and muscovite. The dissolution of calcite and the concurrent formation of dolomite comprise most of the $CO_2$ interaction with the minerals when calcite is present. A small amount of pyrite dissolves, and a corresponding amount of siderite forms.

The amount of $CO_2$ dissolved in the formation water ranges from 0.69 to 1.05 moles/kg (30.4 to 46.2 g/kg) and is the dominant component of the $CO_2$ interaction with the formation water. The total average amount of $CO_2$ reacting with the minerals and formation water is 4.8 kg/m$^3$ (0.3 lb/ft$^3$) of formation rock.

## Table B-59. Average Mineral and Porosity Values for the ND 7087 Aquifer Zones

Well Name: ND 7087
API Identification: 33-023-00171-0000
State Identification: ND 7087

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 11,040 | 3365.0 | Average | 0.032 | 0.006 | 0.111 | 0.000 | 0.000 | 0.000 | 0.104 | 0.231 | 0.000 | 0.000 | 0.000 | 0.000 | 0.555 | 0.000 |
| End | 11,076 | 3376.0 | Minimum | 0.008 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 36 | 11.0 | Maximum | 0.069 | 0.018 | 0.389 | 0.000 | 0.000 | 0.000 | 0.486 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 73 | | Standard deviation | 0.020 | 0.005 | 0.142 | 0.000 | 0.000 | 0.000 | 0.140 | 0.362 | 0.000 | 0.000 | 0.000 | 0.000 | 0.322 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 11,076 | 3376.0 | Average | 0.063 | 0.018 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.217 | 0.000 | 0.000 | 0.000 | 0.000 | 0.783 | 0.000 |
| End | 11,135 | 3394.0 | Minimum | 0.032 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 59 | 18.0 | Maximum | 0.088 | 0.051 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 116 | | Standard deviation | 0.013 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.412 | 0.000 | 0.000 | 0.000 | 0.000 | 0.412 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 11,135 | 3394.0 | Average | 0.042 | 0.036 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.111 | 0.000 | 0.003 | 0.000 | 0.007 | 0.879 | 0.000 |
| End | 11,152 | 3399.1 | Minimum | 0.022 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.693 | 0.000 |
| Thickness | 17 | 5.2 | Maximum | 0.059 | 0.059 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.300 | 0.000 | 0.079 | 0.000 | 0.031 | 1.000 | 0.000 |
| Number of Values | 34 | | Standard deviation | 0.010 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.106 | 0.000 | 0.014 | 0.000 | 0.011 | 0.108 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 11,152 | 3399.1 | Average | 0.029 | 0.012 | 0.000 | 0.000 | 0.000 | 0.008 | 0.104 | 0.327 | 0.000 | 0.032 | 0.000 | 0.001 | 0.528 | 0.000 |
| End | 11,188 | 3410.1 | Minimum | 0.015 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.082 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 36 | 11.0 | Maximum | 0.094 | 0.075 | 0.000 | 0.000 | 0.000 | 0.609 | 0.392 | 0.511 | 0.000 | 0.293 | 0.000 | 0.050 | 0.873 | 0.000 |
| Number of Values | 72 | | Standard deviation | 0.012 | 0.014 | 0.000 | 0.000 | 0.000 | 0.072 | 0.129 | 0.095 | 0.000 | 0.078 | 0.000 | 0.006 | 0.174 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 11,188 | 3410.1 | Average | 0.074 | 0.074 | 0.000 | 0.000 | 0.000 | 0.033 | 0.035 | 0.001 | 0.000 | 0.000 | 0.005 | 0.044 | 0.881 | 0.000 |
| End | 11,286 | 3440.0 | Minimum | 0.020 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 98 | 29.9 | Maximum | 0.138 | 0.138 | 0.040 | 0.000 | 0.000 | 0.769 | 0.317 | 0.209 | 0.000 | 0.000 | 0.185 | 0.156 | 1.000 | 0.000 |
| Number of Values | 195 | | Standard deviation | 0.037 | 0.037 | 0.003 | 0.000 | 0.000 | 0.107 | 0.052 | 0.015 | 0.000 | 0.000 | 0.024 | 0.044 | 0.129 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 11,286 | 3440.0 | Average | 0.019 | 0.005 | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.282 | 0.000 | 0.004 | 0.000 | 0.023 | 0.687 | 0.000 |
| End | 11,474 | 3497.3 | Minimum | 0.008 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.106 | 0.000 | 0.000 | 0.000 | 0.000 | 0.379 | 0.000 |
| Thickness | 188 | 57.3 | Maximum | 0.066 | 0.051 | 0.000 | 0.000 | 0.000 | 0.348 | 0.075 | 0.532 | 0.000 | 0.344 | 0.000 | 0.085 | 0.839 | 0.000 |
| Number of Values | 376 | | Standard deviation | 0.007 | 0.006 | 0.000 | 0.000 | 0.000 | 0.034 | 0.004 | 0.064 | 0.000 | 0.030 | 0.000 | 0.021 | 0.066 | 0.000 |

Continued…

## Table B-59. Average Mineral and Porosity Values for the ND 7087 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Shale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 11,474 | 3497.3 | Average | 0.057 | 0.042 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.307 | 0.000 | 0.002 | 0.000 | 0.046 | 0.645 | 0.000 |
| End | 11,572 | 3527.2 | Minimum | 0.020 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.054 | 0.000 | 0.000 | 0.000 | 0.000 | 0.442 | 0.000 |
| Thickness | 98 | 29.9 | Maximum | 0.124 | 0.114 | 0.000 | 0.000 | 0.000 | 0.000 | 0.053 | 0.525 | 0.000 | 0.117 | 0.000 | 0.210 | 0.942 | 0.000 |
| Number of Values | 198 | | Standard deviation | 0.034 | 0.038 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.129 | 0.000 | 0.013 | 0.000 | 0.054 | 0.118 | 0.000 |
| Zone 8 | | | | | | | | | | | | | | | | | |
| Start | 11,572 | 3527.2 | Average | 0.025 | 0.003 | 0.000 | 0.506 | 0.000 | 0.000 | 0.030 | 0.442 | 0.000 | 0.005 | 0.000 | 0.012 | 0.005 | 0.000 |
| End | 11,627 | 3543.9 | Minimum | 0.021 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.228 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 55 | 16.8 | Maximum | 0.039 | 0.016 | 0.000 | 0.615 | 0.000 | 0.000 | 0.277 | 0.543 | 0.000 | 0.123 | 0.000 | 0.113 | 0.528 | 0.000 |
| Number of Values | 109 | | Standard deviation | 0.003 | 0.004 | 0.000 | 0.084 | 0.000 | 0.000 | 0.060 | 0.058 | 0.000 | 0.020 | 0.000 | 0.027 | 0.051 | 0.000 |
| Zone 9 | | | | | | | | | | | | | | | | | |
| Start | 11,627 | 3543.9 | Average | 0.030 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.008 | 0.406 | 0.000 | 0.002 | 0.000 | 0.025 | 0.560 | 0.000 |
| End | 11,672 | 3557.6 | Minimum | 0.020 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.472 | 0.000 |
| Thickness | 45 | 13.7 | Maximum | 0.061 | 0.053 | 0.000 | 0.000 | 0.000 | 0.000 | 0.361 | 0.471 | 0.000 | 0.056 | 0.000 | 0.103 | 0.636 | 0.000 |
| Number of Values | 89 | | Standard deviation | 0.011 | 0.012 | 0.000 | 0.000 | 0.000 | 0.000 | 0.041 | 0.054 | 0.000 | 0.009 | 0.000 | 0.023 | 0.037 | 0.000 |
| Zone 10 | | | | | | | | | | | | | | | | | |
| Start | 11,672 | 3557.6 | Average | 0.108 | 0.108 | 0.016 | 0.275 | 0.000 | 0.035 | 0.051 | 0.002 | 0.000 | 0.000 | 0.000 | 0.062 | 0.559 | 0.000 |
| End | 11,686 | 3561.9 | Minimum | 0.051 | 0.051 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 14 | 4.3 | Maximum | 0.150 | 0.150 | 0.185 | 1.000 | 0.000 | 0.319 | 0.269 | 0.042 | 0.000 | 0.000 | 0.000 | 0.140 | 0.917 | 0.000 |
| Number of Values | 28 | | Standard deviation | 0.037 | 0.038 | 0.048 | 0.416 | 0.000 | 0.088 | 0.072 | 0.008 | 0.000 | 0.000 | 0.000 | 0.059 | 0.375 | 0.000 |
| Zone 11 | | | | | | | | | | | | | | | | | |
| Start | 11,686 | 3561.9 | Average | 0.054 | 0.044 | 0.000 | 0.000 | 0.000 | 0.016 | 0.031 | 0.189 | 0.000 | 0.005 | 0.000 | 0.036 | 0.723 | 0.000 |
| End | 11,736 | 3577.1 | Minimum | 0.014 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.431 | 0.000 |
| Thickness | 50 | 15.2 | Maximum | 0.154 | 0.154 | 0.000 | 0.000 | 0.000 | 0.446 | 0.272 | 0.377 | 0.000 | 0.106 | 0.000 | 0.131 | 0.956 | 0.000 |
| Number of Values | 102 | | Standard deviation | 0.048 | 0.055 | 0.000 | 0.000 | 0.000 | 0.071 | 0.067 | 0.148 | 0.000 | 0.020 | 0.000 | 0.044 | 0.140 | 0.000 |
| Zone 12 | | | | | | | | | | | | | | | | | |
| Start | 11,736 | 3577.1 | Average | 0.093 | 0.090 | 0.000 | 0.000 | 0.000 | 0.000 | 0.117 | 0.054 | 0.000 | 0.000 | 0.000 | 0.012 | 0.817 | 0.000 |
| End | 11,778 | 3589.9 | Minimum | 0.069 | 0.060 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.577 | 0.000 |
| Thickness | 42 | 12.8 | Maximum | 0.116 | 0.108 | 0.000 | 0.000 | 0.000 | 0.000 | 0.321 | 0.423 | 0.000 | 0.000 | 0.000 | 0.102 | 0.975 | 0.000 |
| Number of Values | 84 | | Standard deviation | 0.009 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.085 | 0.130 | 0.000 | 0.000 | 0.000 | 0.017 | 0.102 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 11,040 | 3365.0 | Average | 0.046 | 0.031 | 0.006 | 0.043 | 0.000 | 0.007 | 0.027 | 0.233 | 0.000 | 0.004 | 0.001 | 0.025 | 0.654 | 0.000 |
| End | 11,778 | 3589.9 | Minimum | 0.008 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 738 | 224.9 | Maximum | 0.154 | 0.154 | 0.389 | 1.000 | 0.000 | 0.769 | 0.486 | 1.000 | 0.000 | 0.344 | 0.185 | 0.210 | 1.000 | 0.000 |
| Number of Values | 1476 | | Standard deviation | 0.034 | 0.040 | 0.040 | 0.149 | 0.000 | 0.052 | 0.069 | 0.209 | 0.000 | 0.026 | 0.009 | 0.037 | 0.273 | 0.000 |

## Table B-60. ND 7087 Mineral Summary

Well Name: ND 7087
API Identification: 33-023-00171-0000
State Identification: ND 7087

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, ft | 11,040 | 11,076 | 11,135 | 11,152 | 11,188 | 11,286 | 11,474 | 11,572 | 11,627 | 11,672 | 11,686 | 11,736 | 11,040 |
| End, ft | 11,076 | 11,135 | 11,152 | 11,188 | 11,286 | 11,474 | 11,572 | 11,627 | 11,672 | 11,686 | 11,736 | 11,778 | 11,778 |
| Thickness, ft | 36.0 | 59.0 | 17.0 | 36.0 | 98.0 | 188.0 | 98.0 | 55.0 | 45.0 | 14.0 | 50.0 | 42.0 | 738.0 |
| Start, m | 3365.0 | 3376.0 | 3394.0 | 3399.1 | 3410.1 | 3440.0 | 3497.3 | 3527.2 | 3543.9 | 3557.6 | 3561.9 | 3577.1 | 3365.0 |
| End, m | 3376.0 | 3394.0 | 3399.1 | 3410.1 | 3440.0 | 3497.3 | 3527.2 | 3543.9 | 3557.6 | 3561.9 | 3577.1 | 3589.9 | 3589.9 |
| Thickness, m | 11.0 | 18.0 | 5.2 | 11.0 | 29.9 | 57.3 | 29.9 | 16.8 | 13.7 | 4.3 | 15.2 | 12.8 | 224.9 |
| Temperature, °F | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 |
| Temperature, °C | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 |
| Pressure, psi | 6805 | 6814 | 6821 | 6825 | 6837 | 6862 | 6888 | 6901 | 6910 | 6915 | 6921 | 6929 | 6868 |
| Pressure, kPa | 46,922 | 46,980 | 47,026 | 47,058 | 47,140 | 47,315 | 47,489 | 47,582 | 47,643 | 47,679 | 47,718 | 47,774 | 47,350 |
| Effective Porosity, fraction | 0.006 | 0.018 | 0.036 | 0.012 | 0.074 | 0.005 | 0.042 | 0.003 | 0.010 | 0.108 | 0.044 | 0.090 | 0.031 |
| Mass Fraction | | | | | | | | | | | | | |
| Ankerite | 0.111 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.016 | 0.000 | 0.000 | 0.006 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.506 | 0.000 | 0.275 | 0.000 | 0.000 | 0.043 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.008 | 0.033 | 0.004 | 0.000 | 0.000 | 0.000 | 0.035 | 0.016 | 0.000 | 0.007 |
| Glauconite | 0.104 | 0.000 | 0.000 | 0.104 | 0.035 | 0.000 | 0.001 | 0.030 | 0.008 | 0.051 | 0.031 | 0.117 | 0.027 |
| Illite | 0.231 | 0.217 | 0.111 | 0.327 | 0.001 | 0.282 | 0.307 | 0.442 | 0.406 | 0.002 | 0.189 | 0.054 | 0.233 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.003 | 0.032 | 0.000 | 0.004 | 0.002 | 0.005 | 0.002 | 0.000 | 0.005 | 0.000 | 0.004 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| Pyrite | 0.000 | 0.000 | 0.007 | 0.001 | 0.044 | 0.023 | 0.046 | 0.012 | 0.025 | 0.062 | 0.036 | 0.012 | 0.025 |
| Quartz | 0.555 | 0.783 | 0.879 | 0.528 | 0.881 | 0.687 | 0.645 | 0.005 | 0.560 | 0.559 | 0.723 | 0.817 | 0.654 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-61. Summary of ND 7087 Aquifer Calculation Results

Well Name: ND 7087
API Identification: 33-023-00171-0000
State Identification: ND 7087

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, m | 3365.0 | 3376.0 | 3394.0 | 3399.1 | 3410.1 | 3440.0 | 3497.3 | 3527.2 | 3543.9 | 3557.6 | 3561.9 | 3577.1 | 3365.0 |
| End, m | 3376.0 | 3394.0 | 3399.1 | 3410.1 | 3440.0 | 3497.3 | 3527.2 | 3543.9 | 3557.6 | 3561.9 | 3577.1 | 3589.9 | 3589.9 |
| Thickness, m | 11.0 | 18.0 | 5.2 | 11.0 | 29.9 | 57.3 | 29.9 | 16.8 | 13.7 | 4.3 | 15.2 | 12.8 | 224.9 |
| Start, ft | 11,040.0 | 11,076.0 | 11,135.0 | 11,152.0 | 11,188.0 | 11,286.0 | 11,474.0 | 11,572.0 | 11,627.0 | 11,672.0 | 11,686.0 | 11,736.0 | 11,040.0 |
| End, ft | 11,076.0 | 11,135.0 | 11,152.0 | 11,188.0 | 11,286.0 | 11,474.0 | 11,572.0 | 11,627.0 | 11,672.0 | 11,686.0 | 11,736.0 | 11,778.0 | 11,778.0 |
| Thickness, ft | 36.0 | 59.0 | 17.0 | 36.0 | 98.0 | 188.0 | 98.0 | 55.0 | 45.0 | 14.0 | 50.0 | 42.0 | 738.0 |
| **Minerals Without $CO_2$** | | | | | | | | | | | | | |
| pH | 5.519 | 5.374 | 5.407 | 5.452 | 5.252 | NA | 5.391 | NA | NA | 5.648 | 5.414 | 5.309 | 5.914 |
| pE | 8.776 | 9.152 | −2.091 | −2.101 | −1.852 | NA | −2.069 | NA | NA | −2.292 | −2.063 | −1.980 | −2.620 |
| Activity | 0.930 | 0.777 | 0.836 | 0.885 | 0.847 | NA | 0.812 | NA | NA | 0.849 | 0.845 | 0.851 | 0.834 |
| Ionic Strength | 2.224 | 5.362 | 4.377 | 3.354 | 4.120 | NA | 4.808 | NA | NA | 4.147 | 4.212 | 4.067 | 4.452 |
| Total Solution $CO_2$, moles | 1.133E-03 | 4.175E-04 | 2.688E-04 | 9.940E-04 | 2.035E-03 | NA | 3.148E-04 | NA | NA | 1.157E-03 | 9.106E-04 | 2.434E-04 | 4.665E-04 |
| Solution, moles | | | | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 | NA | NA | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0027 | 0.0003 | 0.0003 | 0.0014 | 0.0021 | NA | 0.0003 | NA | NA | 0.0012 | 0.0009 | 0.0003 | 0.0004 |
| Ca | 0.5333 | 0.5320 | 0.5320 | 0.5327 | 0.5330 | NA | 0.5320 | NA | NA | 0.7105 | 0.5324 | 0.5320 | 0.7504 |
| Cl | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | NA | 5.9200 | NA | NA | 5.9200 | 5.9200 | 5.9200 | 5.9200 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 | NA | NA | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0059 | 0.0016 | 0.0025 | 0.0037 | 0.1701 | NA | 0.0021 | NA | NA | 0.0826 | 0.0026 | 0.0675 | 0.0007 |
| Mg | 0.2379 | 0.2408 | 0.2404 | 0.2394 | 0.1559 | NA | 0.2406 | NA | NA | 0.0221 | 0.2401 | 0.2078 | 0.0230 |
| Na | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | NA | 4.3740 | NA | NA | 4.3740 | 4.3740 | 4.3740 | 4.3740 |
| S | 0.0008 | 0.0008 | 0.0008 | 0.0009 | 0.0009 | NA | 0.0008 | NA | NA | 0.0008 | 0.0009 | 0.0008 | 0.0008 |
| Si | 0.0028 | 0.0007 | 0.0011 | 0.0016 | 0.0012 | NA | 0.0009 | NA | NA | 0.0012 | 0.0011 | 0.0012 | 0.0011 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 | NA | NA | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 64.290 | 0.000 | 0.000 | 36.350 |
| Celadonite | 115.000 | 0.000 | 0.000 | 52.540 | 2.802 | NA | 0.142 | NA | NA | 2.757 | 4.254 | 7.400 | 5.466 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 286.700 | 0.000 | 0.000 | 9.954 | 6.285 | NA | 0.000 | NA | NA | 6.513 | 5.060 | 0.000 | 6.174 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 286.000 | 80.070 | 20.660 | 184.500 | 0.096 | NA | 50.530 | NA | NA | 0.092 | 29.200 | 3.817 | 51.920 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |

* Calculation did not converge to a solution.

Continued…

**Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kaolinite | 0.000 | 0.000 | 0.894 | 27.020 | 0.000 | NA | 0.473 | NA | NA | 0.000 | 1.220 | 0.000 | 1.279 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.442 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.145 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 4.054 | 1.734 | 12.620 | NA | 24.060 | NA | NA | 12.170 | 17.680 | 2.646 | 17.540 |
| Quartz | 4397.000 | 1849.000 | 1045.000 | 1906.000 | 503.300 | NA | 678.700 | NA | NA | 217.700 | 712.200 | 369.400 | 930.100 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 63.940 | 0.000 | 0.000 | 35.910 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 2.815 | NA | 0.000 | NA | NA | 2.725 | 0.000 | 5.809 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 286.700 | 0.000 | 0.000 | 9.953 | 6.284 | NA | 0.000 | NA | NA | 6.691 | 5.059 | 0.000 | 6.392 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 18.350 | 26.370 | 7.460 | 53.190 | 0.000 | NA | 16.900 | NA | NA | 0.000 | 7.797 | 0.000 | 14.620 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.178 | 0.000 | 0.000 | 0.000 |
| Muscovite | 224.700 | 41.590 | 10.900 | 130.600 | 0.511 | NA | 26.420 | NA | NA | 0.022 | 18.150 | 3.180 | 30.840 |
| Phlogopite | 62.150 | 6.640 | 1.690 | 32.860 | 0.000 | NA | 4.226 | NA | NA | 0.000 | 3.819 | 0.827 | 6.116 |
| Pyrite | 0.000 | 0.000 | 4.054 | 1.734 | 12.620 | NA | 24.060 | NA | NA | 12.170 | 17.680 | 2.646 | 17.540 |
| Quartz | 4962.000 | 1932.000 | 1066.000 | 2219.000 | 503.400 | NA | 731.300 | NA | NA | 217.500 | 752.400 | 377.100 | 996.500 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | −0.356 | 0.000 | 0.000 | −0.437 |
| Celadonite | −115.000 | 0.000 | 0.000 | −52.540 | 0.013 | NA | −0.142 | NA | NA | −0.032 | −4.254 | −1.590 | −5.466 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | −0.001 | 0.000 | 0.000 | −0.001 | −0.001 | NA | 0.000 | NA | NA | 0.177 | 0.000 | 0.000 | 0.218 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −286.000 | −80.070 | −20.660 | −184.500 | −0.096 | NA | −50.530 | NA | NA | −0.092 | −29.200 | −3.817 | −51.920 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 18.350 | 26.370 | 6.567 | 26.170 | 0.000 | NA | 16.430 | NA | NA | 0.000 | 6.577 | 0.000 | 13.340 |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.178 | 0.000 | 0.000 | 0.000 |
| Muscovite | 224.700 | 41.590 | 10.900 | 130.600 | 0.069 | NA | 26.420 | NA | NA | 0.022 | 18.150 | 3.180 | 30.690 |
| Phlogopite | 62.150 | 6.640 | 1.690 | 32.860 | 0.000 | NA | 4.226 | NA | NA | 0.000 | 3.819 | 0.827 | 6.116 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 564.000 | 82.800 | 21.410 | 313.300 | 0.074 | NA | 52.610 | NA | NA | −0.149 | 40.160 | 7.695 | 66.460 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | | | | | |
| $CaCO_3$ | 1.52E-06 | 7.28E-07 | 4.49E-07 | 1.53E-06 | 1.87E-06 | NA | 5.38E-07 | NA | NA | 5.75E-06 | 1.51E-06 | 2.70E-07 | 5.75E-06 |
| $CaHCO_3^+$ | 1.61E-04 | 8.46E-05 | 5.26E-05 | 1.76E-04 | 3.21E-04 | NA | 6.30E-05 | NA | NA | 3.95E-04 | 1.76E-04 | 4.06E-05 | 2.08E-04 |
| $CO_2$ | 6.84E-04 | 2.18E-04 | 1.45E-04 | 5.64E-04 | 1.34E-03 | NA | 1.67E-04 | NA | NA | 4.94E-04 | 4.96E-04 | 1.50E-04 | 1.25E-04 |
| $CO_3^{2-}$ | 3.18E-08 | 6.44E-09 | 4.92E-09 | 2.21E-08 | 2.19E-08 | NA | 5.34E-09 | NA | NA | 5.02E-08 | 1.72E-08 | 3.20E-09 | 4.39E-08 |
| $FeCO_3$ | | | 9.66E-13 | 3.08E-11 | 2.02E-11 | NA | 8.45E-13 | NA | NA | 2.74E-11 | 1.08E-11 | 6.65E-13 | 9.75E-12 |
| $FeCO_3^+$ | | | 2.48E-23 | 8.38E-22 | 9.14E-22 | NA | 2.20E-23 | NA | NA | 4.50E-22 | 2.97E-22 | 2.26E-23 | 7.35E-23 |
| $FeHCO_3^+$ | | | 1.07E-09 | 3.35E-08 | 3.27E-08 | NA | 9.38E-10 | NA | NA | 1.78E-08 | 1.19E-08 | 9.50E-10 | 3.35E-09 |
| $HCO_3^-$ | 1.76E-04 | 3.99E-05 | 2.96E-05 | 1.28E-04 | 1.91E-04 | NA | 3.26E-05 | NA | NA | 1.76E-04 | 1.03E-04 | 2.45E-05 | 8.19E-05 |
| $MgCO_3$ | 1.66E-07 | 9.03E-08 | 5.05E-08 | 1.65E-07 | 1.34E-07 | NA | 6.27E-08 | NA | NA | 4.39E-08 | 1.67E-07 | 2.58E-08 | 4.39E-08 |
| $MgHCO_3^+$ | 8.01E-05 | 4.79E-05 | 2.71E-05 | 8.63E-05 | 1.05E-04 | NA | 3.36E-05 | NA | NA | 1.38E-05 | 8.95E-05 | 1.77E-05 | 7.26E-06 |
| $NaCO_3^-$ | 6.44E-10 | 3.25E-10 | 1.94E-10 | 6.53E-10 | 8.07E-10 | NA | 2.35E-10 | NA | NA | 1.85E-09 | 6.48E-10 | 1.16E-10 | 1.76E-09 |
| $NaHCO_3$ | 2.97E-05 | 2.66E-05 | 1.35E-05 | 3.79E-05 | 7.88E-05 | NA | 1.76E-05 | NA | NA | 7.28E-05 | 4.40E-05 | 9.89E-06 | 3.84E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | NA | 0.000E+00 | NA | NA | −3.559E-01 | 0.000E+00 | 0.000E+00 | −4.365E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | −2.530E-03 | 0.000E+00 | 0.000E+00 | −1.319E-03 | −1.938E-03 | NA | 0.000E+00 | NA | NA | 3.548E-01 | −8.154E-04 | 0.000E+00 | 4.362E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | NA | 0.000E+00 | NA | NA | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | −2.530E-03 | 0.000E+00 | 0.000E+00 | −1.319E-03 | −1.938E-03 | NA | 0.000E+00 | NA | NA | −1.100E-03 | −8.154E-04 | 0.000E+00 | −3.000E-04 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 6.844E-04 | 2.177E-04 | 1.454E-04 | 5.644E-04 | 1.337E-03 | NA | 1.674E-04 | NA | NA | 4.938E-04 | 4.961E-04 | 1.503E-04 | 1.249E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 4.484E-04 | 1.998E-04 | 1.233E-04 | 4.296E-04 | 6.976E-04 | NA | 1.474E-04 | NA | NA | 6.628E-04 | 4.145E-04 | 9.310E-05 | 3.417E-04 |
| Total $CO_2$, moles/kg $H_2O$ | −1.397E-03 | 4.175E-04 | 2.687E-04 | −3.250E-04 | 9.623E-05 | NA | 3.148E-04 | NA | NA | 5.662E-05 | 9.519E-05 | 2.434E-04 | 1.666E-04 |
| Water, $g/cm^3$ | 0.006 | 0.018 | 0.036 | 0.012 | 0.074 | NA | 0.042 | NA | NA | 0.108 | 0.044 | 0.090 | 0.031 |
| Water, $kg/m^3$ | 5.666 | 18.326 | 35.783 | 12.319 | 74.097 | NA | 41.949 | NA | NA | 107.739 | 44.320 | 90.423 | 30.929 |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, moles/$m^3$ | −1.433E-02 | 0.000E+00 | 0.000E+00 | −1.625E-02 | −1.436E-01 | NA | 0.000E+00 | NA | NA | −1.185E-01 | −3.614E-02 | 0.000E+00 | −9.279E-03 |
| Dissolved $CO_2$, moles/$m^3$ | 3.878E-03 | 3.990E-03 | 5.203E-03 | 6.953E-03 | 9.907E-02 | NA | 7.022E-03 | NA | NA | 5.320E-02 | 2.199E-02 | 1.359E-02 | 3.863E-03 |
| Solution $CO_2$, moles/$m^3$ | 2.541E-03 | 3.662E-03 | 4.414E-03 | 5.292E-03 | 5.169E-02 | NA | 6.184E-03 | NA | NA | 7.141E-02 | 1.837E-02 | 8.418E-03 | 1.057E-02 |
| Total $CO_2$, moles/$m^3$ | −7.916E-03 | 7.651E-03 | 9.616E-03 | −4.004E-03 | 7.131E-03 | NA | 1.321E-02 | NA | NA | 6.100E-03 | 4.219E-03 | 2.201E-02 | 5.152E-03 |
| Mineral $CO_2$, moles/$ft^3$ | −4.059E-04 | 0.000E+00 | 0.000E+00 | −4.601E-04 | −4.067E-03 | NA | 0.000E+00 | NA | NA | −3.356E-03 | −1.023E-03 | 0.000E+00 | −2.627E-04 |
| Dissolved $CO_2$, moles/$ft^3$ | 1.098E-04 | 1.130E-04 | 1.473E-04 | 1.969E-04 | 2.805E-03 | NA | 1.988E-04 | NA | NA | 1.507E-03 | 6.226E-04 | 3.848E-04 | 1.094E-04 |
| Solution $CO_2$, moles/$ft^3$ | 7.195E-05 | 1.037E-04 | 1.250E-04 | 1.499E-04 | 1.464E-03 | NA | 1.751E-04 | NA | NA | 2.022E-03 | 5.202E-04 | 2.384E-04 | 2.993E-04 |
| Total $CO_2$, moles/$ft^3$ | −2.242E-04 | 2.167E-04 | 2.723E-04 | −1.134E-04 | 2.019E-04 | NA | 3.740E-04 | NA | NA | 1.727E-04 | 1.195E-04 | 6.232E-04 | 1.459E-04 |
| Mineral $CO_2$, kg/$m^3$ | −6.309E-04 | 0.000E+00 | 0.000E+00 | −7.151E-04 | −6.321E-03 | NA | 0.000E+00 | NA | NA | −5.216E-03 | −1.590E-03 | 0.000E+00 | −4.083E-04 |
| Dissolved $CO_2$, kg/$m^3$ | 1.707E-04 | 1.756E-04 | 2.290E-04 | 3.060E-04 | 4.360E-03 | NA | 3.090E-04 | NA | NA | 2.341E-03 | 9.677E-04 | 5.981E-04 | 1.700E-04 |
| Solution $CO_2$, kg/$m^3$ | 1.118E-04 | 1.611E-04 | 1.942E-04 | 2.329E-04 | 2.275E-03 | NA | 2.722E-04 | NA | NA | 3.143E-03 | 8.085E-04 | 3.705E-04 | 4.651E-04 |
| Total $CO_2$, kg/$m^3$ | −3.484E-04 | 3.367E-04 | 4.232E-04 | −1.762E-04 | 3.138E-04 | NA | 5.812E-04 | NA | NA | 2.685E-04 | 1.857E-04 | 9.686E-04 | 2.268E-04 |
| Mineral $CO_2$, lb/$ft^3$ | −3.938E-05 | 0.000E+00 | 0.000E+00 | −4.464E-05 | −3.946E-04 | NA | 0.000E+00 | NA | NA | −3.256E-04 | −9.929E-05 | 0.000E+00 | −2.549E-05 |
| Dissolved $CO_2$, lb/$ft^3$ | 1.065E-05 | 1.096E-05 | 1.429E-05 | 1.910E-05 | 2.722E-04 | NA | 1.929E-05 | NA | NA | 1.462E-04 | 6.041E-05 | 3.734E-05 | 1.061E-05 |
| Solution $CO_2$, lb/$ft^3$ | 6.981E-06 | 1.006E-05 | 1.213E-05 | 1.454E-05 | 1.420E-04 | NA | 1.699E-05 | NA | NA | 1.962E-04 | 5.047E-05 | 2.313E-05 | 2.903E-05 |
| Total $CO_2$, lb/$ft^3$ | −2.175E-05 | 2.102E-05 | 2.642E-05 | −1.100E-05 | 1.959E-05 | NA | 3.628E-05 | NA | NA | 1.676E-05 | 1.159E-05 | 6.047E-05 | 1.416E-05 |
| Weighted Average of Zones | | | | | | | | | | | | | |
| Total Thickness, m | 137.2 | | | | | | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | −1.823E-03 | | | | | | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.323E-03 | | | | | | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 8.329E-04 | | | | | | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 3.325E-04 | | | | | | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | −1.138E-04 | | | | | | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 8.258E-05 | | | | | | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 5.200E-05 | | | | | | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 2.076E-05 | | | | | | | | | | | | |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | | | | | | | |
| pH | 5.285 | 5.149 | 5.181 | 5.224 | 4.963 | NA | 5.166 | NA | NA | 4.459 | 5.187 | 5.059 | 4.049 |
| pE | 9.016 | 9.380 | −1.556 | −1.608 | −1.314 | NA | −1.537 | NA | NA | −0.745 | −1.564 | −1.423 | −0.323 |
| Activity | 0.907 | 0.761 | 0.818 | 0.865 | 0.829 | NA | 0.794 | NA | NA | 0.825 | 0.826 | 0.831 | 0.846 |
| Ionic Strength | 2.285 | 5.445 | 4.390 | 3.360 | 4.054 | NA | 4.848 | NA | NA | 3.891 | 4.222 | 4.074 | 3.912 |
| Total Solution $CO_2$, moles | 1.44E+00 | 1.07E+00 | 1.18E+00 | 1.30E+00 | 1.03E+00 | NA | 1.15E+00 | NA | NA | 8.95E-01 | 1.22E+00 | 1.13E+00 | 8.77E-01 |
| Solution, moles | | | | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 | NA | NA | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 3.4650 | 0.6785 | 1.1080 | 1.8500 | 1.0530 | NA | 0.9153 | NA | NA | 0.9315 | 1.2270 | 1.1720 | 0.9724 |
| Ca | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 | NA | NA | 0.1153 | 0.0000 | 0.0000 | 0.7310 |
| Cl | 5.9200 | 5.9200 | 5.9200 | 5.9200 | 5.9200 | NA | 5.9200 | NA | NA | 5.9200 | 5.9200 | 5.9200 | 5.9200 |
| Fe | 0.0000 | 0.0000 | 0.0004 | 0.0002 | 0.0009 | NA | 0.0006 | NA | NA | 0.0008 | 0.0003 | 0.0006 | 0.0005 |
| K | 0.0097 | 0.0027 | 0.0041 | 0.0061 | 0.4081 | NA | 0.0034 | NA | NA | 1.3450 | 0.0043 | 0.1245 | 0.0694 |
| Mg | 1.2430 | 0.8930 | 0.9746 | 1.0840 | 0.6807 | NA | 0.9449 | NA | NA | 0.0037 | 0.9936 | 0.8745 | 0.0232 |
| Na | 4.3740 | 4.3740 | 4.3740 | 4.3740 | 4.3740 | NA | 4.3740 | NA | NA | 4.3740 | 4.3740 | 4.3740 | 4.3740 |
| S | 0.0008 | 0.0008 | 0.0262 | 0.0412 | 0.0128 | NA | 0.0221 | NA | NA | 0.0024 | 0.0287 | 0.0196 | 0.0018 |
| Si | 0.0028 | 0.0007 | 0.0011 | 0.0016 | 0.0012 | NA | 0.0009 | NA | NA | 0.0012 | 0.0011 | 0.0012 | 0.0013 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | NA | 0.0000 | NA | NA | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 64.290 | 0.000 | 0.000 | 36.350 |
| Celadonite | 115.000 | 0.000 | 0.000 | 52.540 | 2.802 | NA | 0.142 | NA | NA | 2.757 | 4.254 | 7.400 | 5.466 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | NA | 300.000 | NA | NA | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 286.700 | 0.000 | 0.000 | 9.954 | 6.285 | NA | 0.000 | NA | NA | 6.513 | 5.060 | 0.000 | 6.174 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 286.000 | 80.070 | 20.660 | 184.500 | 0.096 | NA | 50.530 | NA | NA | 0.092 | 29.200 | 3.817 | 51.920 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.894 | 27.020 | 0.000 | NA | 0.473 | NA | NA | 0.000 | 1.220 | 0.000 | 1.279 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.442 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.145 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 4.054 | 1.734 | 12.620 | NA | 24.060 | NA | NA | 12.170 | 17.680 | 2.646 | 17.540 |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 4397.000 | 1849.000 | 1045.000 | 1906.000 | 503.300 | NA | 678.700 | NA | NA | 217.700 | 712.200 | 369.400 | 930.100 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 61.790 | 0.000 | 0.000 | 17.580 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 1.757 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 6.280 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | 295.500 | 298.300 | 297.800 | 297.100 | 297.900 | NA | 298.000 | NA | NA | 295.700 | 297.700 | 297.800 | 280.700 |
| Dolomite | 287.300 | 0.532 | 0.532 | 10.490 | 6.817 | NA | 0.532 | NA | NA | 9.434 | 5.592 | 0.532 | 24.740 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 17.840 | 25.970 | 7.041 | 52.740 | 0.000 | NA | 16.490 | NA | NA | 0.000 | 7.371 | 0.000 | 8.604 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.701 | NA | 0.000 | NA | NA | 1.009 | 0.000 | 0.000 | 0.000 |
| Muscovite | 225.200 | 41.990 | 11.320 | 131.000 | 0.630 | NA | 26.840 | NA | NA | 0.653 | 18.570 | 3.209 | 36.890 |
| Phlogopite | 61.640 | 6.245 | 1.268 | 32.400 | 0.000 | NA | 3.814 | NA | NA | 0.000 | 3.391 | 0.270 | 0.000 |
| Pyrite | 0.000 | 0.000 | 4.041 | 1.714 | 12.610 | NA | 24.050 | NA | NA | 12.170 | 17.660 | 2.637 | 17.540 |
| Quartz | 4963.000 | 1933.000 | 1067.000 | 2220.000 | 505.200 | NA | 732.100 | NA | NA | 224.000 | 753.300 | 376.800 | 1009.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.012 | 0.020 | 0.005 | NA | 0.010 | NA | NA | 0.000 | 0.014 | 0.009 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | −2.504 | 0.000 | 0.000 | −18.770 |
| Celadonite | −115.000 | 0.000 | 0.000 | −52.540 | −1.045 | NA | −0.142 | NA | NA | −2.757 | −4.254 | −1.119 | −5.466 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | −4.529 | −1.742 | −2.184 | −2.934 | −2.122 | NA | −1.989 | NA | NA | −4.268 | −2.305 | −2.245 | −19.340 |
| Dolomite | 0.532 | 0.532 | 0.532 | 0.532 | 0.532 | NA | 0.532 | NA | NA | 2.920 | 0.532 | 0.532 | 18.570 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −286.000 | −80.070 | −20.660 | −184.500 | −0.096 | NA | −50.530 | NA | NA | −0.092 | −29.200 | −3.817 | −51.920 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 17.840 | 25.970 | 6.147 | 25.710 | 0.000 | NA | 16.020 | NA | NA | 0.000 | 6.151 | 0.000 | 7.325 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.701 | NA | 0.000 | NA | NA | 1.009 | 0.000 | 0.000 | 0.000 |
| Muscovite | 225.200 | 41.990 | 11.320 | 131.000 | 0.188 | NA | 26.840 | NA | NA | 0.653 | 18.570 | 3.209 | 36.740 |
| Phlogopite | 61.640 | 6.245 | 1.268 | 32.400 | 0.000 | NA | 3.814 | NA | NA | 0.000 | 3.391 | 0.270 | 0.000 |
| Pyrite | 0.000 | 0.000 | −0.013 | −0.020 | −0.006 | NA | −0.011 | NA | NA | −0.001 | −0.014 | −0.009 | −0.001 |
| Quartz | 565.100 | 83.590 | 22.260 | 314.300 | 1.846 | NA | 53.430 | NA | NA | 6.362 | 41.020 | 7.395 | 78.700 |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.012 | 0.020 | 0.005 | NA | 0.010 | NA | NA | 0.000 | 0.014 | 0.009 | 0.000 |
| Final Solution, moles | | | | | | | | | | | | | |
| $CaCO_3$ | 9.72E-10 | 8.63E-10 | 9.04E-10 | 9.37E-10 | 3.39E-09 | NA | 8.73E-10 | NA | NA | 5.75E-06 | 8.89E-10 | 1.74E-09 | 5.75E-06 |
| $CaHCO_3^+$ | 1.76E-07 | 1.67E-07 | 1.78E-07 | 1.82E-07 | 1.14E-06 | NA | 1.71E-07 | NA | NA | 6.23E-03 | 1.75E-07 | 4.67E-07 | 1.60E-02 |
| $CO_2$ | 1.05E+00 | 6.88E-01 | 7.90E-01 | 9.06E-01 | 8.29E-01 | NA | 7.56E-01 | NA | NA | 8.62E-01 | 8.26E-01 | 8.44E-01 | 8.50E-01 |
| $CO_3^{2-}$ | 1.63E-05 | 7.11E-06 | 9.23E-06 | 1.21E-05 | 3.48E-06 | NA | 8.37E-06 | NA | NA | 3.47E-07 | 9.89E-06 | 5.55E-06 | 5.34E-08 |
| $FeCO_3$ | | | 4.78E-08 | 4.78E-08 | 4.78E-08 | NA | 4.78E-08 | NA | NA | 5.12E-09 | 4.78E-08 | 4.78E-08 | 6.56E-10 |
| $FeCO_3^+$ | | | 4.19E-18 | 4.04E-18 | 7.54E-18 | NA | 4.22E-18 | NA | NA | 3.03E-18 | 4.18E-18 | 5.85E-18 | 1.02E-18 |
| $FeHCO_3^+$ | | | 8.94E-05 | 8.80E-05 | 1.52E-04 | NA | 8.90E-05 | NA | NA | 5.26E-05 | 8.93E-05 | 1.21E-04 | 1.73E-05 |
| $HCO_3^-$ | 1.53E-01 | 7.37E-02 | 9.35E-02 | 1.19E-01 | 5.93E-02 | NA | 8.57E-02 | NA | NA | 1.91E-02 | 9.95E-02 | 7.56E-02 | 7.52E-03 |
| $MgCO_3$ | 2.59E-04 | 2.92E-04 | 2.79E-04 | 2.69E-04 | 7.44E-05 | NA | 2.89E-04 | NA | NA | 4.39E-08 | 2.83E-04 | 1.45E-04 | 4.39E-08 |
| $MgHCO_3^+$ | 2.15E-01 | 2.58E-01 | 2.51E-01 | 2.38E-01 | 1.14E-01 | NA | 2.59E-01 | NA | NA | 2.17E-04 | 2.55E-01 | 1.77E-01 | 5.56E-04 |
| $NaCO_3^-$ | 3.24E-07 | 3.43E-07 | 3.54E-07 | 3.52E-07 | 1.25E-07 | NA | 3.56E-07 | NA | NA | 1.23E-08 | 3.63E-07 | 1.99E-07 | 1.83E-09 |
| $NaHCO_3$ | 2.57E-02 | 4.76E-02 | 4.17E-02 | 3.46E-02 | 2.37E-02 | NA | 4.51E-02 | NA | NA | 7.33E-03 | 4.15E-02 | 3.02E-02 | 2.81E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | −2.504 | 0.000 | 0.000 | −18.770 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.064 | 1.064 | 1.064 | 1.064 | 1.064 | NA | 1.064 | NA | NA | 5.840 | 1.064 | 1.064 | 37.140 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.012 | 0.020 | 0.005 | NA | 0.010 | NA | NA | 0.000 | 0.014 | 0.009 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.064 | 1.064 | 1.076 | 1.084 | 1.069 | NA | 1.074 | NA | NA | 3.336 | 1.078 | 1.073 | 18.370 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.046 | 0.688 | 0.790 | 0.906 | 0.829 | NA | 0.756 | NA | NA | 0.862 | 0.826 | 0.844 | 0.850 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.394 | 0.380 | 0.387 | 0.392 | 0.197 | NA | 0.390 | NA | NA | 0.033 | 0.397 | 0.283 | 0.027 |
| Total $CO_2$, moles/kg $H_2O$ | 2.504 | 2.131 | 2.253 | 2.382 | 2.095 | NA | 2.220 | NA | NA | 4.231 | 2.300 | 2.200 | 19.247 |
| Water, $g/cm^3$ | 0.006 | 0.018 | 0.036 | 0.012 | 0.074 | 0.005 | 0.042 | 0.003 | 0.010 | 0.108 | 0.044 | 0.090 | 0.031 |
| Water, $kg/m^3$ | 5.666 | 18.326 | 35.783 | 12.319 | 74.097 | 5.166 | 41.949 | 2.860 | 9.870 | 107.739 | 44.320 | 90.423 | 30.929 |
| Mineral $CO_2$, $moles/m^3$ | 6.028 | 19.499 | 38.512 | 13.354 | 79.219 | NA | 45.057 | NA | NA | 359.416 | 47.760 | 97.008 | 568.158 |
| Dissolved $CO_2$, $moles/m^3$ | 5.926 | 12.599 | 28.265 | 11.165 | 61.404 | NA | 31.692 | NA | NA | 92.860 | 36.613 | 76.308 | 26.295 |
| Solution $CO_2$, $moles/m^3$ | 2.232 | 6.964 | 13.843 | 4.829 | 14.607 | NA | 16.368 | NA | NA | 3.544 | 17.573 | 25.606 | 0.831 |
| Total $CO_2$, $moles/m^3$ | 14.187 | 39.063 | 80.620 | 29.348 | 155.230 | NA | 93.117 | NA | NA | 455.820 | 101.946 | 198.922 | 595.284 |
| Mineral $CO_2$, $moles/ft^3$ | 0.171 | 0.552 | 1.091 | 0.378 | 2.243 | NA | 1.276 | NA | NA | 10.178 | 1.352 | 2.747 | 16.089 |
| Dissolved $CO_2$, $moles/ft^3$ | 0.168 | 0.357 | 0.800 | 0.316 | 1.739 | NA | 0.897 | NA | NA | 2.630 | 1.037 | 2.161 | 0.745 |
| Solution $CO_2$, $moles/ft^3$ | 0.063 | 0.197 | 0.392 | 0.137 | 0.414 | NA | 0.463 | NA | NA | 0.100 | 0.498 | 0.725 | 0.024 |
| Total $CO_2$, $moles/ft^3$ | 0.402 | 1.106 | 2.283 | 0.831 | 4.396 | NA | 2.637 | NA | NA | 12.907 | 2.887 | 5.633 | 16.857 |
| Mineral $CO_2$, $kg/m^3$ | 0.265 | 0.858 | 1.695 | 0.588 | 3.486 | NA | 1.983 | NA | NA | 15.818 | 2.102 | 4.269 | 25.005 |
| Dissolved $CO_2$, $kg/m^3$ | 0.261 | 0.554 | 1.244 | 0.491 | 2.702 | NA | 1.395 | NA | NA | 4.087 | 1.611 | 3.358 | 1.157 |
| Solution $CO_2$, $kg/m^3$ | 0.098 | 0.306 | 0.609 | 0.213 | 0.643 | NA | 0.720 | NA | NA | 0.156 | 0.773 | 1.127 | 0.037 |
| Total $CO_2$, $kg/m^3$ | 0.624 | 1.719 | 3.548 | 1.292 | 6.832 | NA | 4.098 | NA | NA | 20.061 | 4.487 | 8.755 | 26.198 |

* Calculation did not converge to a solution.

Continued…

**Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, lb/ft$^3$ | 0.017 | 0.054 | 0.106 | 0.037 | 0.218 | NA | 0.124 | NA | NA | 0.987 | 0.131 | 0.267 | 1.561 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.016 | 0.035 | 0.078 | 0.031 | 0.169 | NA | 0.087 | NA | NA | 0.255 | 0.101 | 0.210 | 0.072 |
| Solution $CO_2$, lb/ft$^3$ | 0.006 | 0.019 | 0.038 | 0.013 | 0.040 | NA | 0.045 | NA | NA | 0.010 | 0.048 | 0.070 | 0.002 |
| Total $CO_2$, lb/ft$^3$ | 0.039 | 0.107 | 0.221 | 0.081 | 0.426 | NA | 0.256 | NA | NA | 1.252 | 0.280 | 0.547 | 1.635 |
| Weighted Average of Zones | | | | | | | | | | | | | |
| Total Thickness, m | 137.2 | | | | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 2.560 | | | | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 1.692 | | | | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 0.581 | | | | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 4.833 | | | | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.160 | | | | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.106 | | | | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.036 | | | | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 0.302 | | | | | | | | | | | | |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | | | | | | |
| pH | −0.234 | −0.225 | −0.226 | −0.228 | −0.289 | NA | −0.225 | NA | NA | −1.189 | −0.227 | −0.250 | −1.865 |
| pE | 0.240 | 0.228 | 0.535 | 0.493 | 0.538 | NA | 0.532 | NA | NA | 1.547 | 0.499 | 0.557 | 2.297 |
| Activity | −0.023 | −0.016 | −0.018 | −0.020 | −0.018 | NA | −0.018 | NA | NA | −0.024 | −0.019 | −0.020 | 0.012 |
| Ionic Strength | 0.061 | 0.083 | 0.013 | 0.006 | −0.066 | NA | 0.040 | NA | NA | −0.256 | 0.010 | 0.007 | −0.540 |
| Total Solution $CO_2$, moles | 1.439 | 1.067 | 1.177 | 1.297 | 1.024 | NA | 1.146 | NA | NA | 0.894 | 1.222 | 1.127 | 0.877 |
| Solution, moles | | | | | | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 3.462 | 0.678 | 1.108 | 1.849 | 1.051 | NA | 0.915 | NA | NA | 0.930 | 1.226 | 1.172 | 0.972 |
| Ca | −0.533 | −0.532 | −0.532 | −0.533 | −0.533 | NA | −0.532 | NA | NA | −0.595 | −0.532 | −0.532 | −0.019 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | NA | 0.001 | NA | NA | 0.001 | 0.000 | 0.001 | 0.001 |
| K | 0.004 | 0.001 | 0.002 | 0.002 | 0.238 | NA | 0.001 | NA | NA | 1.262 | 0.002 | 0.057 | 0.069 |
| Mg | 1.005 | 0.652 | 0.734 | 0.845 | 0.525 | NA | 0.704 | NA | NA | −0.018 | 0.754 | 0.667 | 0.000 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.000 | 0.025 | 0.040 | 0.012 | NA | 0.021 | NA | NA | 0.002 | 0.028 | 0.019 | 0.001 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | NA | 300.000 | NA | NA | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | −2.150 | 0.000 | 0.000 | −18.330 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | −1.058 | NA | 0.000 | NA | NA | −2.725 | 0.000 | 0.471 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | 295.500 | 298.300 | 297.800 | 297.100 | 297.900 | NA | 298.000 | NA | NA | 295.700 | 297.700 | 297.800 | 280.700 |
| Dolomite | 0.600 | 0.532 | 0.532 | 0.537 | 0.533 | NA | 0.532 | NA | NA | 2.743 | 0.533 | 0.532 | 18.348 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.510 | −0.400 | −0.419 | −0.450 | 0.000 | NA | −0.410 | NA | NA | 0.000 | −0.426 | 0.000 | −6.016 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.701 | NA | 0.000 | NA | NA | 0.831 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.500 | 0.400 | 0.420 | 0.400 | 0.119 | NA | 0.420 | NA | NA | 0.631 | 0.420 | 0.029 | 6.050 |
| Phlogopite | −0.510 | −0.395 | −0.422 | −0.460 | 0.000 | NA | −0.412 | NA | NA | 0.000 | −0.428 | −0.557 | −6.116 |
| Pyrite | 0.000 | 0.000 | −0.013 | −0.020 | −0.010 | NA | −0.010 | NA | NA | 0.000 | −0.020 | −0.009 | 0.000 |
| Quartz | 1.000 | 1.000 | 1.000 | 1.000 | 1.800 | NA | 0.800 | NA | NA | 6.500 | 0.900 | −0.300 | 12.500 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.012 | 0.020 | 0.005 | NA | 0.010 | NA | NA | 0.000 | 0.014 | 0.009 | 0.000 |
| Change (initial – final), moles | | | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | −2.148 | 0.000 | 0.000 | −18.334 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | −1.058 | NA | 0.000 | NA | NA | −2.725 | 0.000 | 0.471 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ ND 7087 | 4.529 | 1.742 | 2.184 | 2.934 | 2.122 | NA | 1.989 | NA | NA | 4.268 | 2.305 | 2.245 | 19.340 |
| Dolomite | 0.533 | 0.532 | 0.532 | 0.533 | 0.533 | NA | 0.532 | NA | NA | 2.743 | 0.532 | 0.532 | 18.352 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | −0.510 | −0.400 | −0.420 | −0.460 | 0.000 | NA | −0.410 | NA | NA | 0.000 | −0.426 | 0.000 | −6.015 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.701 | NA | 0.000 | NA | NA | 0.831 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.500 | 0.400 | 0.420 | 0.400 | 0.119 | NA | 0.420 | NA | NA | 0.631 | 0.420 | 0.029 | 6.050 |
| Phlogopite | −0.510 | −0.395 | −0.422 | −0.460 | 0.000 | NA | −0.412 | NA | NA | 0.000 | −0.428 | −0.557 | −6.116 |
| Pyrite | 0.000 | 0.000 | −0.013 | −0.020 | −0.006 | NA | −0.011 | NA | NA | −0.001 | −0.014 | −0.009 | −0.001 |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 1.100 | 0.790 | 0.850 | 1.000 | 1.772 | NA | 0.820 | NA | NA | 6.511 | 0.860 | -0.300 | 12.240 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.012 | 0.020 | 0.005 | NA | 0.010 | NA | NA | 0.000 | 0.014 | 0.009 | 0.000 |
| Final Solution, moles | | | | | | | | | | | | | |
| $CaCO_3$ | −1.52E-06 | −7.28E-07 | −4.48E-07 | −1.53E-06 | −1.87E-06 | NA | −5.37E-07 | NA | NA | 0.00E+00 | −1.51E-06 | −2.68E-07 | 0.00E+00 |
| $CaHCO_3^+$ | −1.61E-04 | −8.44E-05 | −5.24E-05 | −1.75E-04 | −3.20E-04 | NA | −6.29E-05 | NA | NA | 5.83E-03 | −1.76E-04 | −4.02E-05 | 1.57E-02 |
| $CO_2$ | 1.05E+00 | 6.87E-01 | 7.90E-01 | 9.06E-01 | 8.27E-01 | NA | 7.55E-01 | NA | NA | 8.61E-01 | 8.26E-01 | 8.44E-01 | 8.50E-01 |
| $CO_3^{2-}$ | 1.63E-05 | 7.10E-06 | 9.23E-06 | 1.21E-05 | 3.46E-06 | NA | 8.36E-06 | NA | NA | 2.97E-07 | 9.87E-06 | 5.54E-06 | 9.45E-09 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 4.78E-08 | 4.78E-08 | 4.78E-08 | NA | 4.78E-08 | NA | NA | 5.10E-09 | 4.78E-08 | 4.78E-08 | 6.46E-10 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 4.19E-18 | 4.04E-18 | 7.53E-18 | NA | 4.22E-18 | NA | NA | 3.03E-18 | 4.18E-18 | 5.85E-18 | 1.02E-18 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 8.94E-05 | 8.79E-05 | 1.52E-04 | NA | 8.90E-05 | NA | NA | 5.26E-05 | 8.93E-05 | 1.21E-04 | 1.72E-05 |
| $HCO_3^-$ | 1.53E-01 | 7.37E-02 | 9.35E-02 | 1.19E-01 | 5.91E-02 | NA | 8.57E-02 | NA | NA | 1.89E-02 | 9.94E-02 | 7.56E-02 | 7.44E-03 |
| $MgCO_3$ | 2.59E-04 | 2.92E-04 | 2.79E-04 | 2.69E-04 | 7.43E-05 | NA | 2.89E-04 | NA | NA | 0.00E+00 | 2.83E-04 | 1.45E-04 | 0.00E+00 |
| $MgHCO_3^+$ | 2.15E-01 | 2.58E-01 | 2.51E-01 | 2.38E-01 | 1.14E-01 | NA | 2.59E-01 | NA | NA | 2.03E-04 | 2.55E-01 | 1.77E-01 | 5.49E-04 |
| $NaCO_3^-$ | 3.23E-07 | 3.42E-07 | 3.53E-07 | 3.51E-07 | 1.25E-07 | NA | 3.56E-07 | NA | NA | 1.05E-08 | 3.62E-07 | 1.99E-07 | 7.80E-11 |
| $NaHCO_3$ | 2.57E-02 | 4.76E-02 | 4.16E-02 | 3.45E-02 | 2.36E-02 | NA | 4.51E-02 | NA | NA | 7.26E-03 | 4.15E-02 | 3.02E-02 | 2.77E-03 |
| $CO_2$ (calcite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | NA | 0.000 | NA | NA | −2.148 | 0.000 | 0.000 | −18.334 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.067 | 1.064 | 1.064 | 1.065 | 1.066 | NA | 1.064 | NA | NA | 5.485 | 1.065 | 1.064 | 36.704 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.012 | 0.020 | 0.005 | NA | 0.010 | NA | NA | 0.000 | 0.014 | 0.009 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.067 | 1.064 | 1.076 | 1.085 | 1.071 | NA | 1.074 | NA | NA | 3.337 | 1.078 | 1.073 | 18.370 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.045 | 0.687 | 0.790 | 0.906 | 0.827 | NA | 0.755 | NA | NA | 0.861 | 0.826 | 0.844 | 0.850 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.394 | 0.380 | 0.387 | 0.392 | 0.196 | NA | 0.390 | NA | NA | 0.032 | 0.396 | 0.283 | 0.027 |
| Total $CO_2$, moles/kg $H_2O$ | 2.505 | 2.131 | 2.253 | 2.383 | 2.095 | NA | 2.219 | NA | NA | 4.231 | 2.300 | 2.200 | 19.247 |
| Water, $g/cm^3$ | 0.006 | 0.018 | 0.036 | 0.012 | 0.074 | 0.005 | 0.042 | 0.003 | 0.010 | 0.108 | 0.044 | 0.090 | 0.031 |
| Water, $kg/m^3$ | 5.666 | 18.326 | 35.783 | 12.319 | 74.097 | 5.166 | 41.949 | 2.860 | 9.870 | 107.739 | 44.320 | 90.423 | 30.929 |
| Mineral $CO_2$, $moles/m^3$ | 6.043 | 19.499 | 38.512 | 13.370 | 79.363 | NA | 45.057 | NA | NA | 359.535 | 47.796 | 97.008 | 568.167 |
| Dissolved $CO_2$, $moles/m^3$ | 5.923 | 12.595 | 28.259 | 11.158 | 61.305 | NA | 31.685 | NA | NA | 92.807 | 36.591 | 76.294 | 26.292 |
| Solution $CO_2$, $moles/m^3$ | 2.230 | 6.960 | 13.838 | 4.824 | 14.555 | NA | 16.361 | NA | NA | 3.472 | 17.555 | 25.598 | 0.820 |
| Total $CO_2$, $moles/m^3$ | 14.195 | 39.055 | 80.610 | 29.352 | 155.223 | NA | 93.104 | NA | NA | 455.813 | 101.942 | 198.900 | 595.279 |
| Mineral $CO_2$, $moles/ft^3$ | 0.171 | 0.552 | 1.091 | 0.379 | 2.247 | NA | 1.276 | NA | NA | 10.181 | 1.353 | 2.747 | 16.089 |
| Dissolved $CO_2$, $moles/ft^3$ | 0.168 | 0.357 | 0.800 | 0.316 | 1.736 | NA | 0.897 | NA | NA | 2.628 | 1.036 | 2.160 | 0.744 |
| Solution $CO_2$, $moles/ft^3$ | 0.063 | 0.197 | 0.392 | 0.137 | 0.412 | NA | 0.463 | NA | NA | 0.098 | 0.497 | 0.725 | 0.023 |
| Total $CO_2$, $moles/ft^3$ | 0.402 | 1.106 | 2.283 | 0.831 | 4.395 | NA | 2.636 | NA | NA | 12.907 | 2.887 | 5.632 | 16.857 |
| Mineral $CO_2$, $kg/m^3$ | 0.266 | 0.858 | 1.695 | 0.588 | 3.493 | NA | 1.983 | NA | NA | 15.823 | 2.104 | 4.269 | 25.005 |
| Dissolved $CO_2$, $kg/m^3$ | 0.261 | 0.554 | 1.244 | 0.491 | 2.698 | NA | 1.394 | NA | NA | 4.084 | 1.610 | 3.358 | 1.157 |
| Solution $CO_2$, $kg/m^3$ | 0.098 | 0.306 | 0.609 | 0.212 | 0.641 | NA | 0.720 | NA | NA | 0.153 | 0.773 | 1.127 | 0.036 |
| Total $CO_2$, $kg/m^3$ | 0.625 | 1.719 | 3.548 | 1.292 | 6.831 | NA | 4.098 | NA | NA | 20.060 | 4.486 | 8.754 | 26.198 |

* Calculation did not converge to a solution.

Continued…

## Table B-61. Summary of ND 7087 Aquifer Calculation Results (continued)

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6* | Aquifer Zone 7 | Aquifer Zone 8* | Aquifer Zone 9* | Aquifer Zone 10 | Aquifer Zone 11 | Aquifer Zone 12 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, lb/ft$^3$ | 0.017 | 0.054 | 0.106 | 0.037 | 0.218 | NA | 0.124 | NA | NA | 0.988 | 0.131 | 0.267 | 1.561 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.016 | 0.035 | 0.078 | 0.031 | 0.168 | NA | 0.087 | NA | NA | 0.255 | 0.101 | 0.210 | 0.072 |
| Solution $CO_2$, lb/ft$^3$ | 0.006 | 0.019 | 0.038 | 0.013 | 0.040 | NA | 0.045 | NA | NA | 0.010 | 0.048 | 0.070 | 0.002 |
| Total $CO_2$, lb/ft$^3$ | 0.039 | 0.107 | 0.221 | 0.081 | 0.426 | NA | 0.256 | NA | NA | 1.252 | 0.280 | 0.546 | 1.635 |
| Weighted Average of Zones | | | | | | | | | | | | | |
| Total Thickness, m | 137.2 | | | | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 2.562 | | | | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 1.690 | | | | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 0.580 | | | | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 4.832 | | | | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.160 | | | | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.106 | | | | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.036 | | | | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 0.302 | | | | | | | | | | | | |

* Calculation did not converge to a solution.

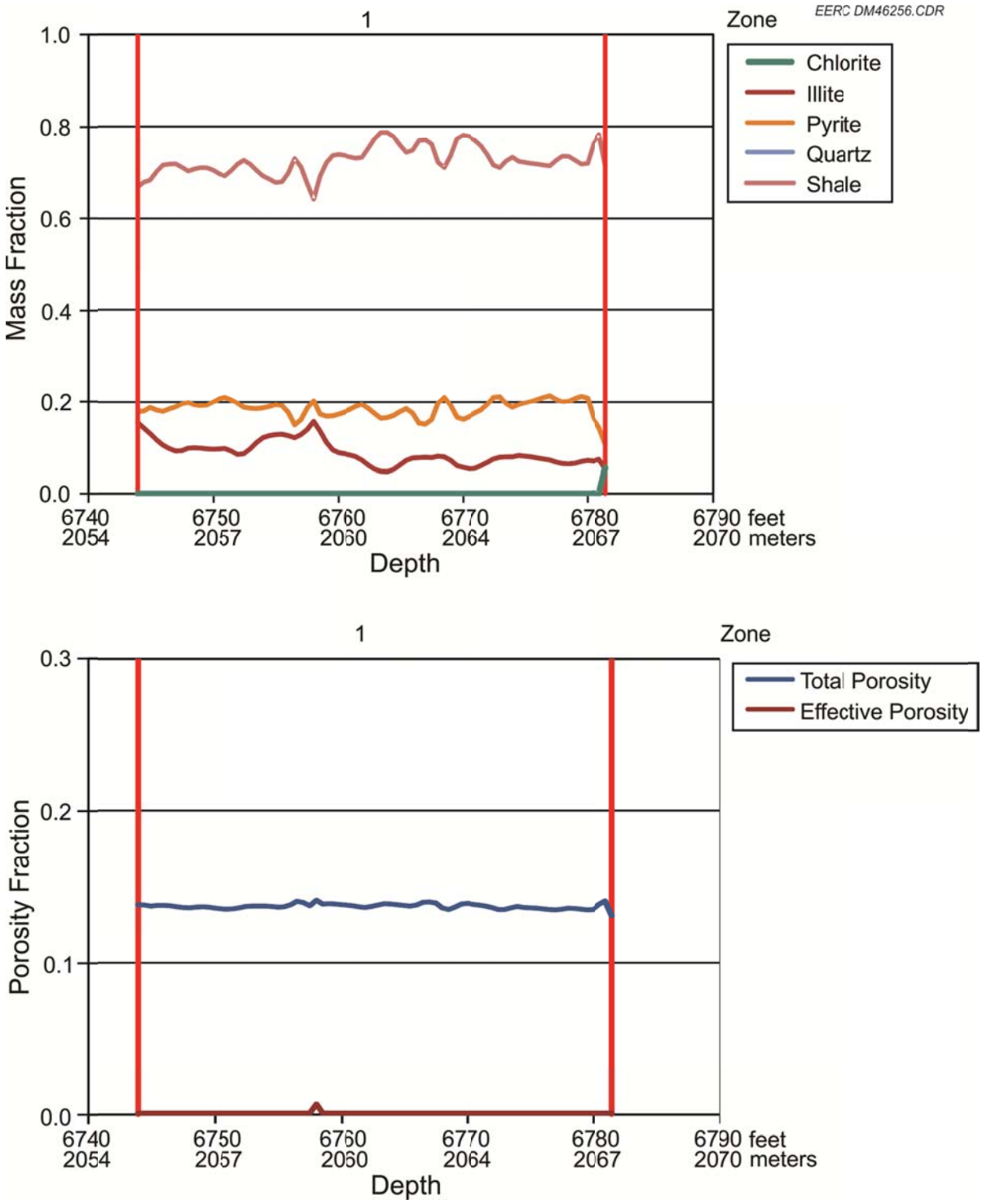



Figure B-18. ND 7087 mineral composition and porosity as a function of depth.

**MT API 21320**

The water composition used for MT API 21320 is from the MT API 05008 well 7.6 miles (12 km) to the east. Mineral data were available for 86% of the COSS represented in this well. The total COSS thickness is not known, as the well did not penetrate into the Precambrian.

The geology of the aquifer penetrated by the well is somewhat complex. Zones 1 and 2 are predominantly quartz. In Zones 3 and 10, the majority of material is quartz, with calcite, glauconite, and illite present. Dolomite is also present in Zone 10. Zone 4 has calcite and glauconite in roughly equal amounts, with moderate illite and quartz present. Zone 5 is primarily glauconite, with a moderate amount of dolomite. Zones 6 and 7 are mostly quartz, with moderate dolomite and illite. Zone 8 has roughly equal amounts of glauconite, illite, and quartz, with some dolomite present. Zone 9 is made up of calcite and quartz in an approximate 1:2 ratio. Some pyrite is present in all the zones. Zones 4, 6, 7, and 8 have very low porosities, with the porosities of the other zones ranging from 0.018 to 0.930.

Less kaolinite and phlogopite forms, with generally corresponding increases in quartz and muscovite. The dissolution of calcite and the concurrent formation of dolomite make up the most of the $CO_2$ interaction with the minerals when calcite is present. A small amount of pyrite dissolves, and a corresponding amount of siderite forms. Zone 4 was calculated to form a very large amount of dolomite, with the associated depletion of calcite. In this zone, all of $CO_2$ introduced reacted.

The amount of $CO_2$ dissolved in the formation water ranges from 1.13 to 1.39 moles/kg (49.7 to 61.2 g/kg) and is the dominant component of the $CO_2$ interaction with the formation water. The total average amount of $CO_2$ reacting with the minerals and formation water is 5.1 kg/m$^3$ (0.3 lb/ft$^3$) of formation rock. These values may be higher because of the complete depletion of the reactant $CO_2$ in Zone 4.

## Table B-62. Average Mineral and Porosity Values for the MT API 21320 Aquifer Zones

Well Name: MT API 21320
API Identification: 25-083-21320-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 12,265 | 3738.4 | Average | 0.094 | 0.093 | 0.000 | 0.090 | 0.000 | 0.006 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 | 0.071 | 0.823 | 0.000 |
| End | 12,280 | 3743.0 | Minimum | 0.066 | 0.063 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.583 | 0.000 |
| Thickness | 15 | 4.6 | Maximum | 0.113 | 0.113 | 0.000 | 0.313 | 0.000 | 0.142 | 0.000 | 0.094 | 0.000 | 0.000 | 0.000 | 0.127 | 0.940 | 0.000 |
| Number of Values | 32 | | Standard deviation | 0.011 | 0.012 | 0.000 | 0.117 | 0.000 | 0.026 | 0.000 | 0.021 | 0.000 | 0.000 | 0.000 | 0.029 | 0.113 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 12,280 | 3743.0 | Average | 0.058 | 0.052 | 0.000 | 0.014 | 0.000 | 0.009 | 0.001 | 0.081 | 0.000 | 0.000 | 0.000 | 0.038 | 0.857 | 0.000 |
| End | 12,320 | 3755.1 | Minimum | 0.013 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.456 | 0.000 |
| Thickness | 40 | 12.2 | Maximum | 0.124 | 0.124 | 0.000 | 0.468 | 0.000 | 0.174 | 0.037 | 0.250 | 0.000 | 0.000 | 0.000 | 0.136 | 0.974 | 0.000 |
| Number of Values | 80 | | Standard deviation | 0.029 | 0.033 | 0.000 | 0.071 | 0.000 | 0.031 | 0.004 | 0.070 | 0.000 | 0.000 | 0.000 | 0.037 | 0.090 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 12,320 | 3755.1 | Average | 0.036 | 0.031 | 0.000 | 0.167 | 0.000 | 0.000 | 0.118 | 0.064 | 0.000 | 0.000 | 0.000 | 0.027 | 0.624 | 0.000 |
| End | 12,330 | 3758.2 | Minimum | 0.009 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 10 | 3.0 | Maximum | 0.065 | 0.065 | 0.000 | 0.482 | 0.000 | 0.000 | 0.843 | 0.166 | 0.000 | 0.000 | 0.000 | 0.088 | 0.970 | 0.000 |
| Number of Values | 20 | | Standard deviation | 0.022 | 0.028 | 0.000 | 0.210 | 0.000 | 0.000 | 0.229 | 0.066 | 0.000 | 0.000 | 0.000 | 0.034 | 0.242 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 12,330 | 3758.2 | Average | 0.018 | 0.002 | 0.000 | 0.395 | 0.000 | 0.000 | 0.243 | 0.189 | 0.000 | 0.000 | 0.000 | 0.022 | 0.151 | 0.000 |
| End | 12,350 | 3764.3 | Minimum | 0.013 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.024 | 0.146 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 20 | 6.1 | Maximum | 0.035 | 0.015 | 0.000 | 0.592 | 0.000 | 0.002 | 0.803 | 0.254 | 0.000 | 0.000 | 0.000 | 0.094 | 0.648 | 0.000 |
| Number of Values | 40 | | Standard deviation | 0.004 | 0.002 | 0.000 | 0.184 | 0.000 | 0.000 | 0.187 | 0.025 | 0.000 | 0.000 | 0.000 | 0.022 | 0.176 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 12,350 | 3764.3 | Average | 0.022 | 0.019 | 0.000 | 0.000 | 0.000 | 0.146 | 0.736 | 0.043 | 0.000 | 0.000 | 0.000 | 0.010 | 0.065 | 0.000 |
| End | 12,364 | 3768.6 | Minimum | 0.018 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.160 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 14 | 4.3 | Maximum | 0.028 | 0.028 | 0.000 | 0.000 | 0.000 | 0.394 | 0.973 | 0.285 | 0.000 | 0.000 | 0.000 | 0.036 | 0.559 | 0.000 |
| Number of Values | 28 | | Standard deviation | 0.003 | 0.008 | 0.000 | 0.000 | 0.000 | 0.148 | 0.228 | 0.090 | 0.000 | 0.000 | 0.000 | 0.012 | 0.164 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 12,364 | 3768.6 | Average | 0.016 | 0.002 | 0.000 | 0.000 | 0.000 | 0.219 | 0.081 | 0.163 | 0.000 | 0.000 | 0.000 | 0.008 | 0.529 | 0.000 |
| End | 12,456 | 3796.6 | Minimum | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.069 | 0.000 |
| Thickness | 92 | 28.0 | Maximum | 0.028 | 0.027 | 0.000 | 0.000 | 0.000 | 0.432 | 0.906 | 0.292 | 0.000 | 0.000 | 0.000 | 0.069 | 0.842 | 0.000 |
| Number of Values | 184 | | Standard deviation | 0.005 | 0.004 | 0.000 | 0.000 | 0.000 | 0.132 | 0.152 | 0.066 | 0.000 | 0.000 | 0.000 | 0.015 | 0.144 | 0.000 |

Continued…

## Table B-62. Average Mineral and Porosity Values for the MT API 21320 Aquifer Zones (continued)

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Ankerite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 12,456 | 3796.6 | Average | 0.020 | 0.005 | 0.000 | 0.000 | 0.000 | 0.141 | 0.012 | 0.175 | 0.000 | 0.000 | 0.000 | 0.019 | 0.653 | 0.000 |
| End | 12,660 | 3858.8 | Minimum | 0.007 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.066 | 0.000 | 0.000 | 0.000 | 0.000 | 0.301 | 0.000 |
| Thickness | 204 | 62.2 | Maximum | 0.057 | 0.041 | 0.000 | 0.000 | 0.000 | 0.447 | 0.277 | 0.298 | 0.000 | 0.000 | 0.000 | 0.102 | 0.869 | 0.000 |
| Number of Values | 408 | | Standard deviation | 0.005 | 0.005 | 0.000 | 0.000 | 0.000 | 0.124 | 0.047 | 0.052 | 0.000 | 0.000 | 0.000 | 0.022 | 0.121 | 0.000 |
| Zone 8 | | | | | | | | | | | | | | | | | |
| Start | 12,660 | 3858.8 | Average | 0.026 | 0.005 | 0.000 | 0.000 | 0.000 | 0.123 | 0.216 | 0.255 | 0.000 | 0.000 | 0.000 | 0.021 | 0.384 | 0.000 |
| End | 12,845 | 3915.2 | Minimum | 0.012 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 185 | 56.4 | Maximum | 0.109 | 0.088 | 0.000 | 0.000 | 0.000 | 0.626 | 0.781 | 0.374 | 0.000 | 0.000 | 0.000 | 0.214 | 0.806 | 0.000 |
| Number of Values | 369 | | Standard deviation | 0.013 | 0.012 | 0.000 | 0.000 | 0.000 | 0.168 | 0.182 | 0.067 | 0.000 | 0.000 | 0.000 | 0.030 | 0.191 | 0.000 |
| Zone 9 | | | | | | | | | | | | | | | | | |
| Start | 12,845 | 3915.2 | Average | 0.048 | 0.047 | 0.000 | 0.363 | 0.000 | 0.005 | 0.002 | 0.011 | 0.000 | 0.000 | 0.000 | 0.040 | 0.580 | 0.000 |
| End | 12,902 | 3932.5 | Minimum | 0.009 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 57 | 17.4 | Maximum | 0.082 | 0.082 | 0.000 | 0.944 | 0.000 | 0.217 | 0.219 | 0.222 | 0.000 | 0.000 | 0.000 | 0.115 | 0.969 | 0.000 |
| Number of Values | 115 | | Standard deviation | 0.016 | 0.018 | 0.000 | 0.175 | 0.000 | 0.030 | 0.021 | 0.038 | 0.000 | 0.000 | 0.000 | 0.028 | 0.151 | 0.000 |
| Zone 10 | | | | | | | | | | | | | | | | | |
| Start | 12,902 | 3932.5 | Average | 0.024 | 0.018 | 0.000 | 0.088 | 0.000 | 0.166 | 0.091 | 0.082 | 0.000 | 0.000 | 0.000 | 0.045 | 0.529 | 0.000 |
| End | 12,950 | 3947.2 | Minimum | 0.008 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 48 | 14.6 | Maximum | 0.052 | 0.052 | 0.000 | 0.503 | 0.000 | 0.554 | 0.769 | 0.347 | 0.000 | 0.000 | 0.000 | 0.122 | 0.891 | 0.000 |
| Number of Values | 94 | | Standard deviation | 0.009 | 0.013 | 0.000 | 0.153 | 0.000 | 0.152 | 0.174 | 0.085 | 0.000 | 0.000 | 0.000 | 0.033 | 0.207 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 12,265 | 3738.4 | Average | 0.028 | 0.014 | 0.000 | 0.053 | 0.000 | 0.120 | 0.103 | 0.162 | 0.000 | 0.000 | 0.000 | 0.024 | 0.538 | 0.000 |
| End | 12,950 | 3947.2 | Minimum | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Thickness | 685 | 208.8 | Maximum | 0.124 | 0.124 | 0.000 | 0.944 | 0.000 | 0.626 | 0.973 | 0.374 | 0.000 | 0.000 | 0.000 | 0.214 | 0.974 | 0.000 |
| Number of Values | 1370 | | Standard deviation | 0.019 | 0.024 | 0.000 | 0.142 | 0.000 | 0.145 | 0.184 | 0.099 | 0.000 | 0.000 | 0.000 | 0.029 | 0.228 | 0.000 |

## Table B-63. Average Mineral and Porosity Values for the MT API 21320 Aquifer Zones

Well Name: MT API 21320
API Identification: 25-083-21320-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, ft | 12,265 | 12,280 | 12,320 | 12,330 | 12,350 | 12,364 | 12,456 | 12,660 | 12,845 | 12,902 | 12,265 |
| End, ft | 12,280 | 12,320 | 12,330 | 12,350 | 12,364 | 12,456 | 12,660 | 12,845 | 12,902 | 12,950 | 12,950 |
| Thickness, ft | 15.0 | 40.0 | 10.0 | 20.0 | 14.0 | 92.0 | 204.0 | 185.0 | 57.0 | 48.0 | 685.0 |
| Start, m | 3738.4 | 3743.0 | 3755.1 | 3758.2 | 3764.3 | 3768.6 | 3796.6 | 3858.8 | 3915.2 | 3932.5 | 3738.4 |
| End, m | 3743.0 | 3755.1 | 3758.2 | 3764.3 | 3768.6 | 3796.6 | 3858.8 | 3915.2 | 3932.5 | 3947.2 | 3947.2 |
| Thickness, m | 4.6 | 12.2 | 3.0 | 6.1 | 4.3 | 28.0 | 62.2 | 56.4 | 17.4 | 14.6 | 208.8 |
| Temperature, °F | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 | 221.0 |
| Temperature, °C | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 | 105.0 |
| Pressure, psi | 7970 | 7975 | 7979 | 7982 | 7985 | 7995 | 8021 | 8055 | 8076 | 8086 | 8029 |
| Pressure, kPa | 54,953 | 54,986 | 55,017 | 55,035 | 55,056 | 55,120 | 55,301 | 55,538 | 55,685 | 55,749 | 55,361 |
| Effective Porosity, fraction | 0.093 | 0.052 | 0.031 | 0.002 | 0.019 | 0.002 | 0.005 | 0.005 | 0.047 | 0.018 | 0.014 |
| Mass Fraction | | | | | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.090 | 0.014 | 0.167 | 0.395 | 0.000 | 0.000 | 0.000 | 0.000 | 0.363 | 0.088 | 0.053 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.006 | 0.009 | 0.000 | 0.000 | 0.146 | 0.219 | 0.141 | 0.123 | 0.005 | 0.166 | 0.120 |
| Glauconite | 0.000 | 0.001 | 0.118 | 0.243 | 0.736 | 0.081 | 0.012 | 0.216 | 0.002 | 0.091 | 0.103 |
| Illite | 0.010 | 0.081 | 0.064 | 0.189 | 0.043 | 0.163 | 0.175 | 0.255 | 0.011 | 0.082 | 0.162 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.071 | 0.038 | 0.027 | 0.022 | 0.010 | 0.008 | 0.019 | 0.021 | 0.040 | 0.045 | 0.024 |
| Quartz | 0.823 | 0.857 | 0.624 | 0.151 | 0.065 | 0.529 | 0.653 | 0.384 | 0.580 | 0.529 | 0.538 |
| Shale | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-64. Summary of MT API 21320 Aquifer Calculation Results

Well Name: MT API 21320
API Identification: 25-083-21320-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, m | 3738.4 | 3743.0 | 3755.1 | 3758.2 | 3764.3 | 3768.6 | 3796.6 | 3858.8 | 3915.2 | 3932.5 | 3738.4 |
| End, m | 3743.0 | 3755.1 | 3758.2 | 3764.3 | 3768.6 | 3796.6 | 3858.8 | 3915.2 | 3932.5 | 3947.2 | 3947.2 |
| Thickness, m | 4.6 | 12.2 | 3.0 | 6.1 | 4.3 | 28.0 | 62.2 | 56.4 | 17.4 | 14.6 | 208.8 |
| Start, ft | 12,265.0 | 12,280.0 | 12,320.0 | 12,330.0 | 12,350.0 | 12,364.0 | 12,456.0 | 12,660.0 | 12,845.0 | 12,902.0 | 12,265.0 |
| End, ft | 12,280.0 | 12,320.0 | 12,330.0 | 12,350.0 | 12,364.0 | 12,456.0 | 12,660.0 | 12,845.0 | 12,902.0 | 12,950.0 | 12,950.0 |
| Thickness, ft | 15.0 | 40.0 | 10.0 | 20.0 | 14.0 | 92.0 | 204.0 | 185.0 | 57.0 | 48.0 | 685.0 |
| **Minerals Without $CO_2$** | | | | | | | | | | | |
| pH | 6.068 | 6.064 | 5.961 | 6.240 | 5.646 | 5.918 | 5.662 | 5.838 | 6.069 | 5.976 | 6.008 |
| pE | −2.723 | −2.719 | −2.591 | −2.896 | −2.237 | −2.544 | −2.211 | −2.443 | −2.723 | −2.606 | −2.640 |
| Activity | 0.861 | 0.855 | 0.872 | 0.976 | 0.874 | 0.962 | 0.511 | 0.956 | 0.861 | 0.884 | 0.906 |
| Ionic Strength | 3.998 | 4.115 | 3.746 | 0.821 | 3.686 | 1.275 | 8.039 | 1.457 | 3.990 | 3.463 | 2.927 |
| Total Solution $CO_2$, moles | 3.843E-04 | 3.810E-04 | 5.459E-04 | 6.712E-04 | 7.435E-04 | 6.641E-04 | 3.292E-04 | 8.737E-04 | 3.845E-04 | 5.547E-04 | 5.718E-04 |
| Solution, moles | | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0004 | 0.0004 | 0.0006 | 0.0048 | 0.0009 | 0.0029 | 0.0001 | 0.0033 | 0.0004 | 0.0007 | 0.0009 |
| Ca | 0.6824 | 0.6825 | 0.6769 | 0.6704 | 0.5974 | 0.5984 | 0.5970 | 0.5986 | 0.6824 | 0.6764 | 0.6756 |
| Cl | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0007 | 0.0007 | 0.0118 | 0.0309 | 0.0249 | 0.0049 | 0.0002 | 0.0450 | 0.0007 | 0.0127 | 0.0144 |
| Mg | 0.0221 | 0.0220 | 0.0221 | 0.0205 | 0.0951 | 0.1047 | 0.1076 | 0.0845 | 0.0221 | 0.0222 | 0.0222 |
| Na | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 |
| S | 0.0010 | 0.0010 | 0.0010 | 0.0012 | 0.0010 | 0.0011 | 0.0009 | 0.0011 | 0.0010 | 0.0010 | 0.0010 |
| Si | 0.0010 | 0.0009 | 0.0011 | 0.0066 | 0.0011 | 0.0041 | 0.0002 | 0.0035 | 0.0010 | 0.0012 | 0.0015 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 24.530 | 6.822 | 143.800 | 6502.000 | 0.000 | 0.000 | 0.000 | 0.000 | 201.400 | 138.200 | 100.500 |
| Celadonite | 0.000 | 0.076 | 23.690 | 932.500 | 264.100 | 242.900 | 14.470 | 276.900 | 0.317 | 33.320 | 45.290 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.850 | 2.500 | 0.000 | 0.553 | 122.200 | 1522.000 | 392.600 | 367.100 | 1.399 | 142.500 | 122.700 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.712 | 10.570 | 14.340 | 808.900 | 17.100 | 542.800 | 235.500 | 365.600 | 1.608 | 33.540 | 79.440 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 16.190 | 15.880 | 19.170 | 304.700 | 13.080 | 80.320 | 81.290 | 98.460 | 18.320 | 59.770 | 37.740 |
| Quartz | 374.400 | 713.100 | 895.000 | 4134.000 | 167.200 | 11,280.000 | 5599.000 | 3520.000 | 536.500 | 1389.000 | 1690.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 24.360 | 6.651 | 143.700 | 6502.000 | 0.000 | 0.000 | 0.000 | 0.000 | 201.200 | 138.100 | 100.400 |
| Celadonite | 0.000 | 0.000 | 16.490 | 528.000 | 255.500 | 0.000 | 0.000 | 93.990 | 0.000 | 16.520 | 5.537 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.936 | 2.586 | 0.080 | 0.622 | 122.200 | 1522.000 | 392.600 | 367.100 | 1.485 | 142.600 | 122.800 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.238 | 3.472 | 0.000 | 0.000 | 0.000 | 19.000 | 68.840 | 0.000 | 0.326 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.368 | 5.509 | 12.200 | 687.600 | 14.550 | 442.400 | 131.300 | 310.800 | 1.042 | 28.510 | 67.530 |
| Phlogopite | 0.059 | 0.906 | 3.598 | 202.300 | 4.300 | 126.200 | 24.440 | 91.440 | 0.240 | 8.397 | 19.880 |
| Pyrite | 16.190 | 15.880 | 19.170 | 304.700 | 13.080 | 80.320 | 81.290 | 98.460 | 18.320 | 59.770 | 37.740 |
| Quartz | 375.100 | 724.100 | 926.600 | 5914.000 | 205.000 | 12,400.000 | 5876.000 | 4324.000 | 538.900 | 1463.000 | 1865.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Change (initial – final), moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.171 | −0.171 | −0.159 | −0.142 | 0.000 | 0.000 | 0.000 | 0.000 | -0.171 | −0.158 | −0.157 |
| Celadonite | 0.000 | −0.076 | −7.201 | −404.500 | −8.612 | −242.900 | −14.470 | −182.900 | −0.317 | −16.800 | −39.760 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.086 | 0.086 | 0.080 | 0.069 | 0.000 | −0.001 | 0.001 | −0.001 | 0.086 | 0.079 | 0.078 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −0.712 | −10.570 | −14.340 | −808.900 | −17.100 | −542.800 | −235.500 | −365.600 | −1.608 | −33.540 | −79.440 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.238 | 3.472 | 0.000 | 0.000 | 0.000 | 19.000 | 68.840 | 0.000 | 0.326 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.368 | 5.509 | 12.200 | 687.600 | 14.550 | 442.400 | 131.300 | 310.800 | 1.042 | 28.510 | 67.530 |
| Phlogopite | 0.059 | 0.906 | 3.598 | 202.300 | 4.300 | 126.200 | 24.440 | 91.440 | 0.240 | 8.397 | 19.880 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.735 | 11.100 | 31.620 | 1780.000 | 37.760 | 1128.000 | 277.100 | 804.500 | 2.401 | 73.850 | 174.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | | | | |
| $CaCO_3$ | 6.21E-06 | 6.21E-06 | 6.21E-06 | 6.21E-06 | 2.81E-06 | 2.61E-06 | 1.96E-06 | 2.92E-06 | 6.21E-06 | 6.21E-06 | 6.21E-06 |
| $CaHCO_3^+$ | 1.70E-04 | 1.70E-04 | 2.22E-04 | 1.34E-04 | 2.08E-04 | 1.19E-04 | 9.47E-05 | 1.59E-04 | 1.70E-04 | 2.19E-04 | 2.12E-04 |
| $CO_2$ | 7.84E-05 | 7.68E-05 | 1.41E-04 | 2.18E-04 | 3.15E-04 | 2.97E-04 | 1.02E-04 | 4.18E-04 | 7.85E-05 | 1.47E-04 | 1.58E-04 |
| $CO_3^{2-}$ | 6.09E-08 | 5.89E-08 | 6.59E-08 | 1.99E-07 | 3.43E-08 | 7.54E-08 | 1.00E-08 | 7.77E-08 | 6.10E-08 | 7.18E-08 | 8.52E-08 |
| $FeCO_3$ | 2.53E-11 | 2.19E-11 | 4.50E-11 | 2.04E-09 | 3.37E-11 | 4.99E-10 | 1.74E-13 | 5.09E-10 | 2.55E-11 | 6.38E-11 | 1.24E-10 |
| $FeCO_3^+$ | 1.54E-22 | 1.34E-22 | 3.80E-22 | 9.73E-21 | 6.44E-22 | 5.39E-21 | 2.38E-24 | 6.91E-21 | 1.56E-22 | 5.30E-22 | 9.90E-22 |
| $FeHCO_3^+$ | 6.22E-09 | 5.40E-09 | 1.45E-08 | 3.94E-07 | 2.24E-08 | 2.04E-07 | 7.55E-11 | 2.49E-07 | 6.28E-09 | 2.02E-08 | 3.79E-08 |
| $HCO_3^-$ | 8.36E-05 | 8.11E-05 | 1.18E-04 | 2.87E-04 | 1.27E-04 | 1.99E-04 | 3.03E-05 | 2.37E-04 | 8.38E-05 | 1.26E-04 | 1.45E-04 |
| $MgCO_3$ | 5.35E-08 | 5.35E-08 | 5.35E-08 | 5.35E-08 | 1.18E-07 | 1.27E-07 | 1.70E-07 | 1.14E-07 | 5.35E-08 | 5.35E-08 | 5.35E-08 |
| $MgHCO_3^+$ | 6.22E-06 | 6.22E-06 | 8.12E-06 | 4.89E-06 | 3.72E-05 | 2.45E-05 | 3.49E-05 | 2.63E-05 | 6.22E-06 | 8.03E-06 | 7.75E-06 |
| $NaCO_3^-$ | 3.39E-09 | 3.39E-09 | 3.42E-09 | 3.06E-09 | 1.75E-09 | 1.56E-09 | 1.50E-09 | 1.77E-09 | 3.39E-09 | 3.42E-09 | 3.44E-09 |
| $NaHCO_3$ | 3.99E-05 | 4.06E-05 | 5.04E-05 | 2.08E-05 | 5.32E-05 | 2.21E-05 | 6.48E-05 | 3.03E-05 | 3.98E-05 | 4.78E-05 | 4.28E-05 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (calcite), moles/kg $H_2O$ | −1.705E-01 | −1.708E-01 | −1.589E-01 | −1.418E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | −1.705E-01 | −1.583E-01 | −1.565E-01 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 1.714E-01 | 1.716E-01 | 1.591E-01 | 1.378E-01 | 3.922E-04 | −1.673E-03 | 1.187E-03 | −2.034E-03 | 1.714E-01 | 1.588E-01 | 1.568E-01 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 8.800E-04 | 8.400E-04 | 2.400E-04 | −3.960E-03 | 3.922E-04 | −1.673E-03 | 1.187E-03 | −2.034E-03 | 8.600E-04 | 5.000E-04 | 3.200E-04 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 7.836E-05 | 7.680E-05 | 1.414E-04 | 2.184E-04 | 3.149E-04 | 2.968E-04 | 1.023E-04 | 4.175E-04 | 7.848E-05 | 1.470E-04 | 1.584E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 3.059E-04 | 3.042E-04 | 4.045E-04 | 4.527E-04 | 4.285E-04 | 3.672E-04 | 2.268E-04 | 4.562E-04 | 3.060E-04 | 4.077E-04 | 4.134E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 1.264E-03 | 1.221E-03 | 7.859E-04 | −3.289E-03 | 1.136E-03 | −1.009E-03 | 1.516E-03 | −1.160E-03 | 1.245E-03 | 1.055E-03 | 8.918E-04 |
| Water, g/cm$^3$ | 0.093 | 0.052 | 0.031 | 0.002 | 0.019 | 0.002 | 0.005 | 0.005 | 0.047 | 0.018 | 0.014 |
| Water, kg/m$^3$ | 92.973 | 51.705 | 30.959 | 1.713 | 18.863 | 2.134 | 5.259 | 5.088 | 47.136 | 17.531 | 14.461 |
| Mineral $CO_2$, moles/m$^3$ | 8.182E-02 | 4.343E-02 | 7.430E-03 | −6.784E-03 | 7.398E-03 | −3.569E-03 | 6.244E-03 | −1.035E-02 | 4.054E-02 | 8.765E-03 | 4.628E-03 |
| Dissolved $CO_2$, moles/m$^3$ | 7.285E-03 | 3.971E-03 | 4.378E-03 | 3.742E-04 | 5.940E-03 | 6.334E-04 | 5.380E-04 | 2.124E-03 | 3.699E-03 | 2.577E-03 | 2.291E-03 |
| Solution $CO_2$, moles/m$^3$ | 2.844E-02 | 1.573E-02 | 1.252E-02 | 7.756E-04 | 8.083E-03 | 7.837E-04 | 1.193E-03 | 2.321E-03 | 1.442E-02 | 7.147E-03 | 5.979E-03 |
| Total $CO_2$, moles/m$^3$ | 1.175E-01 | 6.313E-02 | 2.433E-02 | −5.635E-03 | 2.142E-02 | −2.152E-03 | 7.974E-03 | −5.904E-03 | 5.866E-02 | 1.849E-02 | 1.290E-02 |
| Mineral $CO_2$, moles/ft$^3$ | 2.317E-03 | 1.230E-03 | 2.104E-04 | −1.921E-04 | 2.095E-04 | −1.011E-04 | 1.768E-04 | −2.931E-04 | 1.148E-03 | 2.482E-04 | 1.310E-04 |
| Dissolved $CO_2$, moles/ft$^3$ | 2.063E-04 | 1.124E-04 | 1.240E-04 | 1.060E-05 | 1.682E-04 | 1.794E-05 | 1.523E-05 | 6.016E-05 | 1.048E-04 | 7.297E-05 | 6.486E-05 |
| Solution $CO_2$, moles/ft$^3$ | 8.054E-04 | 4.454E-04 | 3.546E-04 | 2.196E-05 | 2.289E-04 | 2.219E-05 | 3.378E-05 | 6.573E-05 | 4.085E-04 | 2.024E-04 | 1.693E-04 |
| Total $CO_2$, moles/ft$^3$ | 3.328E-03 | 1.788E-03 | 6.890E-04 | −1.596E-04 | 6.066E-04 | −6.095E-05 | 2.258E-04 | −1.672E-04 | 1.661E-03 | 5.235E-04 | 3.652E-04 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, kg/m$^3$ | 3.601E-03 | 1.911E-03 | 3.270E-04 | −2.986E-04 | 3.256E-04 | −1.571E-04 | 2.748E-04 | −4.555E-04 | 1.784E-03 | 3.858E-04 | 2.037E-04 |
| Dissolved $CO_2$, kg/m$^3$ | 3.206E-04 | 1.748E-04 | 1.927E-04 | 1.647E-05 | 2.614E-04 | 2.788E-05 | 2.368E-05 | 9.350E-05 | 1.628E-04 | 1.134E-04 | 1.008E-04 |
| Solution $CO_2$, kg/m$^3$ | 1.252E-03 | 6.922E-04 | 5.512E-04 | 3.413E-05 | 3.557E-04 | 3.449E-05 | 5.250E-05 | 1.022E-04 | 6.348E-04 | 3.145E-04 | 2.631E-04 |
| Total $CO_2$, kg/m$^3$ | 5.173E-03 | 2.778E-03 | 1.071E-03 | −2.480E-04 | 9.428E-04 | −9.473E-05 | 3.510E-04 | −2.598E-04 | 2.582E-03 | 8.137E-04 | 5.676E-04 |
| Mineral $CO_2$, lb/ft$^3$ | 2.248E-04 | 1.193E-04 | 2.041E-05 | −1.864E-05 | 2.033E-05 | −9.807E-06 | 1.715E-05 | −2.844E-05 | 1.114E-04 | 2.408E-05 | 1.271E-05 |
| Dissolved $CO_2$, lb/ft$^3$ | 2.002E-05 | 1.091E-05 | 1.203E-05 | 1.028E-06 | 1.632E-05 | 1.740E-06 | 1.478E-06 | 5.837E-06 | 1.016E-05 | 7.080E-06 | 6.293E-06 |
| Solution $CO_2$, lb/ft$^3$ | 7.814E-05 | 4.321E-05 | 3.441E-05 | 2.131E-06 | 2.221E-05 | 2.153E-06 | 3.277E-06 | 6.377E-06 | 3.963E-05 | 1.963E-05 | 1.643E-05 |
| Total $CO_2$, lb/ft$^3$ | 3.229E-04 | 1.735E-04 | 6.685E-05 | −1.548E-05 | 5.885E-05 | −5.913E-06 | 2.191E-05 | −1.622E-05 | 1.612E-04 | 5.080E-05 | 3.543E-05 |
| Weighted Average of Zones | | | | | | | | | | | |
| Total Thickness, m | 208.8 | | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 3.064E-04 | | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 8.340E-05 | | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 2.069E-04 | | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 5.966E-04 | | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 1.913E-05 | | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 5.207E-06 | | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 1.291E-05 | | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 3.725E-05 | | | | | | | | | | |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | | | | | |
| pH | 4.006 | 4.004 | 4.621 | 6.240 | 5.244 | 5.481 | 5.297 | 5.372 | 4.003 | 4.670 | 4.732 |
| pE | −0.190 | −0.188 | −0.827 | −2.896 | −1.544 | −1.805 | −1.531 | −1.685 | −0.185 | −0.881 | −0.951 |
| Activity | 0.840 | 0.838 | 0.866 | 0.976 | 0.843 | 0.920 | 0.501 | 0.917 | 0.840 | 0.877 | 0.891 |
| Ionic Strength | 3.997 | 4.034 | 2.906 | 0.821 | 3.778 | 1.668 | 8.832 | 1.746 | 3.972 | 2.607 | 2.262 |
| Total Solution $CO_2$, moles | 1.17E+00 | 1.17E+00 | 1.39E+00 | 6.71E-04 | 1.78E+00 | 2.41E+00 | 1.33E+00 | 2.24E+00 | 1.20E+00 | 1.49E+00 | 1.55E+00 |
| Solution, moles | | | | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 1.1670 | 1.1450 | 2.0220 | 0.0048 | 2.0420 | 10.5000 | 0.3169 | 8.2800 | 1.2100 | 2.5020 | 3.1340 |
| Ca | 0.6624 | 0.6627 | 0.0559 | 0.6704 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6620 | 0.0492 | 0.0440 |
| Cl | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 | 5.3320 |
| Fe | 0.0005 | 0.0005 | 0.0015 | 0.0001 | 0.0002 | 0.0003 | 0.0024 | 0.0004 | 0.0006 | 0.0013 | 0.0012 |
| K | 0.0775 | 0.0764 | 1.3950 | 0.0309 | 0.0658 | 0.0127 | 0.0005 | 0.1398 | 0.0790 | 1.4410 | 1.5000 |
| Mg | 0.0216 | 0.0216 | 0.0019 | 0.0205 | 1.0630 | 2.7420 | 0.7962 | 1.9950 | 0.0216 | 0.0017 | 0.0015 |
| Na | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 | 3.9240 |
| S | 0.0020 | 0.0020 | 0.0038 | 0.0012 | 0.0513 | 0.3004 | 0.0113 | 0.1864 | 0.0020 | 0.0049 | 0.0066 |
| Si | 0.0010 | 0.0009 | 0.0014 | 0.0066 | 0.0011 | 0.0041 | 0.0002 | 0.0035 | 0.0010 | 0.0016 | 0.0019 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 24.530 | 6.822 | 143.800 | 6502.000 | 0.000 | 0.000 | 0.000 | 0.000 | 201.400 | 138.200 | 100.500 |
| Celadonite | 0.000 | 0.076 | 23.690 | 932.500 | 264.100 | 242.900 | 14.470 | 276.900 | 0.317 | 33.320 | 45.290 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.850 | 2.500 | 0.000 | 0.553 | 122.200 | 1522.000 | 392.600 | 367.100 | 1.399 | 142.500 | 122.700 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.712 | 10.570 | 14.340 | 808.900 | 17.100 | 542.800 | 235.500 | 365.600 | 1.608 | 33.540 | 79.440 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 16.190 | 15.880 | 19.170 | 304.700 | 13.080 | 80.320 | 81.290 | 98.460 | 18.320 | 59.770 | 37.740 |
| Quartz | 374.400 | 713.100 | 895.000 | 4134.000 | 167.200 | 11,280.000 | 5599.000 | 3520.000 | 536.500 | 1389.000 | 1690.000 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 24.200 | 3.953 | 117.000 | 6202.000 | 0.000 | 0.000 | 0.000 | 0.000 | 200.500 | 96.960 | 35.800 |
| Celadonite | 0.000 | 0.000 | 0.000 | 678.000 | 256.200 | 0.000 | 0.000 | 95.030 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | 298.600 | 296.100 | 270.100 | 0.000 | 296.700 | 288.200 | 298.500 | 290.400 | 298.100 | 255.100 | 231.100 |
| Dolomite | 1.114 | 5.304 | 27.380 | 300.600 | 122.800 | 1523.000 | 393.200 | 367.700 | 2.204 | 184.400 | 188.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.294 | 2.680 | 0.000 | 0.000 | 0.000 | 17.930 | 68.410 | 0.000 | 0.204 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 18.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 22.780 | 23.180 |
| Muscovite | 0.350 | 6.339 | 12.890 | 687.600 | 14.570 | 443.400 | 131.700 | 310.800 | 1.203 | 29.230 | 68.280 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 52.260 | 3.548 | 125.100 | 24.020 | 90.260 | 0.000 | 0.000 | 0.000 |
| Pyrite | 16.190 | 15.880 | 19.170 | 304.700 | 13.060 | 80.170 | 81.280 | 98.360 | 18.320 | 59.760 | 37.740 |
| Quartz | 375.200 | 726.000 | 947.200 | 5764.000 | 204.400 | 12,400.000 | 5877.000 | 4324.000 | 539.400 | 1484.000 | 1875.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.025 | 0.149 | 0.003 | 0.092 | 0.000 | 0.001 | 0.002 |
| Change (initial – final), moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.329 | −2.869 | −26.840 | −300.100 | 0.000 | 0.000 | 0.000 | 0.000 | −0.869 | −41.270 | −64.710 |
| Celadonite | 0.000 | −0.076 | −23.690 | −254.500 | −7.922 | −242.900 | −14.470 | −181.900 | −0.317 | −33.320 | −45.290 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | −1.365 | −3.882 | −29.940 | −300.000 | −3.261 | −11.840 | −1.514 | −9.566 | −1.949 | −44.860 | −68.950 |
| Dolomite | 0.264 | 2.804 | 27.380 | 300.100 | 0.598 | 0.598 | 0.598 | 0.598 | 0.805 | 41.810 | 65.260 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −0.712 | −10.570 | −14.340 | −808.900 | −17.100 | −542.800 | −235.500 | −365.600 | −1.608 | −33.540 | −79.440 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.294 | 2.680 | 0.000 | 0.000 | 0.000 | 17.930 | 68.410 | 0.000 | 0.204 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 18.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 22.780 | 23.180 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Muscovite | 0.350 | 6.339 | 12.890 | 687.600 | 14.570 | 443.400 | 131.700 | 310.800 | 1.203 | 29.230 | 68.280 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 52.260 | 3.548 | 125.100 | 24.020 | 90.260 | 0.000 | 0.000 | 0.000 |
| Pyrite | −0.001 | −0.001 | −0.001 | 0.000 | −0.025 | −0.150 | −0.005 | −0.093 | −0.001 | −0.002 | −0.003 |
| Quartz | 0.854 | 12.910 | 52.260 | 1630.000 | 37.190 | 1130.000 | 277.900 | 803.800 | 2.880 | 94.660 | 184.800 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.025 | 0.149 | 0.003 | 0.092 | 0.000 | 0.001 | 0.002 |
| Final Solution, moles | | | | | | | | | | | |
| $CaCO_3$ | 6.21E-06 | 6.21E-06 | 6.21E-06 | 6.21E-06 | 7.45E-10 | 4.46E-10 | 2.95E-10 | 7.33E-10 | 6.21E-06 | 6.21E-06 | 6.21E-06 |
| $CaHCO_3^+$ | 1.96E-02 | 1.96E-02 | 5.17E-03 | 1.34E-04 | 1.38E-07 | 5.49E-08 | 3.07E-08 | 1.16E-07 | 1.98E-02 | 4.71E-03 | 4.17E-03 |
| $CO_2$ | 1.14E+00 | 1.13E+00 | 1.32E+00 | 2.18E-04 | 1.17E+00 | 1.59E+00 | 6.04E-01 | 1.59E+00 | 1.17E+00 | 1.41E+00 | 1.47E+00 |
| $CO_3^{2-}$ | 6.47E-08 | 6.39E-08 | 1.14E-06 | 1.99E-07 | 1.95E-05 | 5.87E-05 | 1.13E-05 | 3.63E-05 | 6.52E-08 | 1.47E-06 | 1.93E-06 |
| $FeCO_3$ | 1.39E-09 | 1.33E-09 | 6.32E-08 | 2.04E-09 | 6.95E-08 | 6.95E-08 | 6.95E-08 | 6.95E-08 | 1.44E-09 | 6.95E-08 | 6.95E-08 |
| $FeCO_3^+$ | 2.88E-18 | 2.77E-18 | 3.29E-17 | 9.73E-21 | 6.51E-18 | 4.07E-18 | 4.23E-18 | 5.36E-18 | 3.02E-18 | 3.26E-17 | 2.83E-17 |
| $FeHCO_3^+$ | 3.94E-05 | 3.79E-05 | 4.73E-04 | 3.94E-07 | 1.16E-04 | 7.69E-05 | 6.49E-05 | 9.86E-05 | 4.12E-05 | 4.74E-04 | 4.20E-04 |
| $HCO_3^-$ | 1.03E-02 | 1.02E-02 | 4.73E-02 | 2.87E-04 | 1.82E-01 | 3.92E-01 | 7.75E-02 | 3.07E-01 | 1.04E-02 | 5.61E-02 | 6.63E-02 |
| $MgCO_3$ | 5.35E-08 | 5.35E-08 | 5.35E-08 | 5.35E-08 | 4.46E-04 | 7.46E-04 | 1.13E-03 | 4.54E-04 | 5.35E-08 | 5.35E-08 | 5.35E-08 |
| $MgHCO_3^+$ | 7.18E-04 | 7.19E-04 | 1.89E-04 | 4.89E-06 | 3.52E-01 | 3.90E-01 | 4.97E-01 | 3.04E-01 | 7.25E-04 | 1.73E-04 | 1.53E-04 |
| $NaCO_3^-$ | 3.60E-09 | 3.59E-09 | 4.84E-08 | 3.06E-09 | 9.77E-07 | 1.08E-06 | 1.40E-06 | 7.68E-07 | 3.60E-09 | 5.65E-08 | 6.53E-08 |
| $NaHCO_3$ | 4.88E-03 | 4.91E-03 | 1.47E-02 | 2.08E-05 | 7.54E-02 | 4.22E-02 | 1.52E-01 | 3.87E-02 | 4.92E-03 | 1.50E-02 | 1.47E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −0.329 | −2.869 | −26.840 | −300.100 | 0.000 | 0.000 | 0.000 | 0.000 | −0.869 | −41.270 | −64.710 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.528 | 5.608 | 54.760 | 600.200 | 1.195 | 1.195 | 1.195 | 1.195 | 1.610 | 83.620 | 130.520 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.025 | 0.149 | 0.003 | 0.092 | 0.000 | 0.001 | 0.002 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.199 | 2.739 | 27.920 | 300.100 | 1.220 | 1.345 | 1.198 | 1.288 | 0.740 | 42.351 | 65.812 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.135 | 1.131 | 1.323 | 0.000 | 1.174 | 1.589 | 0.604 | 1.592 | 1.167 | 1.413 | 1.467 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.035 | 0.035 | 0.068 | 0.000 | 0.610 | 0.825 | 0.727 | 0.650 | 0.036 | 0.076 | 0.086 |
| Total $CO_2$, moles/kg $H_2O$ | 1.370 | 3.905 | 29.311 | 300.101 | 3.004 | 3.759 | 2.529 | 3.530 | 1.943 | 43.840 | 67.364 |

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**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Water g/cm$^3$ | 0.093 | 0.052 | 0.031 | 0.002 | 0.019 | 0.002 | 0.005 | 0.005 | 0.047 | 0.018 | 0.014 |
| Water kg/m$^3$ | 92.973 | 51.705 | 30.959 | 1.713 | 18.863 | 2.134 | 5.259 | 5.088 | 47.136 | 17.531 | 14.461 |
| Mineral $CO_2$, moles/m$^3$ | 18.511 | 141.619 | 864.384 | 514.131 | 23.017 | 2.869 | 6.300 | 6.551 | 34.895 | 742.431 | 951.716 |
| Dissolved $CO_2$, moles/m$^3$ | 105.525 | 58.478 | 40.959 | 0.000 | 22.145 | 3.391 | 3.174 | 8.101 | 55.007 | 24.771 | 21.215 |
| Solution $CO_2$, moles/m$^3$ | 3.300 | 1.834 | 2.101 | 0.001 | 11.502 | 1.760 | 3.825 | 3.309 | 1.694 | 1.341 | 1.240 |
| Total $CO_2$, moles/m$^3$ | 127.335 | 201.931 | 907.444 | 514.132 | 56.664 | 8.021 | 13.298 | 17.962 | 91.596 | 768.542 | 974.171 |
| Mineral $CO_2$, moles/ft$^3$ | 0.524 | 4.010 | 24.477 | 14.559 | 0.652 | 0.081 | 0.178 | 0.186 | 0.988 | 21.023 | 26.950 |
| Dissolved $CO_2$, moles/ft$^3$ | 2.988 | 1.656 | 1.160 | 0.000 | 0.627 | 0.096 | 0.090 | 0.229 | 1.558 | 0.701 | 0.601 |
| Solution $CO_2$, moles/ft$^3$ | 0.093 | 0.052 | 0.059 | 0.000 | 0.326 | 0.050 | 0.108 | 0.094 | 0.048 | 0.038 | 0.035 |
| Total $CO_2$, moles/ft$^3$ | 3.606 | 5.718 | 25.696 | 14.559 | 1.605 | 0.227 | 0.377 | 0.509 | 2.594 | 21.763 | 27.586 |
| Mineral $CO_2$, kg/m$^3$ | 0.815 | 6.233 | 38.042 | 22.627 | 1.013 | 0.126 | 0.277 | 0.288 | 1.536 | 32.674 | 41.885 |
| Dissolved $CO_2$, kg/m$^3$ | 4.644 | 2.574 | 1.803 | 0.000 | 0.975 | 0.149 | 0.140 | 0.357 | 2.421 | 1.090 | 0.934 |
| Solution $CO_2$, kg/m$^3$ | 0.145 | 0.081 | 0.092 | 0.000 | 0.506 | 0.077 | 0.168 | 0.146 | 0.075 | 0.059 | 0.055 |
| Total $CO_2$, kg/m$^3$ | 5.604 | 8.887 | 39.937 | 22.627 | 2.494 | 0.353 | 0.585 | 0.790 | 4.031 | 33.824 | 42.873 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral $CO_2$, lb/ft$^3$ | 0.051 | 0.389 | 2.375 | 1.413 | 0.063 | 0.008 | 0.017 | 0.018 | 0.096 | 2.040 | 2.615 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.290 | 0.161 | 0.113 | 0.000 | 0.061 | 0.009 | 0.009 | 0.022 | 0.151 | 0.068 | 0.058 |
| Solution $CO_2$, lb/ft$^3$ | 0.009 | 0.005 | 0.006 | 0.000 | 0.032 | 0.005 | 0.011 | 0.009 | 0.005 | 0.004 | 0.003 |
| Total $CO_2$, lb/ft$^3$ | 0.350 | 0.555 | 2.493 | 1.413 | 0.156 | 0.022 | 0.037 | 0.049 | 0.252 | 2.112 | 2.676 |
| Weighted Average of Zones | | | | | | | | | | | |
| Total Thickness, m | 208.8 | | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 4.213 | | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 0.734 | | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 0.130 | | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 5.077 | | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.263 | | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.046 | | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.008 | | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 0.317 | | | | | | | | | | |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Start, m | 3738.4 | 3743.0 | 3755.1 | 3758.2 | 3764.3 | 3768.6 | 3796.6 | 3858.8 | 3915.2 | 3932.5 | 3738.4 |
| End, m | 3743.0 | 3755.1 | 3758.2 | 3764.3 | 3768.6 | 3796.6 | 3858.8 | 3915.2 | 3932.5 | 3947.2 | 3947.2 |
| Thickness, m | 4.6 | 12.2 | 3.0 | 6.1 | 4.3 | 28.0 | 62.2 | 56.4 | 17.4 | 14.6 | 208.8 |
| Start, ft | 12,265.0 | 12,280.0 | 12,320.0 | 12,330.0 | 12,350.0 | 12,364.0 | 12,456.0 | 12,660.0 | 12,845.0 | 12,902.0 | 12,265.0 |
| End, ft | 12,280.0 | 12,320.0 | 12,330.0 | 12,350.0 | 12,364.0 | 12,456.0 | 12,660.0 | 12,845.0 | 12,902.0 | 12,950.0 | 12,950.0 |
| Thickness, ft | 15.0 | 40.0 | 10.0 | 20.0 | 14.0 | 92.0 | 204.0 | 185.0 | 57.0 | 48.0 | 685.0 |
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | | | | |
| pH | −2.062 | −2.060 | −1.340 | 0.000 | −0.402 | −0.437 | −0.365 | −0.466 | −2.066 | −1.306 | −1.276 |
| pE | 2.533 | 2.531 | 1.764 | 0.000 | 0.693 | 0.739 | 0.680 | 0.758 | 2.538 | 1.725 | 1.689 |
| Activity | −0.021 | −0.017 | −0.006 | 0.000 | −0.031 | −0.042 | −0.010 | −0.039 | −0.021 | −0.007 | −0.015 |
| Ionic Strength | −0.001 | −0.081 | −0.840 | 0.000 | 0.092 | 0.393 | 0.793 | 0.289 | −0.018 | −0.856 | −0.665 |
| Total Solution $CO_2$, moles | 1.171 | 1.166 | 1.390 | 0.000 | 1.783 | 2.413 | 1.331 | 2.241 | 1.203 | 1.489 | 1.551 |
| Solution, moles | | | | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 1.167 | 1.145 | 2.021 | 0.000 | 2.041 | 10.497 | 0.317 | 8.277 | 1.210 | 2.501 | 3.133 |
| Ca | −0.020 | -0.020 | −0.621 | 0.000 | −0.597 | −0.598 | −0.597 | −0.599 | −0.020 | −0.627 | −0.632 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.001 | 0.001 | 0.001 |
| K | 0.077 | 0.076 | 1.383 | 0.000 | 0.041 | 0.008 | 0.000 | 0.095 | 0.078 | 1.428 | 1.486 |
| Mg | 0.000 | 0.000 | −0.020 | 0.000 | 0.968 | 2.637 | 0.689 | 1.911 | 0.000 | −0.020 | −0.021 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.001 | 0.001 | 0.003 | 0.000 | 0.050 | 0.299 | 0.010 | 0.185 | 0.001 | 0.004 | 0.006 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

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**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.160 | −2.698 | −26.700 | −300.000 | 0.000 | 0.000 | 0.000 | 0.000 | −0.700 | −41.140 | −64.600 |
| Celadonite | 0.000 | 0.000 | −16.490 | 150.000 | 0.700 | 0.000 | 0.000 | 1.040 | 0.000 | −16.520 | −5.537 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | 298.600 | 296.100 | 270.100 | 0.000 | 296.700 | 288.200 | 298.500 | 290.400 | 298.100 | 255.100 | 231.100 |
| Dolomite | 0.178 | 2.718 | 27.300 | 299.978 | 0.600 | 1.000 | 0.600 | 0.600 | 0.719 | 41.800 | 65.200 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.056 | −0.792 | 0.000 | 0.000 | 0.000 | −1.070 | −0.430 | 0.000 | −0.122 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 18.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 22.780 | 23.180 |
| Muscovite | −0.018 | 0.830 | 0.690 | 0.000 | 0.020 | 1.000 | 0.400 | 0.000 | 0.161 | 0.720 | 0.750 |
| Phlogopite | −0.059 | −0.906 | −3.598 | −150.040 | −0.752 | −1.100 | −0.420 | −1.180 | −0.240 | −8.397 | −19.880 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | −0.020 | −0.150 | −0.010 | −0.100 | 0.000 | −0.010 | 0.000 |
| Quartz | 0.100 | 1.900 | 20.600 | −150.000 | −0.600 | 0.000 | 1.000 | 0.000 | 0.500 | 21.000 | 10.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.025 | 0.149 | 0.003 | 0.092 | 0.000 | 0.001 | 0.002 |
| Change (initial – final), moles | | | | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.158 | −2.698 | −26.681 | −299.958 | 0.000 | 0.000 | 0.000 | 0.000 | −0.699 | −41.112 | −64.554 |
| Celadonite | 0.000 | 0.000 | −16.489 | 150.000 | 0.690 | 0.000 | 0.000 | 1.000 | 0.000 | −16.520 | −5.530 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21320 | 1.365 | 3.882 | 29.940 | 300.000 | 3.261 | 11.840 | 1.514 | 9.566 | 1.949 | 44.860 | 68.950 |
| Dolomite | 0.178 | 2.718 | 27.300 | 300.031 | 0.597 | 0.598 | 0.597 | 0.599 | 0.719 | 41.731 | 65.182 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Zone 8 | Aquifer Zone 9 | Aquifer Zone 10 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.056 | −0.792 | 0.000 | 0.000 | 0.000 | −1.070 | −0.430 | 0.000 | −0.122 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 18.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 22.780 | 23.180 |
| Muscovite | −0.018 | 0.830 | 0.690 | 0.000 | 0.020 | 1.000 | 0.400 | 0.000 | 0.161 | 0.720 | 0.750 |
| Phlogopite | −0.059 | −0.906 | −3.598 | −150.040 | −0.752 | −1.100 | −0.420 | −1.180 | −0.240 | −8.397 | −19.880 |
| Pyrite | −0.001 | −0.001 | −0.001 | 0.000 | −0.025 | −0.150 | −0.005 | −0.093 | −0.001 | −0.002 | −0.003 |
| Quartz | 0.119 | 1.810 | 20.640 | −150.000 | −0.570 | 2.000 | 0.800 | −0.700 | 0.479 | 20.810 | 9.900 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.025 | 0.149 | 0.003 | 0.092 | 0.000 | 0.001 | 0.002 |
| Final Solution, moles | | | | | | | | | | | |
| $CaCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | −2.81E-06 | −2.61E-06 | −1.96E-06 | −2.92E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $CaHCO_3^+$ | 1.94E-02 | 1.95E-02 | 4.95E-03 | 0.00E+00 | −2.08E-04 | −1.19E-04 | −9.47E-05 | −1.59E-04 | 1.96E-02 | 4.49E-03 | 3.96E-03 |
| $CO_2$ | 1.13E+00 | 1.13E+00 | 1.32E+00 | 0.00E+00 | 1.17E+00 | 1.59E+00 | 6.03E-01 | 1.59E+00 | 1.17E+00 | 1.41E+00 | 1.47E+00 |
| $CO_3^{2-}$ | 3.82E-09 | 5.05E-09 | 1.07E-06 | 0.00E+00 | 1.95E-05 | 5.86E-05 | 1.13E-05 | 3.62E-05 | 4.21E-09 | 1.40E-06 | 1.84E-06 |
| $FeCO_3$ | 1.36E-09 | 1.31E-09 | 6.32E-08 | 0.00E+00 | 6.94E-08 | 6.90E-08 | 6.95E-08 | 6.90E-08 | 1.41E-09 | 6.94E-08 | 6.93E-08 |
| $FeCO_3^+$ | 2.88E-18 | 2.77E-18 | 3.29E-17 | 0.00E+00 | 6.51E-18 | 4.07E-18 | 4.23E-18 | 5.35E-18 | 3.02E-18 | 3.26E-17 | 2.83E-17 |
| $FeHCO_3^+$ | 3.94E-05 | 3.79E-05 | 4.73E-04 | 0.00E+00 | 1.16E-04 | 7.67E-05 | 6.49E-05 | 9.83E-05 | 4.12E-05 | 4.74E-04 | 4.20E-04 |
| $HCO_3^-$ | 1.02E-02 | 1.01E-02 | 4.72E-02 | 0.00E+00 | 1.81E-01 | 3.92E-01 | 7.75E-02 | 3.07E-01 | 1.03E-02 | 5.60E-02 | 6.61E-02 |
| $MgCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.46E-04 | 7.46E-04 | 1.13E-03 | 4.53E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $MgHCO_3^+$ | 7.11E-04 | 7.13E-04 | 1.81E-04 | 0.00E+00 | 3.52E-01 | 3.90E-01 | 4.97E-01 | 3.04E-01 | 7.19E-04 | 1.65E-04 | 1.45E-04 |
| $NaCO_3^-$ | 2.08E-10 | 2.05E-10 | 4.50E-08 | 0.00E+00 | 9.75E-07 | 1.08E-06 | 1.40E-06 | 7.66E-07 | 2.12E-10 | 5.31E-08 | 6.19E-08 |
| $NaHCO_3$ | 4.84E-03 | 4.87E-03 | 1.46E-02 | 0.00E+00 | 7.53E-02 | 4.22E-02 | 1.51E-01 | 3.87E-02 | 4.88E-03 | 1.50E-02 | 1.47E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −0.158 | −2.698 | −26.681 | −299.958 | 0.000 | 0.000 | 0.000 | 0.000 | −0.699 | −41.112 | −64.554 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.356 | 5.436 | 54.601 | 600.062 | 1.195 | 1.197 | 1.194 | 1.197 | 1.438 | 83.461 | 130.363 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.025 | 0.149 | 0.003 | 0.092 | 0.000 | 0.001 | 0.002 |

Continued…

**Table B-64. Summary of MT API 21320 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Zone 8 | Zone 9 | Zone 10 | Total |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.198 | 2.738 | 27.920 | 300.104 | 1.220 | 1.346 | 1.197 | 1.290 | 0.739 | 42.350 | 65.811 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.135 | 1.131 | 1.323 | 0.000 | 1.174 | 1.589 | 0.603 | 1.592 | 1.167 | 1.413 | 1.467 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.035 | 0.035 | 0.067 | 0.000 | 0.609 | 0.825 | 0.727 | 0.650 | 0.036 | 0.076 | 0.085 |
| Total $CO_2$, moles/kg $H_2O$ | 1.368 | 3.904 | 29.310 | 300.104 | 3.003 | 3.760 | 2.527 | 3.531 | 1.942 | 43.839 | 67.363 |
| Water, g/cm$^3$ | 0.093 | 0.052 | 0.031 | 0.002 | 0.019 | 0.002 | 0.005 | 0.005 | 0.047 | 0.018 | 0.014 |
| Water, kg/m$^3$ | 92.973 | 51.705 | 30.959 | 1.713 | 18.863 | 2.134 | 5.259 | 5.088 | 47.136 | 17.531 | 14.461 |
| Mineral $CO_2$, moles/m$^3$ | 18.429 | 141.576 | 864.376 | 514.138 | 23.009 | 2.873 | 6.294 | 6.562 | 34.854 | 742.422 | 951.712 |
| Dissolved $CO_2$, moles/m$^3$ | 105.517 | 58.474 | 40.955 | 0.000 | 22.139 | 3.390 | 3.173 | 8.099 | 55.004 | 24.768 | 21.212 |
| Solution $CO_2$, moles/m$^3$ | 3.271 | 1.818 | 2.089 | 0.000 | 11.494 | 1.760 | 3.823 | 3.307 | 1.679 | 1.334 | 1.234 |
| Total $CO_2$, moles/m$^3$ | 127.218 | 201.868 | 907.420 | 514.138 | 56.643 | 8.023 | 13.291 | 17.968 | 91.537 | 768.524 | 974.158 |
| Mineral $CO_2$, moles/ft$^3$ | 0.522 | 4.009 | 24.477 | 14.559 | 0.652 | 0.081 | 0.178 | 0.186 | 0.987 | 21.023 | 26.950 |
| Dissolved $CO_2$, moles/ft$^3$ | 2.988 | 1.656 | 1.160 | 0.000 | 0.627 | 0.096 | 0.090 | 0.229 | 1.558 | 0.701 | 0.601 |
| Solution $CO_2$, moles/ft$^3$ | 0.093 | 0.051 | 0.059 | 0.000 | 0.325 | 0.050 | 0.108 | 0.094 | 0.048 | 0.038 | 0.035 |
| Total $CO_2$, moles/ft$^3$ | 3.602 | 5.716 | 25.695 | 14.559 | 1.604 | 0.227 | 0.376 | 0.509 | 2.592 | 21.762 | 27.585 |
| Mineral $CO_2$, kg/m$^3$ | 0.811 | 6.231 | 38.041 | 22.627 | 1.013 | 0.126 | 0.277 | 0.289 | 1.534 | 32.674 | 41.885 |
| Dissolved $CO_2$, kg/m$^3$ | 4.644 | 2.573 | 1.802 | 0.000 | 0.974 | 0.149 | 0.140 | 0.356 | 2.421 | 1.090 | 0.934 |
| Solution $CO_2$, kg/m$^3$ | 0.144 | 0.080 | 0.092 | 0.000 | 0.506 | 0.077 | 0.168 | 0.146 | 0.074 | 0.059 | 0.054 |
| Total $CO_2$, kg/m$^3$ | 5.599 | 8.884 | 39.936 | 22.627 | 2.493 | 0.353 | 0.585 | 0.791 | 4.029 | 33.823 | 42.873 |
| Mineral $CO_2$, lb/ft$^3$ | 0.051 | 0.389 | 2.375 | 1.413 | 0.063 | 0.008 | 0.017 | 0.018 | 0.096 | 2.040 | 2.615 |
| Dissolved $CO_2$, lb/ft$^3$ | 0.290 | 0.161 | 0.113 | 0.000 | 0.061 | 0.009 | 0.009 | 0.022 | 0.151 | 0.068 | 0.058 |
| Solution $CO_2$, lb/ft$^3$ | 0.009 | 0.005 | 0.006 | 0.000 | 0.032 | 0.005 | 0.011 | 0.009 | 0.005 | 0.004 | 0.003 |
| Total $CO_2$, lb/ft$^3$ | 0.350 | 0.555 | 2.493 | 1.413 | 0.156 | 0.022 | 0.037 | 0.049 | 0.251 | 2.111 | 2.676 |
| Weighted Average of Zones | | | | | | | | | | | |
| Total Thickness, m | 208.8 | | | | | | | | | | |
| Mineral $CO_2$, kg/m$^3$ | 4.213 | | | | | | | | | | |
| Dissolved $CO_2$, kg/m$^3$ | 0.734 | | | | | | | | | | |
| Solution $CO_2$, kg/m$^3$ | 0.130 | | | | | | | | | | |
| Total $CO_2$, kg/m$^3$ | 5.076 | | | | | | | | | | |
| Mineral $CO_2$, lb/ft$^3$ | 0.263 | | | | | | | | | | |
| Dissolved $CO_2$, lb/ft$^3$ | 0.046 | | | | | | | | | | |
| Solution $CO_2$, lb/ft$^3$ | 0.008 | | | | | | | | | | |
| Total $CO_2$, lb/ft$^3$ | 0.317 | | | | | | | | | | |

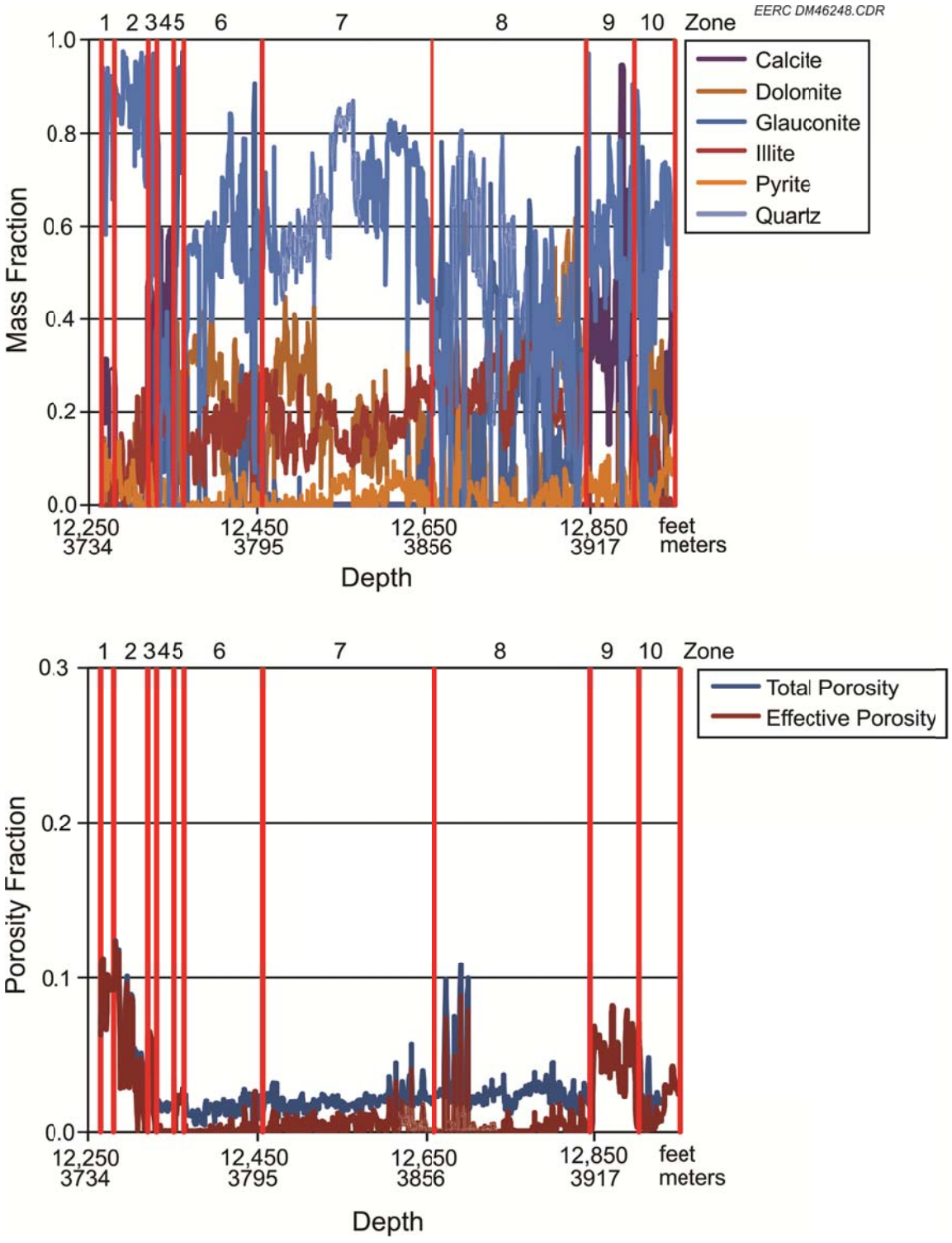



Figure B-19. MT API 21320 mineral composition and porosity as a function of depth.

**MT API 21328**

The water composition used for MT API is from the MT API 05059 well 18 miles (29 km) to the north northeast. Mineral data were available for 86% of the COSS represented in this well. The total COSS thickness is not known, as the well did not penetrate into the Precambrian.

Zones 1 and 2 consist primarily of quartz with moderate amounts of dolomite. Zone 3 is almost exclusively quartz. The majority of Zone 4 is quartz, along with illite and glauconite in a 2:1 ratio. Zone 5 is primarily quartz, with a modest amount of dolomite, and Zone 6 is primarily quartz with a modest amount of illite. Zone 7 contains a moderate amount of quartz, along with calcite, dolomite, glauconite, and illite in roughly equal amounts. The porosity of the zones ranges from 0.014 to 0.066.

Small additional amounts of kaolinite dissolve and less phlogopite forms, with corresponding increases in quartz and muscovite. For most zones, there is a small increase in dolomite and depletion of calcite. The exceptions are Zone 7 and, to a lesser extent, Zone 4, where extensive calcium dissolution and dolomite formation are predicted. A small amount of pyrite also dissolves with the formation of siderite.

The amount of $CO_2$ dissolved in the formation water ranges from 0.73 to 0.95 moles/kg (30.8 to 41.8 g/kg). The total average amount of $CO_2$ reacting with the minerals and formation water is 10.7 kg/m$^3$ (0.7 lb/ft$^3$) of formation rock. Most of this results from the large amount of dolomite forming in Zone 7.

## Table B-65. Average Mineral and Porosity Values for the MT API 21328 Aquifer Zones

Well Name: MT API 21328; API Identification: 25-085-21328-0000

| Depth | feet | meters | Mass Fraction | Total Porosity | Effective Porosity | Biotite | Calcite | Chlorite | Dolomite | Glauconite | Illite | K-Feldspar | Kaolinite | Muscovite | Pyrite | Quartz | Smectite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone 1 | | | | | | | | | | | | | | | | | |
| Start | 10,303 | 3140.4 | Average | 0.062 | 0.062 | 0.000 | 0.002 | 0.000 | 0.180 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.818 | 0.000 |
| End | 10,320 | 3145.5 | Minimum | 0.042 | 0.042 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.731 | 0.000 |
| Thickness | 17 | 5.2 | Maximum | 0.079 | 0.079 | 0.000 | 0.063 | 0.000 | 0.269 | 0.000 | 0.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.937 | 0.000 |
| Number of Values | 35 | | Standard deviation | 0.009 | 0.009 | 0.000 | 0.011 | 0.000 | 0.063 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.058 | 0.000 |
| Zone 2 | | | | | | | | | | | | | | | | | |
| Start | 10,320 | 3145.5 | Average | 0.064 | 0.063 | 0.000 | 0.016 | 0.000 | 0.129 | 0.000 | 0.023 | 0.000 | 0.000 | 0.000 | 0.000 | 0.833 | 0.000 |
| End | 10,346 | 3153.5 | Minimum | 0.016 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.711 | 0.000 |
| Thickness | 26 | 7.9 | Maximum | 0.091 | 0.091 | 0.000 | 0.124 | 0.000 | 0.235 | 0.000 | 0.289 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Number of Values | 53 | | Standard deviation | 0.016 | 0.018 | 0.000 | 0.036 | 0.000 | 0.078 | 0.000 | 0.070 | 0.000 | 0.000 | 0.000 | 0.000 | 0.053 | 0.000 |
| Zone 3 | | | | | | | | | | | | | | | | | |
| Start | 10,346 | 3153.5 | Average | 0.050 | 0.050 | 0.000 | 0.043 | 0.000 | 0.046 | 0.000 | 0.003 | 0.000 | 0.000 | 0.000 | 0.001 | 0.908 | 0.000 |
| End | 10,368 | 3160.2 | Minimum | 0.032 | 0.032 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.717 | 0.000 |
| Thickness | 22 | 6.7 | Maximum | 0.111 | 0.111 | 0.000 | 0.186 | 0.000 | 0.283 | 0.000 | 0.028 | 0.000 | 0.000 | 0.000 | 0.041 | 1.000 | 0.000 |
| Number of Values | 42 | | Standard deviation | 0.018 | 0.018 | 0.000 | 0.048 | 0.000 | 0.076 | 0.000 | 0.007 | 0.000 | 0.000 | 0.000 | 0.006 | 0.064 | 0.000 |
| Zone 4 | | | | | | | | | | | | | | | | | |
| Start | 10,368 | 3160.2 | Average | 0.042 | 0.026 | 0.000 | 0.011 | 0.000 | 0.008 | 0.128 | 0.325 | 0.000 | 0.000 | 0.000 | 0.002 | 0.527 | 0.000 |
| End | 10,388 | 3166.3 | Minimum | 0.015 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.078 | 0.000 | 0.000 | 0.000 | 0.000 | 0.044 | 0.000 |
| Thickness | 20 | 6.1 | Maximum | 0.120 | 0.113 | 0.000 | 0.167 | 0.000 | 0.302 | 0.600 | 0.504 | 0.000 | 0.000 | 0.000 | 0.037 | 0.808 | 0.000 |
| Number of Values | 40 | | Standard deviation | 0.027 | 0.029 | 0.000 | 0.034 | 0.000 | 0.048 | 0.220 | 0.098 | 0.000 | 0.000 | 0.000 | 0.007 | 0.249 | 0.000 |
| Zone 5 | | | | | | | | | | | | | | | | | |
| Start | 10,388 | 3166.3 | Average | 0.067 | 0.066 | 0.000 | 0.064 | 0.000 | 0.145 | 0.000 | 0.014 | 0.000 | 0.000 | 0.000 | 0.015 | 0.762 | 0.000 |
| End | 10,402 | 3170.5 | Minimum | 0.032 | 0.032 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.439 | 0.000 |
| Thickness | 14 | 4.3 | Maximum | 0.163 | 0.163 | 0.000 | 0.179 | 0.000 | 0.535 | 0.000 | 0.125 | 0.000 | 0.000 | 0.000 | 0.072 | 0.901 | 0.000 |
| Number of Values | 30 | | Standard deviation | 0.033 | 0.034 | 0.000 | 0.065 | 0.000 | 0.138 | 0.000 | 0.032 | 0.000 | 0.000 | 0.000 | 0.019 | 0.104 | 0.000 |
| Zone 6 | | | | | | | | | | | | | | | | | |
| Start | 10,402 | 3170.5 | Average | 0.063 | 0.058 | 0.000 | 0.026 | 0.000 | 0.034 | 0.000 | 0.104 | 0.000 | 0.000 | 0.000 | 0.014 | 0.822 | 0.000 |
| End | 10,438 | 3181.5 | Minimum | 0.014 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.597 | 0.000 |
| Thickness | 36 | 11.0 | Maximum | 0.167 | 0.166 | 0.000 | 0.233 | 0.000 | 0.253 | 0.000 | 0.403 | 0.000 | 0.000 | 0.000 | 0.091 | 0.968 | 0.000 |
| Number of Values | 71 | | Standard deviation | 0.037 | 0.040 | 0.000 | 0.050 | 0.000 | 0.065 | 0.000 | 0.122 | 0.000 | 0.000 | 0.000 | 0.028 | 0.111 | 0.000 |
| Zone 7 | | | | | | | | | | | | | | | | | |
| Start | 10,438 | 3181.5 | Average | 0.022 | 0.014 | 0.000 | 0.128 | 0.000 | 0.185 | 0.158 | 0.145 | 0.000 | 0.000 | 0.000 | 0.044 | 0.341 | 0.000 |
| End | 10,451 | 3185.5 | Minimum | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.052 | 0.000 | 0.000 | 0.000 | 0.000 | 0.124 | 0.000 |
| Thickness | 13 | 4.0 | Maximum | 0.064 | 0.060 | 0.000 | 0.368 | 0.000 | 0.488 | 0.396 | 0.270 | 0.000 | 0.000 | 0.000 | 0.109 | 0.801 | 0.000 |
| Number of Values | 26 | | Standard deviation | 0.017 | 0.017 | 0.000 | 0.150 | 0.000 | 0.191 | 0.188 | 0.070 | 0.000 | 0.000 | 0.000 | 0.033 | 0.156 | 0.000 |
| Total Column | | | | | | | | | | | | | | | | | |
| Start | 10,303 | 3140.4 | Average | 0.055 | 0.051 | 0.000 | 0.034 | 0.000 | 0.091 | 0.031 | 0.087 | 0.000 | 0.000 | 0.000 | 0.009 | 0.748 | 0.000 |
| End | 10,451 | 3185.5 | Minimum | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.044 | 0.000 |
| Thickness | 148 | 45.1 | Maximum | 0.167 | 0.166 | 0.000 | 0.368 | 0.000 | 0.535 | 0.600 | 0.504 | 0.000 | 0.000 | 0.000 | 0.109 | 1.000 | 0.000 |
| Number of Values | 297 | | Standard deviation | 0.028 | 0.032 | 0.000 | 0.069 | 0.000 | 0.113 | 0.113 | 0.132 | 0.000 | 0.000 | 0.000 | 0.022 | 0.209 | 0.000 |

**Table B-66. Average Mineral and Porosity Values for the MT API 21328 Aquifer Zones**

Well Name: MT API 21328
API Identification: 25-085-21328-0000

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Start, ft | 10,303 | 10,320 | 10,346 | 10,368 | 10,388 | 10,402 | 10,438 | 10,303 |
| End, ft | 10,320 | 10,346 | 10,368 | 10,388 | 10,402 | 10,438 | 10,451 | 10,451 |
| Thickness, ft | 17.0 | 26.0 | 22.0 | 20.0 | 14.0 | 36.0 | 13.0 | 148.0 |
| Start, m | 3140.4 | 3145.5 | 3153.5 | 3160.2 | 3166.3 | 3170.5 | 3181.5 | 3140.4 |
| End, m | 3145.5 | 3153.5 | 3160.2 | 3166.3 | 3170.5 | 3181.5 | 3185.5 | 3185.5 |
| Thickness, m | 5.2 | 7.9 | 6.7 | 6.1 | 4.3 | 11.0 | 4.0 | 45.1 |
| Temperature, °F | 244.0 | 244.0 | 244.0 | 244.0 | 244.0 | 244.0 | 244.0 | 244.0 |
| Temperature, °C | 117.8 | 117.8 | 117.8 | 117.8 | 117.8 | 117.8 | 117.8 | 117.8 |
| Pressure, psi | 6357 | 6360 | 6365 | 6368 | 6371 | 6376 | 6380 | 6368 |
| Pressure, kPa | 43,828 | 43,854 | 43,883 | 43,909 | 43,930 | 43,960 | 43,990 | 43,908 |
| Effective Porosity, fraction | 0.062 | 0.063 | 0.050 | 0.026 | 0.066 | 0.058 | 0.014 | 0.051 |
| Mass Fraction | | | | | | | | |
| Biotite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.002 | 0.016 | 0.043 | 0.011 | 0.064 | 0.026 | 0.128 | 0.034 |
| Chlorite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 0.180 | 0.129 | 0.046 | 0.008 | 0.145 | 0.034 | 0.185 | 0.091 |
| Glauconite | 0.000 | 0.000 | 0.000 | 0.128 | 0.000 | 0.000 | 0.158 | 0.031 |
| Illite | 0.001 | 0.023 | 0.003 | 0.325 | 0.014 | 0.104 | 0.145 | 0.087 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.001 | 0.002 | 0.015 | 0.014 | 0.044 | 0.009 |
| Quartz | 0.818 | 0.833 | 0.908 | 0.527 | 0.762 | 0.822 | 0.341 | 0.748 |
| Smectite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Table B-67. Summary of MT API 21328 Aquifer Calculation Results

Well Name: MT API 21328
API Identification: 25-085-21328-0000

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Start, m | 3140.4 | 3145.5 | 3153.5 | 3160.2 | 3166.3 | 3170.5 | 3181.5 | 3140.4 |
| End, m | 3145.5 | 3153.5 | 3160.2 | 3166.3 | 3170.5 | 3181.5 | 3185.5 | 3185.5 |
| Thickness, m | 5.2 | 7.9 | 6.7 | 6.1 | 4.3 | 11.0 | 4.0 | 45.1 |
| Start, ft | 10,303.0 | 10,320.0 | 10,346.0 | 10,368.0 | 10,388.0 | 10,402.0 | 10,438.0 | 10,303.0 |
| End, ft | 10,320.0 | 10,346.0 | 10,368.0 | 10,388.0 | 10,402.0 | 10,438.0 | 10,451.0 | 10,451.0 |
| Thickness, ft | 17.0 | 26.0 | 22.0 | 20.0 | 14.0 | 36.0 | 13.0 | 148.0 |
| **Minerals Without $CO_2$** | | | | | | | | |
| pH | 6.178 | 6.177 | 5.536 | 6.198 | 6.177 | 6.175 | 6.080 | 6.180 |
| pE | 6.944 | 6.950 | −2.351 | −2.858 | −2.834 | −2.830 | −2.712 | −2.836 |
| Activity | 0.827 | 0.826 | 0.758 | 0.864 | 0.827 | 0.819 | 0.880 | 0.832 |
| Ionic Strength | 4.043 | 4.070 | 4.874 | 3.396 | 4.059 | 4.183 | 3.063 | 3.965 |
| Total Solution $CO_2$, moles | 5.258E-04 | 5.243E-04 | 1.347E-03 | 5.657E-04 | 5.249E-04 | 5.176E-04 | 9.091E-04 | 5.304E-04 |
| Solution, moles | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.0005 | 0.0005 | 0.0005 | 0.0008 | 0.0005 | 0.0005 | 0.0014 | 0.0006 |
| Ca | 0.2213 | 0.2213 | 0.2213 | 0.2211 | 0.2213 | 0.2213 | 0.2131 | 0.2212 |
| Cl | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 |
| Fe | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| K | 0.0004 | 0.0004 | 0.0004 | 0.0006 | 0.0004 | 0.0004 | 0.0175 | 0.0005 |
| Mg | 0.0071 | 0.0071 | 0.0071 | 0.0073 | 0.0071 | 0.0070 | 0.0070 | 0.0071 |
| Na | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 |
| S | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 | 0.0053 |
| Si | 0.0013 | 0.0013 | 0.0013 | 0.0017 | 0.0013 | 0.0012 | 0.0019 | 0.0013 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.722 | 6.169 | 21.270 | 10.840 | 24.310 | 11.410 | 248.600 | 17.210 |
| Celadonite | 0.000 | 0.000 | 0.000 | 30.410 | 0.000 | 0.000 | 71.520 | 3.623 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 39.220 | 27.670 | 12.430 | 4.161 | 29.950 | 8.041 | 194.800 | 24.610 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.079 | 2.332 | 0.330 | 86.230 | 1.390 | 11.680 | 73.380 | 11.360 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continue)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.508 | 1.565 | 4.855 | 4.920 | 71.260 | 3.786 |
| Quartz | 547.200 | 549.400 | 754.900 | 892.100 | 482.400 | 591.600 | 1104.000 | 622.600 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.636 | 6.082 | 21.180 | 10.750 | 24.220 | 11.330 | 248.500 | 17.120 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 34.800 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Dolomite | 39.260 | 27.720 | 12.480 | 4.209 | 30.000 | 8.090 | 194.900 | 24.660 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.024 | 0.775 | 0.107 | 8.470 | 0.461 | 3.890 | 0.000 | 1.368 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.043 | 1.207 | 0.173 | 64.820 | 0.721 | 6.036 | 62.380 | 8.287 |
| Phlogopite | 0.003 | 0.191 | 0.024 | 17.320 | 0.113 | 0.970 | 18.360 | 2.151 |
| Pyrite | 0.000 | 0.000 | 0.508 | 1.565 | 4.855 | 4.920 | 71.260 | 3.786 |
| Quartz | 547.300 | 551.800 | 755.200 | 1052.000 | 483.800 | 603.700 | 1266.000 | 642.800 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.086 | −0.086 | −0.086 | −0.086 | −0.086 | −.086 | −0.069 | −0.086 |
| Celadonite | 0.000 | 0.000 | 0.000 | −30.410 | 0.000 | 0.000 | −36.730 | −3.623 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Dolomite | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.048 | 0.039 | 0.048 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | −0.079 | −2.332 | −0.330 | −86.230 | −1.390 | −11.680 | −73.380 | −11.360 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.024 | 0.775 | 0.107 | 8.470 | 0.461 | 3.890 | 0.000 | 1.368 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.043 | 1.207 | 0.173 | 64.820 | 0.721 | 6.036 | 62.380 | 8.287 |
| Phlogopite | 0.003 | 0.191 | 0.024 | 17.320 | 0.113 | 0.970 | 18.360 | 2.151 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Quartz | 0.086 | 2.415 | 0.346 | 160.100 | 1.442 | 12.070 | 161.500 | 20.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 5.65E-06 | 5.65E-06 | 5.65E-06 | 5.65E-06 | 5.65E-06 | 5.65E-06 | 5.65E-06 | 5.65E-06 |
| $CaHCO_3^+$ | 1.15E-04 | 1.15E-04 | 1.15E-04 | 1.15E-04 | 1.15E-04 | 1.14E-04 | 1.55E-04 | 1.15E-04 |
| $CO_2$ | 1.47E-04 | 1.46E-04 | 1.47E-04 | 1.64E-04 | 1.46E-04 | 1.43E-04 | 3.34E-04 | 1.49E-04 |
| $CO_3^{2-}$ | 1.61E-07 | 1.60E-07 | 1.61E-07 | 1.91E-07 | 1.60E-07 | 1.55E-07 | 2.19E-07 | 1.64E-07 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 9.82E-12 | 2.22E-11 | 9.67E-12 | 8.34E-12 | 4.70E-11 | 1.08E-11 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 4.71E-23 | 1.06E-22 | 4.64E-23 | 3.99E-23 | 3.21E-22 | 5.20E-23 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 1.91E-09 | 4.32E-09 | 1.88E-09 | 1.61E-09 | 1.23E-08 | 2.11E-09 |
| $HCO_3^-$ | 1.67E-04 | 1.66E-04 | 1.67E-04 | 1.98E-04 | 1.66E-04 | 1.61E-04 | 3.05E-04 | 1.70E-04 |
| $MgCO_3$ | 4.21E-08 | 4.21E-08 | 4.21E-08 | 4.21E-08 | 4.21E-08 | 4.21E-08 | 4.21E-08 | 4.21E-08 |
| $MgHCO_3^+$ | 3.97E-06 | 3.97E-06 | 3.97E-06 | 3.98E-06 | 3.97E-06 | 3.95E-06 | 5.36E-06 | 3.98E-06 |
| $NaCO_3^-$ | 7.23E-09 | 7.23E-09 | 7.23E-09 | 7.14E-09 | 7.23E-09 | 7.25E-09 | 7.38E-09 | 7.21E-09 |
| $NaHCO_3$ | 8.76E-05 | 8.79E-05 | 8.76E-05 | 7.85E-05 | 8.78E-05 | 8.95E-05 | 1.04E-04 | 8.65E-05 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −8.613E-02 | −8.616E-02 | −8.613E-02 | −8.557E-02 | −8.615E-02 | −8.629E-02 | −6.886E-02 | −8.605E-02 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 9.660E-02 | 9.662E-02 | 9.660E-02 | 9.580E-02 | 9.660E-02 | 9.678E-02 | 7.844E-02 | 9.648E-02 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| Mineral $CO_2$, moles/kg $H_2O$ | 1.047E-02 | 1.046E-02 | 1.047E-02 | 1.023E-02 | 1.045E-02 | 1.049E-02 | 9.580E-03 | 1.043E-02 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 1.466E-04 | 1.460E-04 | 1.466E-04 | 1.644E-04 | 1.462E-04 | 1.430E-04 | 3.336E-04 | 1.487E-04 |
| Solution $CO_2$, moles/kg $H_2O$ | 3.792E-04 | 3.783E-04 | 3.791E-04 | 4.013E-04 | 3.786E-04 | 3.747E-04 | 5.756E-04 | 3.817E-04 |
| Total $CO_2$, moles/kg $H_2O$ | 1.100E-02 | 1.098E-02 | 1.100E-02 | 1.080E-02 | 1.097E-02 | 1.101E-02 | 1.049E-02 | 1.096E-02 |
| Water, g/cm$^3$ | 0.062 | 0.063 | 0.050 | 0.026 | 0.066 | 0.058 | 0.014 | 0.051 |
| Water, kg/m$^3$ | 62.039 | 62.743 | 50.133 | 26.008 | 66.163 | 58.273 | 14.467 | 50.980 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, moles/$m^3$ | 6.495E-01 | 6.563E-01 | 5.249E-01 | 2.661E-01 | 6.914E-01 | 6.113E-01 | 1.386E-01 | 5.317E-01 |
| Dissolved $CO_2$, moles/$m^3$ | 9.095E-03 | 9.160E-03 | 7.350E-03 | 4.276E-03 | 9.673E-03 | 8.333E-03 | 4.826E-03 | 7.581E-03 |
| Solution $CO_2$, moles/$m^3$ | 2.352E-02 | 2.374E-02 | 1.901E-02 | 1.044E-02 | 2.505E-02 | 2.183E-02 | 8.327E-03 | 1.946E-02 |
| Total $CO_2$, moles/$m^3$ | 6.822E-01 | 6.892E-01 | 5.513E-01 | 2.808E-01 | 7.261E-01 | 6.415E-01 | 1.517E-01 | 5.588E-01 |
| Mineral $CO_2$, moles/$ft^3$ | 1.839E-02 | 1.858E-02 | 1.486E-02 | 7.534E-03 | 1.958E-02 | 1.731E-02 | 3.925E-03 | 1.506E-02 |
| Dissolved $CO_2$, moles/$ft^3$ | 2.575E-04 | 2.594E-04 | 2.081E-04 | 1.211E-04 | 2.739E-04 | 2.360E-04 | 1.367E-04 | 2.147E-04 |
| Solution $CO_2$, moles/$ft^3$ | 6.661E-04 | 6.722E-04 | 5.382E-04 | 2.956E-04 | 7.093E-04 | 6.183E-04 | 2.358E-04 | 5.510E-04 |
| Total $CO_2$, moles/$ft^3$ | 1.932E-02 | 1.952E-02 | 1.561E-02 | 7.951E-03 | 2.056E-02 | 1.816E-02 | 4.297E-03 | 1.582E-02 |
| Mineral $CO_2$, kg/$m^3$ | 2.859E-02 | 2.888E-02 | 2.310E-02 | 1.171E-02 | 3.043E-02 | 2.690E-02 | 6.099E-03 | 2.340E-02 |
| Dissolved $CO_2$, kg/$m^3$ | 4.003E-04 | 4.032E-04 | 3.235E-04 | 1.882E-04 | 4.257E-04 | 3.667E-04 | 2.124E-04 | 3.336E-04 |
| Solution $CO_2$, kg/$m^3$ | 1.035E-03 | 1.045E-03 | 8.365E-04 | 4.594E-04 | 1.102E-03 | 9.609E-04 | 3.665E-04 | 8.564E-04 |
| Total $CO_2$, kg/$m^3$ | 3.002E-02 | 3.033E-02 | 2.426E-02 | 1.236E-02 | 3.196E-02 | 2.823E-02 | 6.678E-03 | 2.459E-02 |
| Mineral $CO_2$, lb/$ft^3$ | 1.785E-03 | 1.803E-03 | 1.442E-03 | 7.310E-04 | 1.900E-03 | 1.679E-03 | 3.808E-04 | 1.461E-03 |
| Dissolved $CO_2$, lb/$ft^3$ | 2.499E-05 | 2.517E-05 | 2.019E-05 | 1.175E-05 | 2.658E-05 | 2.289E-05 | 1.326E-05 | 2.083E-05 |
| Solution $CO_2$, lb/$ft^3$ | 6.463E-05 | 6.522E-05 | 5.222E-05 | 2.868E-05 | 6.882E-05 | 5.999E-05 | 2.288E-05 | 5.346E-05 |
| Total $CO_2$, lb/$ft^3$ | 1.874E-03 | 1.893E-03 | 1.515E-03 | 7.714E-04 | 1.995E-03 | 1.762E-03 | 4.169E-04 | 1.535E-03 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 45.1 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 2.333E-02 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 3.384E-04 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 8.591E-04 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 2.453E-02 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 1.457E-03 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 2.113E-05 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 5.363E-05 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 1.531E-03 | | | | | | | |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation: / Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| **Minerals with $CO_2$** | | | | | | | | |
| pH | 4.340 | 4.340 | 4.340 | 5.402 | 4.339 | 4.337 | 5.104 | 4.909 |
| pE | 1.283 | 8.789 | −0.604 | −1.802 | −0.604 | −0.602 | −1.448 | −1.209 |
| Activity | 0.814 | 0.813 | 0.814 | 0.855 | 0.814 | 0.811 | 0.901 | 0.821 |
| Ionic Strength | 4.054 | 4.064 | 4.056 | 3.308 | 4.060 | 4.106 | 2.163 | 3.816 |
| Total Solution $CO_2$, moles | 7.63E-01 | 7.63E-01 | 7.64E-01 | 1.15E+00 | 7.65E-01 | 7.61E-01 | 1.07E+00 | 8.32E-01 |
| Solution, moles | | | | | | | | |
| Al | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.7618 | 0.7584 | 0.7630 | 1.7000 | 0.7622 | 0.7444 | 2.6470 | 0.9084 |
| Ca | 0.2195 | 0.2195 | 0.2197 | 0.0000 | 0.2197 | 0.2197 | 0.0143 | 0.0186 |
| Cl | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 | 6.4520 |
| Fe | 0.0000 | 0.0000 | 0.0002 | 0.0001 | 0.0002 | 0.0002 | 0.0004 | 0.0006 |
| K | 0.0298 | 0.0297 | 0.0299 | 0.0040 | 0.0298 | 0.0292 | 0.7122 | 0.4957 |
| Mg | 0.0070 | 0.0070 | 0.0071 | 0.5036 | 0.0071 | 0.0070 | 0.0005 | 0.0006 |
| Na | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 | 6.0060 |
| S | 0.0053 | 0.0053 | 0.0057 | 0.0406 | 0.0057 | 0.0057 | 0.0137 | 0.0066 |
| Si | 0.0012 | 0.0012 | 0.0012 | 0.0018 | 0.0012 | 0.0012 | 0.0030 | 0.0013 |
| Ti | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.722 | 6.169 | 21.270 | 10.840 | 24.310 | 11.410 | 248.600 | 17.210 |
| Celadonite | 0.000 | 0.000 | 0.000 | 30.410 | 0.000 | 0.000 | 71.520 | 3.623 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 39.220 | 27.670 | 12.430 | 4.161 | 29.950 | 8.041 | 194.800 | 24.610 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.079 | 2.332 | 0.330 | 86.230 | 1.390 | 11.680 | 73.380 | 11.360 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.508 | 1.565 | 4.855 | 4.920 | 71.260 | 3.786 |
| Quartz | 547.200 | 549.400 | 754.900 | 892.100 | 482.400 | 591.600 | 1104.000 | 622.600 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.627 | 5.511 | 21.110 | 0.000 | 23.880 | 8.419 | 158.800 | 10.860 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | 299.200 | 298.700 | 299.200 | 287.100 | 298.900 | 296.300 | 207.300 | 292.400 |
| Dolomite | 39.270 | 28.290 | 12.550 | 15.180 | 30.330 | 11.000 | 284.700 | 31.120 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.064 | 0.628 | 0.127 | 4.652 | 0.392 | 2.963 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 52.110 | 0.040 |
| Muscovite | 0.017 | 1.369 | 0.168 | 68.640 | 0.804 | 6.977 | 62.730 | 9.903 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 13.490 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.508 | 1.547 | 4.855 | 4.920 | 71.260 | 3.785 |
| Quartz | 547.300 | 552.200 | 755.300 | 1060.000 | 484.000 | 605.600 | 1303.000 | 647.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.018 | 0.000 | 0.000 | 0.004 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.095 | −0.658 | −0.158 | −10.840 | −0.423 | −2.995 | −89.750 | −6.344 |
| Celadonite | 0.000 | 0.000 | 0.000 | −30.410 | 0.000 | 0.000 | −71.520 | −3.623 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | −0.773 | −1.333 | −0.837 | −12.910 | −1.101 | −3.655 | −92.720 | −7.571 |
| Dolomite | 0.059 | 0.622 | 0.121 | 11.020 | 0.386 | 2.958 | 89.910 | 6.508 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Illite | −0.079 | −2.332 | −0.330 | −86.230 | −1.390 | −11.680 | −73.380 | −11.360 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.064 | 0.628 | 0.127 | 4.652 | 0.392 | 2.963 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 52.110 | 0.040 |
| Muscovite | 0.017 | 1.369 | 0.168 | 68.640 | 0.804 | 6.977 | 62.730 | 9.903 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 13.490 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | −0.018 | 0.000 | 0.000 | −0.004 | −0.001 |
| Quartz | 0.093 | 2.797 | 0.394 | 167.700 | 1.667 | 14.010 | 198.400 | 24.420 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.018 | 0.000 | 0.000 | 0.004 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 5.65E-06 | 5.65E-06 | 5.65E-06 | 1.15E-09 | 5.65E-06 | 7.35E-01 | 5.65E-06 | 5.65E-06 |
| $CaHCO_3^+$ | 7.90E-03 | 7.90E-03 | 7.91E-03 | 1.47E-07 | 7.92E-03 | 1.19E-02 | 1.56E-03 | 2.18E-03 |
| $CO_2$ | 7.36E-01 | 7.36E-01 | 7.38E-01 | 8.15E-01 | 7.38E-01 | 7.92E-03 | 9.57E-01 | 7.62E-01 |
| $CO_3^{2-}$ | 1.68E-07 | 1.68E-07 | 1.68E-07 | 2.37E-05 | 1.68E-07 | 6.36E-03 | 6.11E-06 | 2.34E-06 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 4.97E-10 | 4.42E-08 | 4.94E-10 | 2.74E-04 | 4.42E-08 | 2.27E-08 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 4.04E-19 | 2.42E-18 | 4.02E-19 | 6.25E-06 | 5.88E-18 | 4.68E-18 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 6.64E-06 | 5.43E-05 | 6.62E-06 | 5.65E-06 | 1.16E-04 | 8.35E-05 |
| $HCO_3^-$ | 1.20E-02 | 1.20E-02 | 1.20E-02 | 1.54E-01 | 1.20E-02 | 1.66E-07 | 8.84E-02 | 4.57E-02 |
| $MgCO_3$ | 4.21E-08 | 4.21E-08 | 4.21E-08 | 2.08E-04 | 4.21E-08 | 4.21E-08 | 4.21E-08 | 4.21E-08 |
| $MgHCO_3^+$ | 2.73E-04 | 2.73E-04 | 2.73E-04 | 1.24E-01 | 2.73E-04 | 7.54E-09 | 5.37E-05 | 7.51E-05 |
| $NaCO_3^-$ | 7.54E-09 | 7.54E-09 | 7.54E-09 | 8.16E-07 | 7.54E-09 | 4.67E-10 | 1.47E-07 | 9.83E-08 |
| $NaHCO_3$ | 6.29E-03 | 6.31E-03 | 6.30E-03 | 5.57E-02 | 6.31E-03 | 3.80E-19 | 1.85E-02 | 2.17E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −0.095 | −0.658 | −0.158 | −10.840 | −0.423 | −2.995 | −89.750 | −6.344 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.117 | 1.244 | 0.242 | 22.040 | 0.773 | 5.916 | 179.820 | 13.016 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.018 | 0.000 | 0.000 | 0.004 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.022 | 0.586 | 0.085 | 11.218 | 0.350 | 2.921 | 90.074 | 6.672 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.736 | 0.736 | 0.738 | 0.815 | 0.738 | 0.008 | 0.957 | 0.762 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.026 | 0.026 | 0.026 | 0.334 | 0.026 | 0.753 | 0.109 | 0.070 |
| Total $CO_2$, moles/kg $H_2O$ | 0.785 | 1.348 | 0.849 | 12.367 | 1.115 | 3.682 | 91.139 | 7.504 |
| Water, $g/cm^3$ | 0.062 | 0.063 | 0.050 | 0.026 | 0.066 | 0.058 | 0.014 | 0.051 |
| Water, $kg/m^3$ | 62.039 | 62.743 | 50.133 | 26.008 | 66.163 | 58.273 | 14.467 | 50.980 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, moles/$m^3$ | 1.388 | 36.749 | 4.256 | 291.750 | 23.164 | 170.215 | 1303.090 | 340.139 |
| Dissolved $CO_2$, moles/$m^3$ | 45.685 | 46.185 | 36.978 | 21.200 | 48.848 | 0.462 | 13.839 | 38.842 |
| Solution $CO_2$, moles/$m^3$ | 1.642 | 1.660 | 1.328 | 8.686 | 1.753 | 43.886 | 1.572 | 3.558 |
| Total $CO_2$, moles/$m^3$ | 48.715 | 84.593 | 42.562 | 321.636 | 73.765 | 214.563 | 1318.502 | 382.539 |
| Mineral $CO_2$, moles/$ft^3$ | 0.039 | 1.041 | 0.121 | 8.261 | 0.656 | 4.820 | 36.900 | 9.632 |
| Dissolved $CO_2$, moles/$ft^3$ | 1.294 | 1.308 | 1.047 | 0.600 | 1.383 | 0.013 | 0.392 | 1.100 |
| Solution $CO_2$, moles/$ft^3$ | 0.046 | 0.047 | 0.038 | 0.246 | 0.050 | 1.243 | 0.045 | 0.101 |
| Total $CO_2$, moles/$ft^3$ | 1.379 | 2.395 | 1.205 | 9.108 | 2.089 | 6.076 | 37.336 | 10.832 |
| Mineral $CO_2$, kg/$m^3$ | 0.061 | 1.617 | 0.187 | 12.840 | 1.019 | 7.491 | 57.349 | 14.970 |
| Dissolved $CO_2$, kg/$m^3$ | 2.011 | 2.033 | 1.627 | 0.933 | 2.150 | 0.020 | 0.609 | 1.709 |
| Solution $CO_2$, kg/$m^3$ | 0.072 | 0.073 | 0.058 | 0.382 | 0.077 | 1.931 | 0.069 | 0.157 |
| Total $CO_2$, kg/$m^3$ | 2.144 | 3.723 | 1.873 | 14.155 | 3.246 | 9.443 | 58.027 | 16.836 |
| Mineral $CO_2$, lb/$ft^3$ | 0.004 | 0.101 | 0.012 | 0.802 | 0.064 | 0.468 | 3.580 | 0.935 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.126 | 0.127 | 0.102 | 0.058 | 0.134 | 0.001 | 0.038 | 0.107 |
| Solution $CO_2$, lb/$ft^3$ | 0.005 | 0.005 | 0.004 | 0.024 | 0.005 | 0.121 | 0.004 | 0.010 |
| Total $CO_2$, lb/$ft^3$ | 0.134 | 0.232 | 0.117 | 0.884 | 0.203 | 0.589 | 3.622 | 1.051 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 45.1 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 9.010 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.218 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.565 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 10.793 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.562 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.076 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.035 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.674 | | | | | | | |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| **Difference (minerals with $CO_2$ – minerals without $CO_2$)** | | | | | | | | |
| pH | −1.838 | −1.837 | −1.196 | −0.796 | −1.838 | −1.838 | −0.976 | −1.271 |
| pE | −5.661 | 1.839 | 1.747 | 1.056 | 2.230 | 2.228 | 1.264 | 1.627 |
| Activity | −0.013 | −0.013 | 0.056 | −0.009 | −0.013 | −0.008 | 0.021 | −0.011 |
| Ionic Strength | 0.011 | −0.006 | −0.818 | −0.088 | 0.001 | −0.077 | −0.900 | −0.149 |
| Total Solution $CO_2$, moles | 0.762 | 0.762 | 0.763 | 1.148 | 0.764 | 0.760 | 1.064 | 0.831 |
| Solution, moles | | | | | | | | |
| Al | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C | 0.761 | 0.758 | 0.762 | 1.699 | 0.762 | 0.744 | 2.646 | 0.908 |
| Ca | −0.002 | −0.002 | −0.002 | −0.221 | −0.002 | −0.002 | −0.199 | −0.203 |
| Cl | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Fe | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| K | 0.029 | 0.029 | 0.029 | 0.003 | 0.029 | 0.029 | 0.695 | 0.495 |
| Mg | 0.000 | 0.000 | 0.000 | 0.496 | 0.000 | 0.000 | −0.007 | −0.007 |
| Na | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| S | 0.000 | 0.000 | 0.000 | 0.035 | 0.000 | 0.000 | 0.008 | 0.001 |
| Si | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Initial Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 | 300.000 |
| Dolomite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Muscovite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Phlogopite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pyrite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation:<br>Zone: | Aquifer<br>Zone 1 | Aquifer<br>Zone 2 | Aquifer<br>Zone 3 | Aquifer<br>Zone 4 | Aquifer<br>Zone 5 | Aquifer<br>Zone 6 | Aquifer<br>Zone 7 | Aquifer<br>Total |
|---|---|---|---|---|---|---|---|---|
| Quartz | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Final Minerals, moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.009 | −0.571 | −0.070 | −10.750 | −0.340 | −2.911 | −89.700 | −6.260 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −34.800 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | 299.200 | 298.700 | 299.200 | 287.100 | 298.900 | 296.300 | 207.300 | 292.400 |
| Dolomite | 0.010 | 0.570 | 0.070 | 10.971 | 0.330 | 2.910 | 89.800 | 6.460 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.041 | −0.147 | 0.020 | −3.818 | −0.069 | −0.927 | 0.000 | −1.368 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 52.110 | 0.040 |
| Muscovite | −0.026 | 0.162 | −0.005 | 3.820 | 0.083 | 0.941 | 0.350 | 1.616 |
| Phlogopite | −0.003 | −0.191 | −0.024 | −3.830 | −0.113 | −0.970 | −18.360 | −2.151 |
| Pyrite | 0.000 | 0.000 | 0.000 | −0.018 | 0.000 | 0.000 | 0.000 | −0.001 |
| Quartz | 0.000 | 0.400 | 0.100 | 8.000 | 0.200 | 1.900 | 37.000 | 4.200 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.018 | 0.000 | 0.000 | 0.004 | 0.000 |
| Change (initial – final), moles | | | | | | | | |
| Annite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Calcite | −0.009 | −0.572 | −0.071 | −10.754 | −0.337 | −2.909 | −89.681 | −6.258 |
| Celadonite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | −34.790 | 0.000 |
| Clinochlore-7A | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $CO_2$ MT API 21328 | 0.773 | 1.333 | 0.837 | 12.910 | 1.101 | 3.655 | 92.720 | 7.571 |
| Dolomite | 0.010 | 0.573 | 0.073 | 10.972 | 0.338 | 2.910 | 89.871 | 6.460 |
| Goethite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation: Zone: | Aquifer Zone 1 | Aquifer Zone 2 | Aquifer Zone 3 | Aquifer Zone 4 | Aquifer Zone 5 | Aquifer Zone 6 | Aquifer Zone 7 | Aquifer Total |
|---|---|---|---|---|---|---|---|---|
| Illite | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| K-Feldspar | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Kaolinite | 0.041 | −0.147 | 0.020 | −3.818 | −0.069 | −0.927 | 0.000 | −1.368 |
| Maximum Microcline | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 52.110 | 0.040 |
| Muscovite | −0.026 | 0.162 | −0.005 | 3.820 | 0.083 | 0.941 | 0.350 | 1.616 |
| Phlogopite | −0.003 | −0.191 | −0.024 | −3.830 | −0.113 | −0.970 | −18.360 | −2.151 |
| Pyrite | 0.000 | 0.000 | 0.000 | −0.018 | 0.000 | 0.000 | −0.004 | −0.001 |
| Quartz | 0.007 | 0.382 | 0.049 | 7.600 | 0.225 | 1.940 | 36.900 | 4.220 |
| Rutile | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sanidine High | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Siderite | 0.000 | 0.000 | 0.000 | 0.018 | 0.000 | 0.000 | 0.004 | 0.000 |
| Final Solution, moles | | | | | | | | |
| $CaCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | −5.65E-06 | 0.00E+00 | 7.35E-01 | 0.00E+00 | 0.00E+00 |
| $CaHCO_3^+$ | 7.79E-03 | 7.79E-03 | 7.79E-03 | −1.15E-04 | 7.80E-03 | 1.17E-02 | 1.40E-03 | 2.06E-03 |
| $CO_2$ | 7.36E-01 | 7.36E-01 | 7.37E-01 | 8.15E-01 | 7.38E-01 | 7.78E-03 | 9.56E-01 | 7.62E-01 |
| $CO_3^{2-}$ | 7.10E-09 | 7.70E-09 | 7.00E-09 | 2.35E-05 | 7.40E-09 | 6.36E-03 | 5.89E-06 | 2.17E-06 |
| $FeCO_3$ | 0.00E+00 | 0.00E+00 | 4.87E-10 | 4.42E-08 | 4.84E-10 | 2.73E-04 | 4.42E-08 | 2.27E-08 |
| $FeCO_3^+$ | 0.00E+00 | 0.00E+00 | 4.03E-19 | 2.42E-18 | 4.02E-19 | 6.25E-06 | 5.88E-18 | 4.67E-18 |
| $FeHCO_3^+$ | 0.00E+00 | 0.00E+00 | 6.64E-06 | 5.43E-05 | 6.61E-06 | 5.65E-06 | 1.16E-04 | 8.35E-05 |
| $HCO_3^-$ | 1.18E-02 | 1.18E-02 | 1.18E-02 | 1.54E-01 | 1.18E-02 | −1.61E-04 | 8.81E-02 | 4.56E-02 |
| $MgCO_3$ | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.07E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| $MgHCO_3^+$ | 2.69E-04 | 2.69E-04 | 2.69E-04 | 1.24E-01 | 2.69E-04 | −3.94E-06 | 4.84E-05 | 7.12E-05 |
| $NaCO_3^-$ | 3.14E-10 | 3.11E-10 | 3.10E-10 | 8.08E-07 | 3.08E-10 | −6.78E-09 | 1.40E-07 | 9.11E-08 |
| $NaHCO_3$ | 6.21E-03 | 6.22E-03 | 6.21E-03 | 5.56E-02 | 6.22E-03 | −8.95E-05 | 1.84E-02 | 2.16E-02 |
| $CO_2$ (calcite), moles/kg $H_2O$ | −0.009 | −0.572 | −0.071 | −10.754 | −0.337 | −2.909 | −89.681 | −6.258 |
| $CO_2$ (dolomite), moles/kg $H_2O$ | 0.020 | 1.147 | 0.146 | 21.944 | 0.676 | 5.819 | 179.742 | 12.920 |
| $CO_2$ (siderite), moles/kg $H_2O$ | 0.000 | 0.000 | 0.000 | 0.018 | 0.000 | 0.000 | 0.004 | 0.000 |
| Mineral $CO_2$, moles/kg $H_2O$ | 0.012 | 0.575 | 0.074 | 11.207 | 0.340 | 2.911 | 90.064 | 6.662 |
| Dissolved $CO_2$, moles/kg $H_2O$ | 0.736 | 0.736 | 0.737 | 0.815 | 0.738 | 0.008 | 0.956 | 0.762 |
| Solution $CO_2$, moles/kg $H_2O$ | 0.026 | 0.026 | 0.026 | 0.334 | 0.026 | 0.753 | 0.108 | 0.069 |
| Total $CO_2$, moles/kg $H_2O$ | 0.774 | 1.337 | 0.838 | 12.356 | 1.104 | 3.671 | 91.129 | 7.493 |
| Water, $g/cm^3$ | 0.062 | 0.063 | 0.050 | 0.026 | 0.066 | 0.058 | 0.014 | 0.051 |
| Water, $kg/m^3$ | 62.039 | 62.743 | 50.133 | 26.008 | 66.163 | 58.273 | 14.467 | 50.980 |

Continued…

**Table B-67. Summary of MT API 21328 Aquifer Calculation Results (continued)**

| Formation: | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer | Aquifer |
|---|---|---|---|---|---|---|---|---|
| Zone: | Zone 1 | Zone 2 | Zone 3 | Zone 4 | Zone 5 | Zone 6 | Zone 7 | Total |
| Mineral $CO_2$, moles/$m^3$ | 0.738 | 36.092 | 3.731 | 291.484 | 22.472 | 169.604 | 1302.952 | 339.607 |
| Dissolved $CO_2$, moles/$m^3$ | 45.676 | 46.176 | 36.971 | 21.195 | 48.838 | 0.453 | 13.834 | 38.834 |
| Solution $CO_2$, moles/$m^3$ | 1.618 | 1.636 | 1.309 | 8.676 | 1.728 | 43.864 | 1.564 | 3.539 |
| Total $CO_2$, moles/$m^3$ | 48.033 | 83.904 | 42.011 | 321.355 | 73.038 | 213.921 | 1318.350 | 381.980 |
| Mineral $CO_2$, moles/$ft^3$ | 0.021 | 1.022 | 0.106 | 8.254 | 0.636 | 4.803 | 36.896 | 9.617 |
| Dissolved $CO_2$, moles/$ft^3$ | 1.293 | 1.308 | 1.047 | 0.600 | 1.383 | 0.013 | 0.392 | 1.100 |
| Solution $CO_2$, moles/$ft^3$ | 0.046 | 0.046 | 0.037 | 0.246 | 0.049 | 1.242 | 0.044 | 0.100 |
| Total $CO_2$, moles/$ft^3$ | 1.360 | 2.376 | 1.190 | 9.100 | 2.068 | 6.058 | 37.332 | 10.817 |
| Mineral $CO_2$, kg/$m^3$ | 0.032 | 1.588 | 0.164 | 12.828 | 0.989 | 7.464 | 57.343 | 14.946 |
| Dissolved $CO_2$, kg/$m^3$ | 2.010 | 2.032 | 1.627 | 0.933 | 2.149 | 0.020 | 0.609 | 1.709 |
| Solution $CO_2$, kg/$m^3$ | 0.071 | 0.072 | 0.058 | 0.382 | 0.076 | 1.930 | 0.069 | 0.156 |
| Total $CO_2$, kg/$m^3$ | 2.114 | 3.693 | 1.849 | 14.143 | 3.214 | 9.415 | 58.021 | 16.811 |
| Mineral $CO_2$, lb/$ft^3$ | 0.002 | 0.099 | 0.010 | 0.801 | 0.062 | 0.466 | 3.580 | 0.933 |
| Dissolved $CO_2$, lb/$ft^3$ | 0.125 | 0.127 | 0.102 | 0.058 | 0.134 | 0.001 | 0.038 | 0.107 |
| Solution $CO_2$, lb/$ft^3$ | 0.004 | 0.004 | 0.004 | 0.024 | 0.005 | 0.121 | 0.004 | 0.010 |
| Total $CO_2$, lb/$ft^3$ | 0.132 | 0.231 | 0.115 | 0.883 | 0.201 | 0.588 | 3.622 | 1.049 |
| Weighted Average of Zones | | | | | | | | |
| Total Thickness, m | 45.1 | | | | | | | |
| Mineral $CO_2$, kg/$m^3$ | 8.987 | | | | | | | |
| Dissolved $CO_2$, kg/$m^3$ | 1.217 | | | | | | | |
| Solution $CO_2$, kg/$m^3$ | 0.564 | | | | | | | |
| Total $CO_2$, kg/$m^3$ | 10.768 | | | | | | | |
| Mineral $CO_2$, lb/$ft^3$ | 0.561 | | | | | | | |
| Dissolved $CO_2$, lb/$ft^3$ | 0.076 | | | | | | | |
| Solution $CO_2$, lb/$ft^3$ | 0.035 | | | | | | | |
| Total $CO_2$, lb/$ft^3$ | 0.672 | | | | | | | |

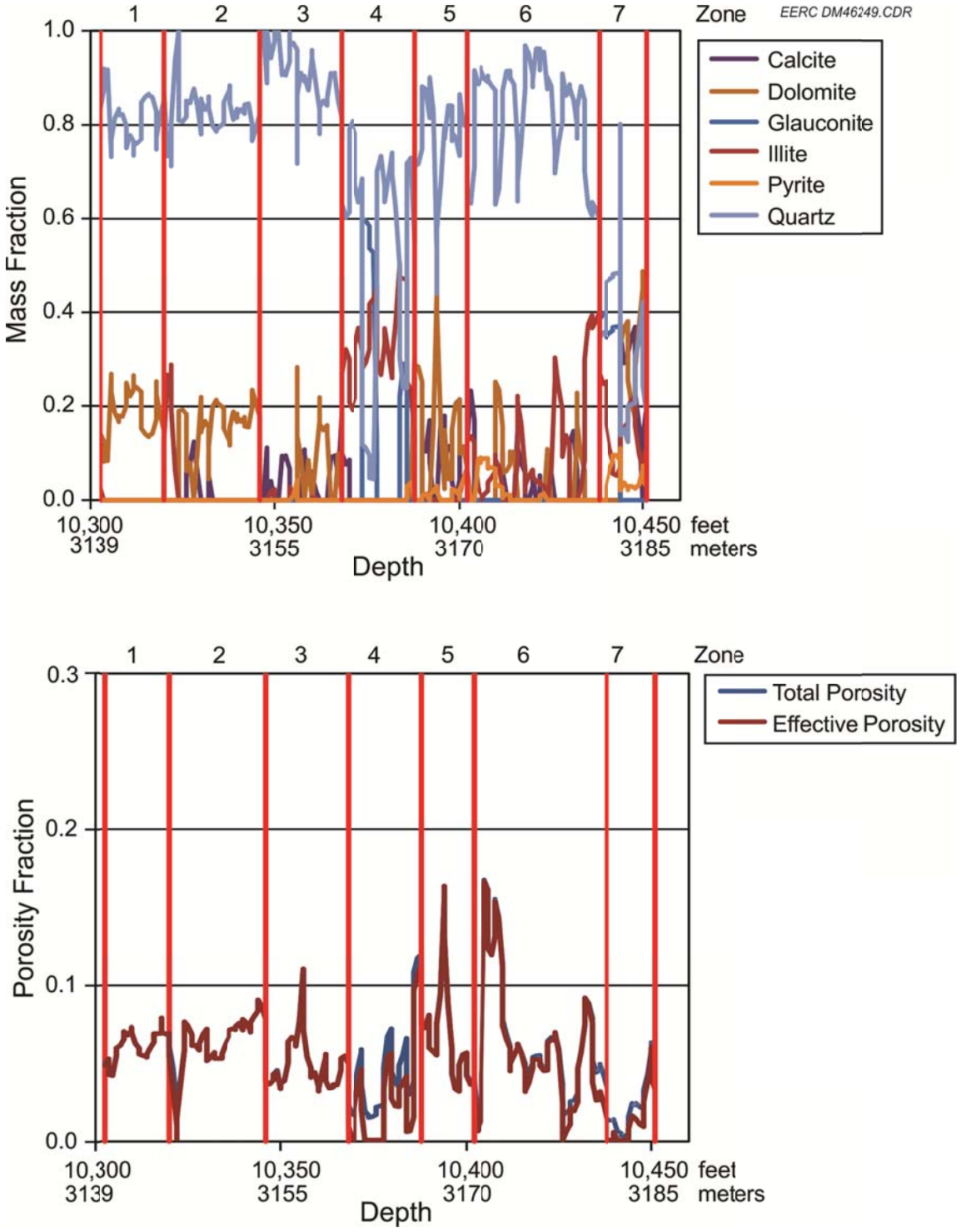



Figure B-20. MT API 21328 mineral composition and porosity as a function of depth.

## CALCULATION PROCEDURE

The calculation procedure use for the PHREEQC calculations follows the method of Talman and others (2012). Table B-68 shows the calculation sequence followed by definitions of each script.

SOLUTION 1 sets the initial conditions for the formation water at ambient pressure and at the temperature at which the water density was determined. The pE value is set to the default value of 4, and the keyword "redox pE" indicates pE was adjusted based on redox reactions. The keyword "charge" is used to balance the cation and anion electrical charge by adjusting the sodium concentration. Sulfur has been converted from the sulfate concentration of the formation water. The alkalinity is expressed in terms of mg C/L and has been converted from the bicarbonate concentration. Note that iron, aluminum, and silica analyses were generally not available for the water samples. The default amount of water is explicitly specified as 1 kg.

In PHASES, a $CO_2$ pseudo solid phase is defined and the equilibrium constant for the reaction $CO_2 + H_2O \rightarrow H^+ + HCO_3^-$ adjusted to provide the concentrations of $H^+$ and $HCO_3^-$ for a given $CO_2$ pressure. The phase is defined and inserted into the PHREEQC calculation script as:

PHASES
$CO_2$_Dueree_Aquifer
$CO_2 + 1H_2O = 1H^+ + 1HCO_3^-$
analytical_expression −83.8565525296237 − 0.0304437 2071.68 32.4462 31.2334

where the line "analytical expression" contains constants for the equation defining the equilibrium constant k:

$$\log10\ k = -83.8565525296237 + (-0.0304437 * T) + (2071.68/T) + (32.44623 * \log10[T]) + (31.2334/T^2) + (0.0 * T^2)$$

where T is the temperature in Kelvin.

From the data provided by Talman and others (2012), a regression expression was derived for the first term of the equation as a function of pressure. The second and subsequent terms are affected by temperature only. This expression is:

Term 1 = 1.43029E-05 * (pressure in kPa) – 84.44817893

At the downhole conditions for the Duerre well example, the pressure without $CO_2$ injection is 29819.8 kPa (4325 psi). The maximum additional pressure due to $CO_2$ injection was taken from the maximum wellhead injection pressure values in the ERCB/AGS Special Report 094 (Bachu and others, 2008) for depths of less than 2500 meters (8202 feet) and with a value of 4 x depth (m) for greater depths. The average depth for the example is 2886 m (9468 ft), giving an additional (4 x depth) $CO_2$ pressure of 11,544 kPa (1674 psi) and a total pressure of 41,364 kPa (5999 psi).

The Term 1 value is −83.8565525296237 as given previously in the PHASES script.

**Table B-68. Sample Input Script for PHREEQC Calculation**

| |
|---|
| TITLE Duerre_Aquifer 9380.5-9557 llnl.dat |
| SOLUTION 1 Duerre_Aquifer |
| temperature 15.555 |
| ph 5.3 |
| pe 4 |
| redox pe |
| units milligram/Liter |
| density 1.18390201775 |
| Na 88703 charge |
| Ca 18796 |
| K 6713 |
| Mg 3090 |
| Cl 185000 |
| Fe 0 |
| S 67 |
| C 14 |
| water 1 #kg |
| |
| PHASES |
| CO2_Duerre_Aquifer |
| CO2 + 1H2O = 1H+ + 1HCO3- |
| analytical_expression -83.8565525296237 -0.0304437 2071.68 32.4462 31.2334 |
| |
| REACTION_TEMPERATURE 1 |
| 15.6 |
| SAVE SOLUTION 1 |
| END |
| |
| USE SOLUTION 1 |
| REACTION_TEMPERATURE 2 |
| 86.67 |
| SAVE SOLUTION 2 |
| END |

Continued…

**Table B-68. Sample Input Script for PHREEQC Calculation (continued)**

| |
|---|
| USE SOLUTION 2 |
| EQUILIBRIUM PHASES 1 |
| #Dolomite 0 CO2(g) 10 |
| #Calcite 0 CO2(g) 10 |
| Kaolinite 0 10 |
| #K-Feldspar 0 KCl 10 |
| SAVE SOLUTION 3 |
| END |
| |
| USE SOLUTION 3 |
| EQUILIBRIUM_PHASES 2 |
| #Phlogopite 0 30 |
| #Calcite 0 30 |
| #Clinochlore-7A 0 30 |
| #Dolomite 0 30 |
| #Celadonite 0 30 |
| #Illite 0 30 |
| #K-Feldspar 0 30 |
| #Kaolinite 0 30 |
| #Muscovite 0 30 |
| #Pyrite 0 30 |
| #Quartz 0 30 |
| #Maximum_microcline 0 30 |
| #Sanidine_high 0 30 |
| #Rutile 0 30 |
| SAVE SOLUTION 4 |
| END |
| |
| USE SOLUTION 4 |
| EQUILIBRIUM_PHASES 3 |
| Phlogopite 0 0.0639833520949109 |
| Calcite 0 0 |
| Clinochlore-7A 0 0 |
| Dolomite 0 0 |
| Celadonite 0 0 |
| Illite 0 3.91232991735416 |
| K-Feldspar 0 1.08393528545554 |

Continued…

**Table B-68. Sample Input Script for PHREEQC Calculation (continued)**

| |
|---|
| Kaolinite 0 27.063107330324 |
| Muscovite 0 21.9061182640955 |
| Pyrite 0 21.7666922182978 |
| Quartz 0 204.403557030154 |
| Annite 0 0 |
| Goethite 0 0 |
| Siderite 0 0 |
| #Magnesite 0 0 |
| Maximum_microcline 0 0 |
| Sanidine_high 0 0 |
| Rutile 0 0 |
| END |
| |
| USE SOLUTION 4 |
| EQUILIBRIUM_PHASES 3 |
| Phlogopite 0 0.0639833520949109 |
| Calcite 0 0 |
| Clinochlore-7A 0 0 |
| Dolomite 0 0 |
| Celadonite 0 0 |
| Illite 0 3.91232991735416 |
| K-Feldspar 0 1.08393528545554 |
| Kaolinite 0 27.063107330324 |
| Muscovite 0 21.9061182640955 |
| Pyrite 0 21.7666922182978 |
| Quartz 0 204.403557030154 |
| Annite 0 0 |
| Goethite 0 0 |
| Siderite 0 0 |
| #Magnesite 0 0 |
| Maximum_microcline 0 0 |
| Sanidine_high 0 0 |
| Rutile 0 0 |
| CO2_Duerre_Aquifer 0 300 |
| END |

REACTION TEMPERATURE 1 simply sets the temperature to that of the initial temperature at which the density of the formation water was measured. The output of the calculation is the same as for the initial conditions of SOLUTION 1. It is retained in the calculation script to allow calculation at ambient temperature if so desired. The resultant SOLUTION 1 is used in the subsequent calculation.

REACTION TEMPERATURE 2 sets the temperature to the value at downhole conditions. Note that no change has been made in the solution chemistry. The output of the calculation gives the solution conditions at this temperature. The resultant SOLUTION 2 is used in the subsequent calculation.

EQUILIBRIUM PHASES 1 equilibrates the formation water with dolomite, calcite, and kaolinite, if these species are present. $CO_2$ is titrated into dolomite and calcite. The net effect is to add a small amount of silica, aluminum, iron, and potassium to the solution. The result of the calculation is to produce a solution that is closer to the in situ formation water, with the saturation indices of these species equal to zero. A titration of KCl with K-feldspar was originally included to achieve K-feldspar saturation. In preliminary calculations, it was found that a large amount (approximately 30 moles) of KCl would be consumed to achieve K-feldspar saturation. The addition of this amount of KCl substantially increased the salt content and changed the composition of the formation water drastically from that of the original solution. Subsequent calculation in the script gave unreasonably low pH values and $CO_2$ reactions. Therefore the K-feldspar titration with KCl was not invoked. It is felt that the behavior of K-feldspar is a result of the thermodynamic values in the llnl.dat data set, since the formation water would be expected to be in equilibrium or very close to equilibrium with K-feldspar if it is present in the mineral ensemble. The resultant is SOLUTION 3 and is used in the subsequent calculations.

EQUILIBRIUM PHASES 2 was intended to equilibrate the formation water with the estimated mineral composition of the rock in contact with the water following the method of Bachu. The values are in moles. This is done prior to addition of any $CO_2$ to separate this change from the effects of $CO_2$ addition. A sufficient number of moles (30 moles) were to be added to ensure sufficient amounts of each mineral are present to achieve equilibrium. Preliminary calculations disclosed that celandonite, clinochlore, illite, K-feldspar, maximum_microline and sanidine consumed all 30 moles of material, with their concentrations remaining zero and with concurrent increases in muscovite, phlogopite, and quartz. Because of the substantial change in the mineral chemistry because of the addition of this material, this section of the script was commented out and removed from the calculation sequence. The resultant SOLUTION 4 is unchanged from SOLUTION 3 and is used in the subsequent calculations.

EQUILIBRIUM PHASES 3 reacts the formation water with the estimated amounts of minerals in contact with the water without $CO_2$. The values are in moles. Besides mineral species known to be present, several possible precipitating mineral species with initially zero starting concentration are included. Note that magnesite was originally included in preliminary calculations, but was not used in the calculation. Magnesite was indicated to have a positive saturation index, so was included. In some cases, this resulted in unrealistically high $CO_2$ reactions to form magnesite at the expense of magnesium-containing clays.

EQUILIBRIUM PHASES 4 reacts the same formation water (SOLUTION 4) with the estimated amounts of minerals in contact with the water and with a large excess of $CO_2$. The values are in moles. Note that the pseudo solid $CO_2$ phase $CO_2$_Duerre is used. Except for the $CO_2$ phase, the calculation is identical to EQUILIBRIUM PHASES 3 calculation.

## REFERENCES


Bachu, S.H., and Christine, M.K., 2008, Stress regime at acid–gas injection operations in western Canada: ERCB/AGS Special Report 094, Alberta Geological Survey, Alberta Energy and Utilities Board, p. 7.

Talman, S., Zhang, M., and Bachu, S., 2012, Geochemical effects of $CO_2$ storage in the Basal Aquifer in the Prairie region of Canada—report for Phase 3: Alberta Innovates Technology Futures, 155 p.

# APPENDIX C

# METHODS AND DATA FROM $CO_2$ EXPOSURE EXPERIMENTS

# METHODS AND DATA FROM $CO_2$ EXPOSURE EXPERIMENTS

## SEM ANALYSIS

SEM (scanning electron microscopy) is a versatile analytical tool capable of image and chemical analyses on a variety of sample types such as polished cross sections, thin sections, rock fragments, and cuttings. Samples can be imaged from 50× to 100,000× in magnifications for detailed information on grain surfaces, grain boundaries, and mineral inclusions. The SEMs are equipped with energy-dispersive spectroscopy (EDS) analytical systems consisting of high-speed silicon drift detectors (SDD) for x-ray detection and Oxford Instruments AZtec and INCA analytical software for EDS quantitation and image analysis. Chemical analyses can be taken on individual points of interest or over larger areas on the sample surface. Mineral maps can be constructed based on the chemistry of the sample surface with the combined EDS and image analyses capabilities.

Sample preparation for SEM analysis consisted of cutting and polishing the samples to a very smooth surface prior to analysis. Once polished, the samples were carbon-coated to conduct a static charge buildup on the sample surface by the electron beam. The postreaction samples were polished before they were put into the reacting vessel but were not subsequently polished so that any surface mineralization could be documented.

The polished and coated samples were analyzed in the SEM using backscattered electron (BSE) imaging and EDS to identify dominant elemental species present in the samples. BSE is an SEM imaging technique in which high-energy electrons strike the sample surface and are reflected back to a dedicated BSE detector. In this imaging technique, heavier element compounds appear as a light gray color because more electrons are returned to the BSE detector than lighter element compounds; thus compositional differences in the sample can be visualized by the gray-level color. There are no BSE calibration standards, and the gray levels for each mineral phase vary from sample to sample. Since quartz was often a common mineral in the samples examined by SEM, the gray-level thresholds were set so that the quartz grains were a medium gray; the clay minerals show up as a darker gray material; carbonate minerals such as calcite and dolomite show up as a medium to light gray; and the heavier element minerals such as pyrite, rutile, and siderite show up as very light gray to white grains.

EDS was used to determine the chemical composition of the compounds using SEM. As the electron beam strikes the sample, electrons are knocked out of their orbital shells. In response, an electron from an outer shell replaces the removed inner electron, and x-rays are generated with an energy level unique to each element. The SDD measures the energy of the x-rays produced across 2000 channels, indicating which elements are present in the point where the beam strikes the sample. The SDD system also counts the number of x-rays generated for each of those channels, which can be compared to calibration standards to determine the weight percent of an element.

## XRF ANALYSIS

X-ray fluorescence (XRF) is the emission of characteristic “secondary” (or fluorescent) x-rays from a material that has been excited by high-energy x-rays or gamma rays. Emission spectra are unique for each element and, therefore, are widely used for elemental and chemical analysis. The spectrographic signatures emitted from the samples were analyzed using XRF to obtain a quantitative estimation of elemental and mineralogical phases.

XRF is more accurate in the identification of the elemental assemblages present in a studied bulk sample; however, the mineralogical identification requires interpretation and is often limited in its application to complex phases.

Prior to XRF analysis, the samples were ground to a fine powder to ensure the homogeneity of the mineral grain sizes. A light element binder was added, and the samples were pressed into pellets prior to analysis. The XRF analyses were performed using a wavelength-dispersive spectrometer equipped with six analyzing crystals that detect elements from boron (Atomic No. 5) to uranium (Atomic No. 92) on the periodic table. Calibration checks are performed daily on the XRF instrument. By convention, the XRF bulk chemical composition data are normally reported as oxides.

## XRD ANALYSIS

X-ray diffraction (XRD) reveals information about the crystallographic structure, chemical composition, and physical properties of materials and thin films. It is based on observing the scattered intensity of an x-ray beam striking a sample as a function of incident and scattered angle, polarization, and wavelength or energy. XRD scans were used to identify sample mineralogy and to provide qualitative and semiquantitative estimates of major and minor sample constituents.

XRD analyzes a bulk sample and is usually considered to be semiquantitative. It is unable to quantify mineralogical phases below 0.5 wt%. If solid solutions are present or amorphous phases exist, it is very difficult to interpret the mineral assemblage. Simple mineral structures, e.g., pyrite ($FeS_2$), can be identified with relatively high precision (±5 wt% error); more complex phases, for example, clays such as illite ($[K,H_3O][Al,Mg,Fe]_2[Si,Al]_4O_{10}[(OH)_2,(H_2O)]$) and others are more difficult to quantify. The error of quantitative identification of major mineral phases for XRD analysis varies from 5% to 30%.

The samples prepared for XRD analysis were micronized (reduced to below 2 μm in size) to increase the number of crystallites exposed to the x-ray beam and to make sure all phases in the sample were randomly oriented. The samples were packed into a top-load sample holder and scanned. An internal standard was added in known amounts for the quantification of the mineral phases using Rietveld full-profile refinements (Rietveld, 1967, 1969). A good internal standard is one that is not naturally present in the sample, does not exhibit preferred orientation, will not react with the sample, and will not significantly overlap phases within the sample. Also, it is beneficial for the internal standard to have an absorption coefficient close to that of the sample. Two different internal standards were used. National Institute of Standards and Technology

Standard Reference Material® (SRM) 1879 is a respirable cristobalite standard, and SRM 640 is a silicon standard. The standards were added in carefully measured quantities and thoroughly mixed with the sample. The addition of internal standards allows for the quantification of amorphous material in a given sample. When the internal standard is absent, the weight percent values are normalized to 100% and reported as relative percentages.

The Rietveld method is a technique for characterizing and quantifying crystalline materials using neutron and XRD data. By using a least squares approach, a theoretical diffraction pattern is derived that fits the collected data using physically meaningful parameters. Because the entire pattern is used, the method is capable of deconvoluting overlapping patterns due to different phases. This makes the Rietveld method the most accurate way to perform quantitative phase analysis. Crystal grain densities are calculated by the Rietveld software based on the cell parameters modeled for a particular mineral phase. Atomic bond angles and bond lengths are used for this calculation.

## REFERENCES

Rietveld, H.M., 1969, A profile refinement method for nuclear and magnetic structures: J. Appl. Crystallogr., v. 2, p. 65–71.

Rietveld, H.M., 1967, Line profiles of neutron powder-diffraction peaks for structure refinement: Acta Crystallogr., v. 22, p. 151–2.




Figure C-1. Sample ND 6264-BI-6086 preexposure.




Figure C-2. Sample ND6264-BI-6086 postexposure.

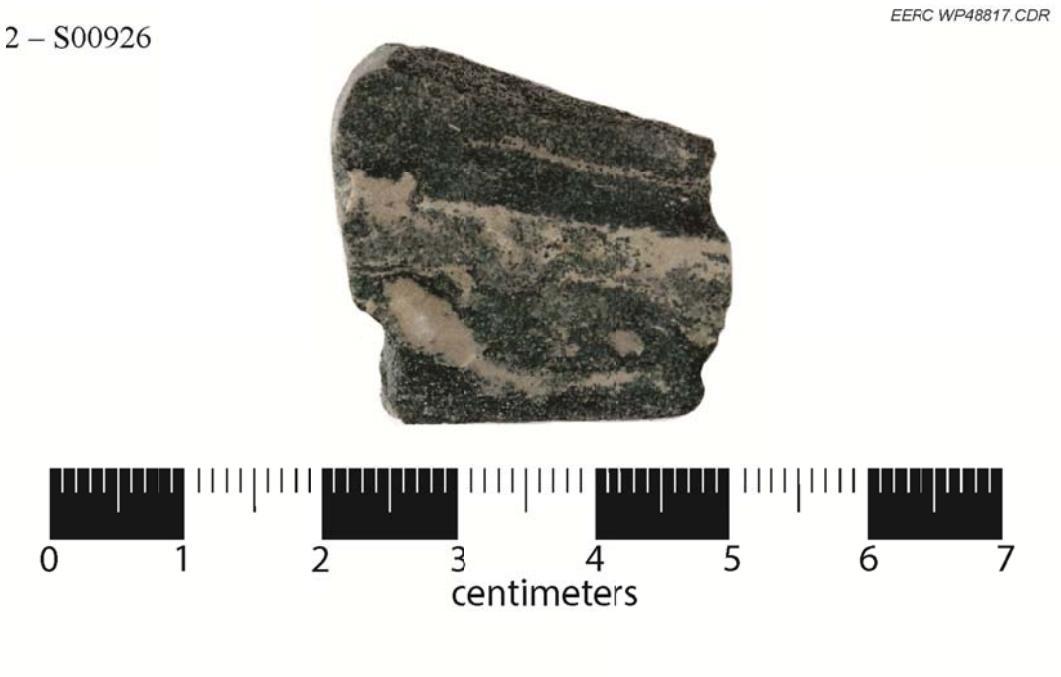



Figure C-3. Sample ND 6264-DW-6113 preexposure.




Figure C-4. Sample ND 6264-DW-6113 postexposure.




Figure C-5. Sample ND 6264-DW-6114.5 preexposure.




Figure C-6. Sample ND 6264-DW-6114.5 postexposure.

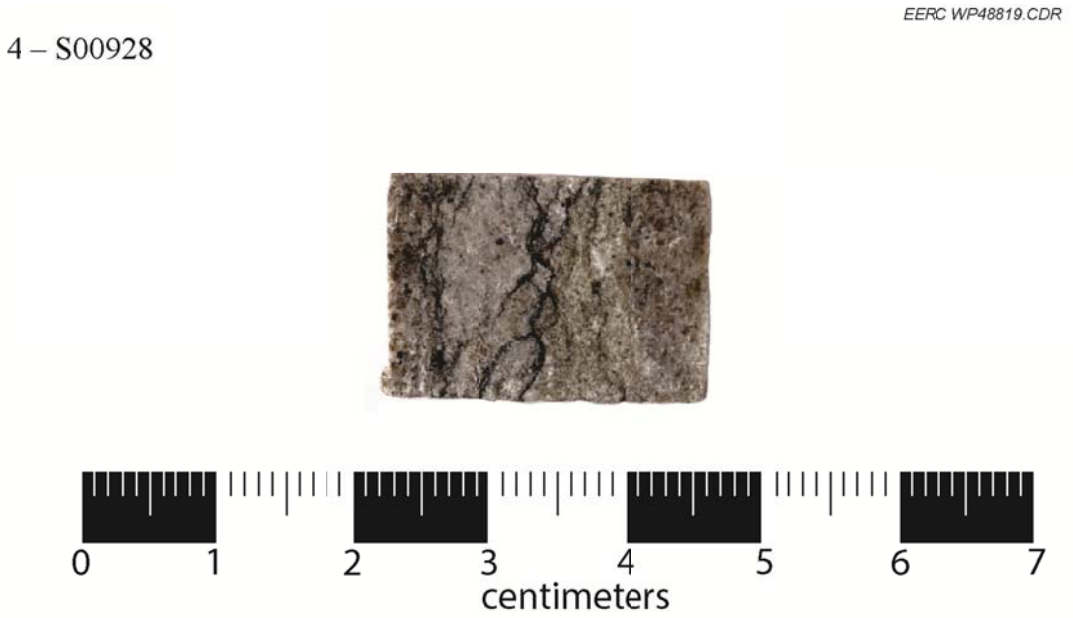



Figure C-7. Sample ND 6264-DW-6126.5 preexposure.




Figure C-8. Sample ND 6264-DW-6126.5 postexposure.




Figure C-9. Sample ND 6264-DW-6165 preexposure.




Figure C-10. Sample ND 6264-DW-6165 postexposure.

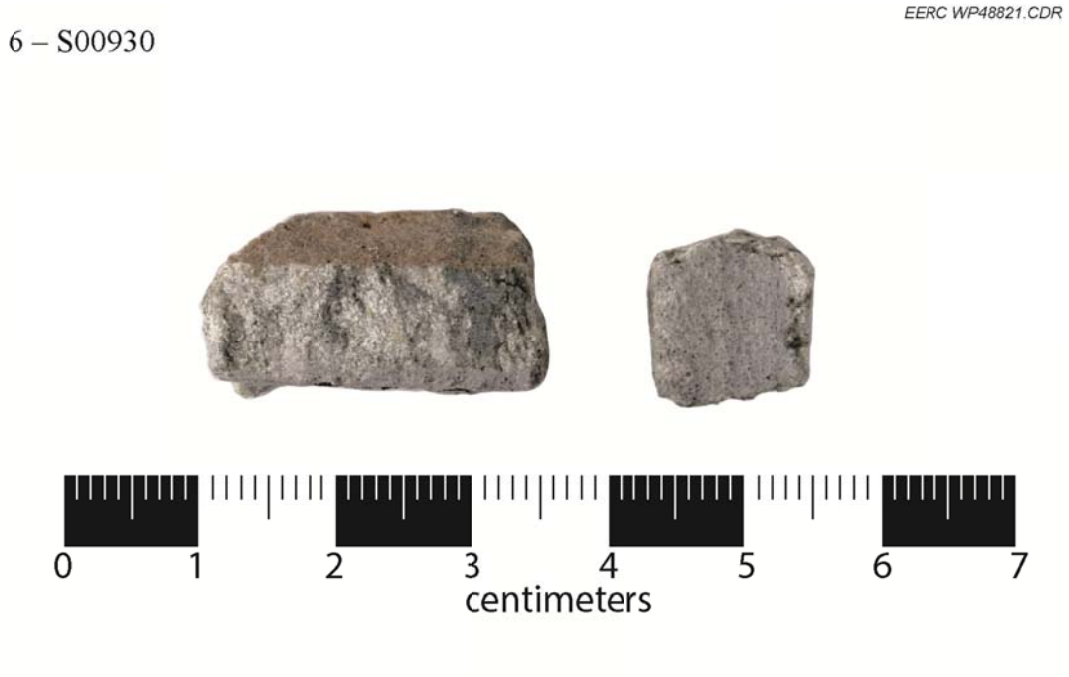



Figure C-11. Sample ND 9257-BI-11789.5 preexposure.




Figure C-12. Sample ND 9257-BI-11789.5 postexposure.

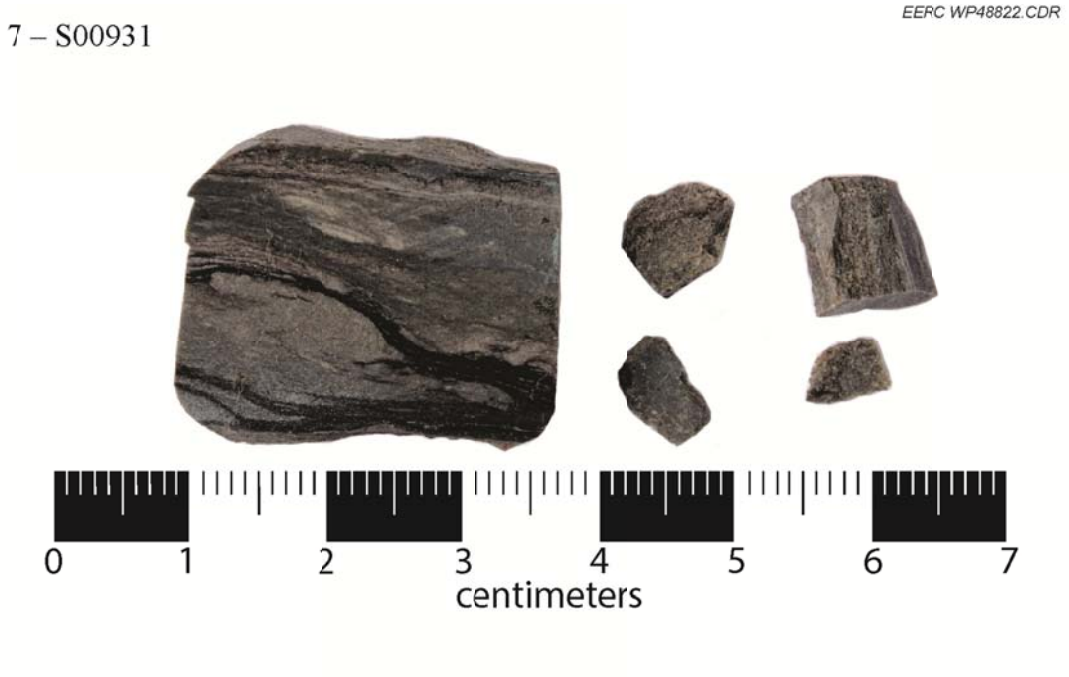



Figure C-13. Sample ND 9257-DW-11832.5 preexposure.

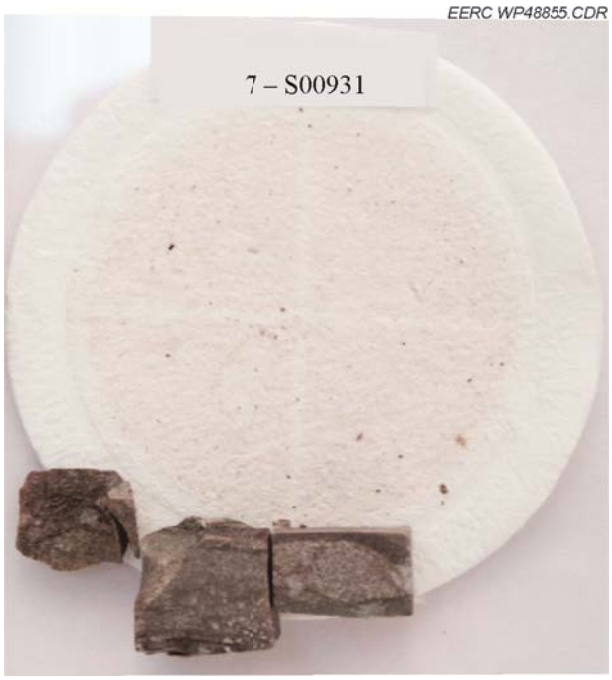



Figure C-14. Sample ND 9257-DW-11832.5 postexposure.

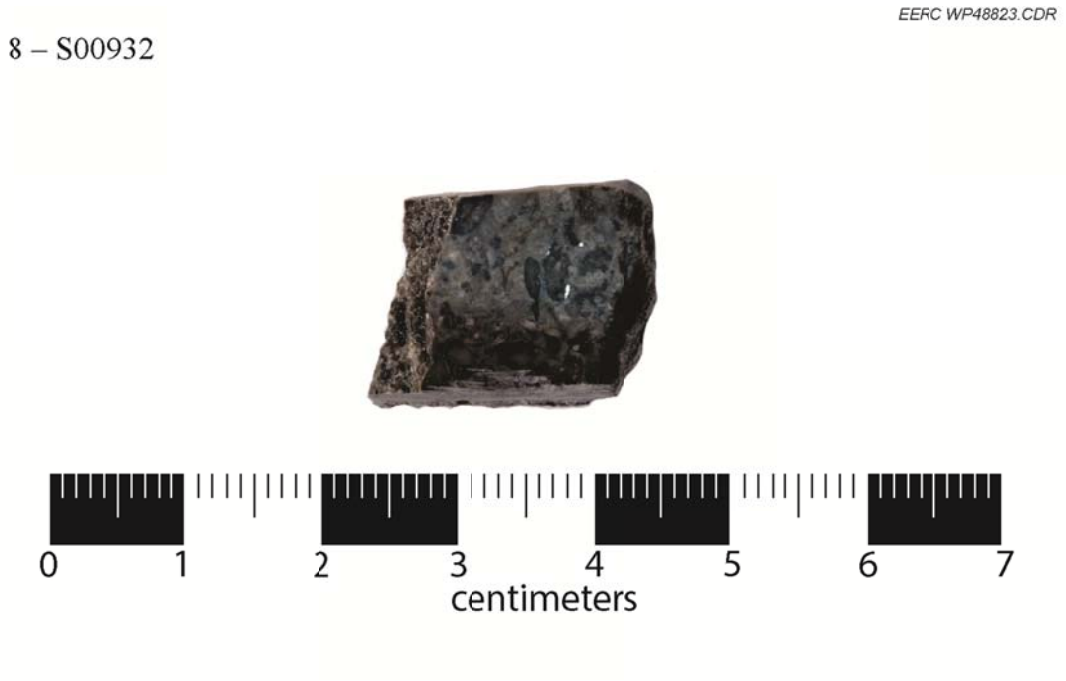



Figure C-15. Sample ND 9257-DW-11858.5 preexposure.

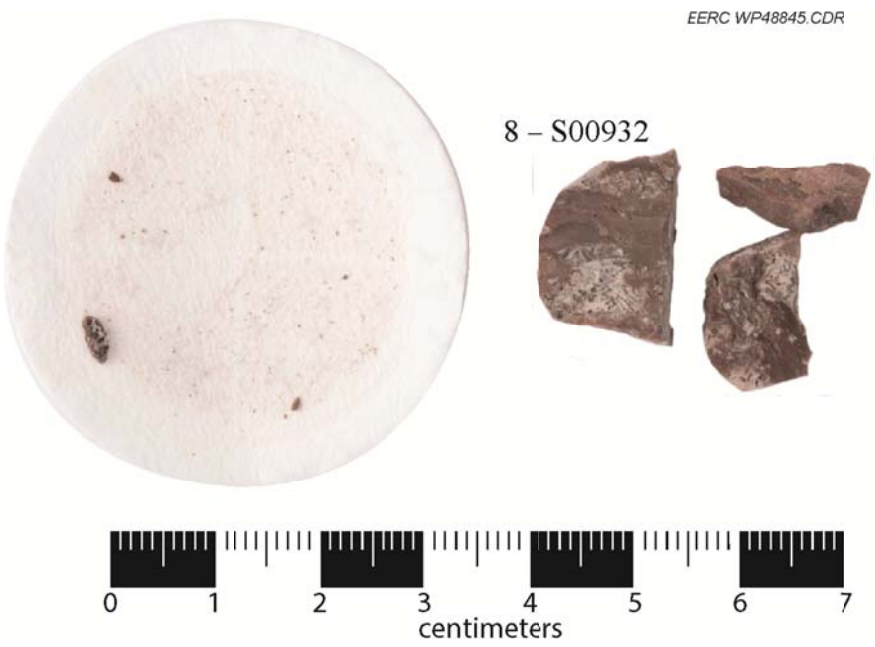



Figure C-16. Sample ND 9257-DW-11858.5 postexposure.




Figure C-17. Sample ND 12596-BI-14802 preexposure.




Figure C-18. Sample ND 12596-BI-14802 postexposure.

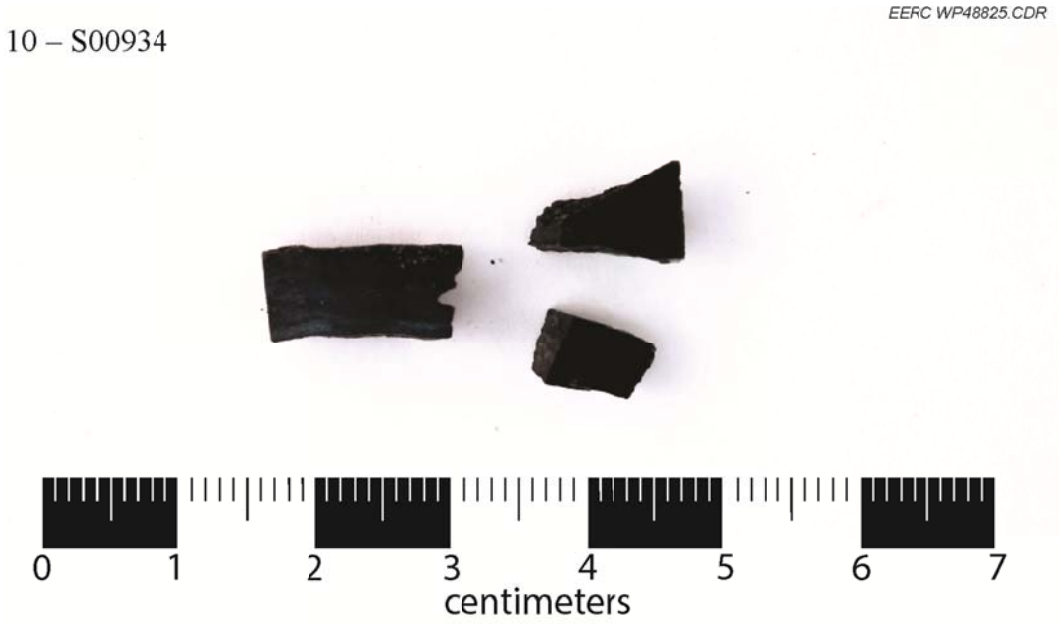



Figure C-19. Sample ND 12596-BI-14831 preexposure.




Figure C-20. Sample ND 12596-BI-14831 postexposure.

**Table C-1. Preexposure XRF Results, % as oxides**

| | ND 6264-BI-6086 | ND 6264-DW-6113 | ND 6264-DW-6114.5 | ND 6264-DW-6126.5 | ND 6264-DW-6165 | ND 9257-BI-11789.5 | ND 9257-DW-11832.5 | ND 9257-DW-11858.5 | ND 12596-BI-14802 | ND 12596-BI-14831 | $Mg_2SiO_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 93.6 | 42.4 | 73.7 | 56.9 | 82.1 | 83.1 | 63.5 | 27.2 | 95.0 | 63.5 | 37.57 |
| $Al_2O_3$ | 1.9 | 5.7 | 5.7 | 2.4 | 8.5 | 7.6 | 15.6 | 5.3 | 1.8 | 23.0 | 0.65 |
| $Fe_2O_3$ | 1.44 | 11.93 | 3.42 | 1.81 | 2.05 | 2.11 | 3.60 | 2.50 | 1.93 | 6.06 | 0.53 |
| $TiO_2$ | 0.12 | 0.22 | 0.20 | 0.11 | 0.28 | 0.29 | 0.57 | 0.18 | 0.22 | 1.24 | 0.10 |
| $P_2O_5$ | 0.00 | 0.33 | 0.03 | 0.00 | 0.30 | 0.08 | 0.18 | 0.11 | 0.02 | 0.06 | 0.03 |
| CaO | 1.0 | 23.1 | 8.3 | 34.6 | 0.6 | 3.5 | 6.1 | 57.2 | 0.1 | 0.2 | 0.47 |
| MgO | 0.35 | 8.68 | 3.81 | 1.07 | 0.57 | 0.66 | 3.92 | 3.64 | 0.15 | 1.58 | 60.45 |
| $Na_2O$ | 0.34 | 0.15 | 0.26 | 0.06 | 0.28 | 0.60 | 0.36 | 0.19 | 0.23 | 0.18 | 0.00 |
| $K_2O$ | 0.59 | 5.79 | 3.85 | 1.84 | 4.69 | 1.72 | 5.96 | 2.88 | 0.28 | 3.77 | 0.03 |
| $SO_3$ | 0.61 | 1.73 | 0.68 | 1.22 | 0.71 | 0.29 | 0.31 | 0.85 | 0.32 | 0.43 | 0.17 |



**Table C-2. Postexposure XRF Results, % as oxides**

| | ND 6264-BI-6086 | ND 6264-DW-6113 | ND 6264-DW-6114.5 | ND 6264-DW-6126.5 | ND 6264-DW-6165 | ND 9257-BI-11789.5 | ND 9257-DW-11832.5 | ND 9257-DW-11858.5 | ND 12596-BI-14802 | ND 12596-BI-14831 | $Mg_2SiO_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 93.0 | 42.1 | 73.6 | 54.9 | 83.3 | 82.1 | 53.7 | 26.5 | 93.6 | 63.5 | 43.58 |
| $Al_2O_3$ | 2.1 | 5.8 | 6.0 | 1.3 | 5.4 | 8.7 | 11.3 | 5.5 | 1.8 | 22.9 | 0.84 |
| $Fe_2O_3$ | 1.81 | 13.69 | 3.28 | 1.76 | 1.83 | 2.29 | 3.65 | 2.63 | 2.49 | 5.63 | 0.73 |
| $TiO_2$ | 0.12 | 0.17 | 0.21 | 0.11 | 0.15 | 0.48 | 0.36 | 0.18 | 0.20 | 1.28 | 0.13 |
| $P_2O_5$ | 0.00 | 0.37 | 0.01 | 0.14 | 1.85 | 0.07 | 0.24 | 0.10 | 0.00 | 0.06 | 0.24 |
| CaO | 0.3 | 17.5 | 7.4 | 38.9 | 2.1 | 1.6 | 17.1 | 55.6 | 0.1 | 0.0 | 4.51 |
| MgO | 0.36 | 7.03 | 3.52 | 1.25 | 0.27 | 0.95 | 7.32 | 5.32 | 0.21 | 1.58 | 45.70 |
| $Na_2O$ | 1.31 | 6.06 | 1.11 | 0.38 | 1.30 | 1.36 | 0.93 | 0.58 | 0.63 | 0.66 | 3.89 |
| $K_2O$ | 0.70 | 5.48 | 4.32 | 0.78 | 3.25 | 2.20 | 5.14 | 2.91 | 0.29 | 4.11 | 0.09 |
| $SO_3$ | 0.28 | 1.82 | 0.50 | 0.48 | 0.52 | 0.21 | 0.28 | 0.62 | 0.67 | 0.35 | 0.28 |

**Table C-3. Preexposure Quantitative XRD, wt%**

| | ND 6264-BI-6086 | ND 6264-DW-6113 | ND 6264-DW-6114.5 | ND 6264-DW-6126.5 | ND 6264-DW-6165 | ND 9257-BI-11789.5 | ND 9257-DW-11832.5 | ND 9257-DW-11858.5 | ND 12596-BI-14802 | ND 12596-BI-14831 |
|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 95.82 | 11.29 | 63.49 | 44.02 | 72.26 | 86.48 | 39.61 | 8.95 | 100.00 | 45.56 |
| Calcite | 1.03 | | – | 42.12 | | 5.22 | 0.62 | 57.96 | | |
| Dolomite | 0.54 | 70.39 | 25.57 | 8.58 | | – | 16.95 | 25.76 | | |
| K-Feldspar | 2.60 | 10.99 | 8.16 | 3.89 | 25.29 | 2.54 | 13.91 | 2.94 | – | 3.52 |
| Illite | | 7.33 | 2.78 | 1.38 | 2.45 | 3.91 | 27.78 | 4.40 | | 27.86 |
| Kaolinite | | | | | | 1.85 | 1.13 | | | 23.08 |
| Halite | – | – | – | – | – | – | ??? | | – | – |
| Rutile | | | | | – | | | | | |
| Pyrite | | | – | | – | – | | – | – | |
| Gypsum | | | | | | | – | | | |
| Wollastonite | | | | | | | | – | | |

**Table C-4. Postexposure Quantitative XRD, wt%**

| | ND 6264-BI-6086 | ND 6264-DW-6113 | ND 6264-DW-6114.5 | ND 6264-DW-6126.5 | ND 6264-DW-6165 | ND 9257-BI-11789.5 | ND 9257-DW-11832.5 | ND 9257-DW-11858.5 | ND 12596-BI-14802 | ND 12596-BI-14831 |
|---|---|---|---|---|---|---|---|---|---|---|
| Quartz | 91.28 | 4.06 | 58.18 | 49.64 | 72.53 | 92.31 | 28.02 | 7.35 | 94.60 | 40.74 |
| Calcite | – | | 1.81 | 41.56 | | 2.33 | 0.09 | 51.84 | | |
| Dolomite | 0.62 | 65.73 | 27.40 | 4.71 | | 0.80 | 42.14 | 32.83 | | |
| K-Feldspar | 5.35 | – | 10.86 | 3.49 | 24.44 | – | 21.40 | 4.40 | 3.60 | 13.65 |
| Illite | | 16.19 | – | – | – | 1.48 | 6.12 | 1.04 | | 10.03 |
| Kaolinite | | | | | | 0.62 | 0.09 | | | 34.85 |
| Halite | 2.76 | 14.01 | 1.48 | 0.60 | 1.66 | 2.25 | 1.80 | | 1.15 | 0.73 |
| Rutile | | | | | 0.33 | | | | | |
| Pyrite | | | 0.27 | | 1.05 | 0.21 | | 1.31 | 0.65 | |
| Gypsum | | | | | | | 0.34 | | | |
| Wollastonite | | | | | | | | 1.23 | | |

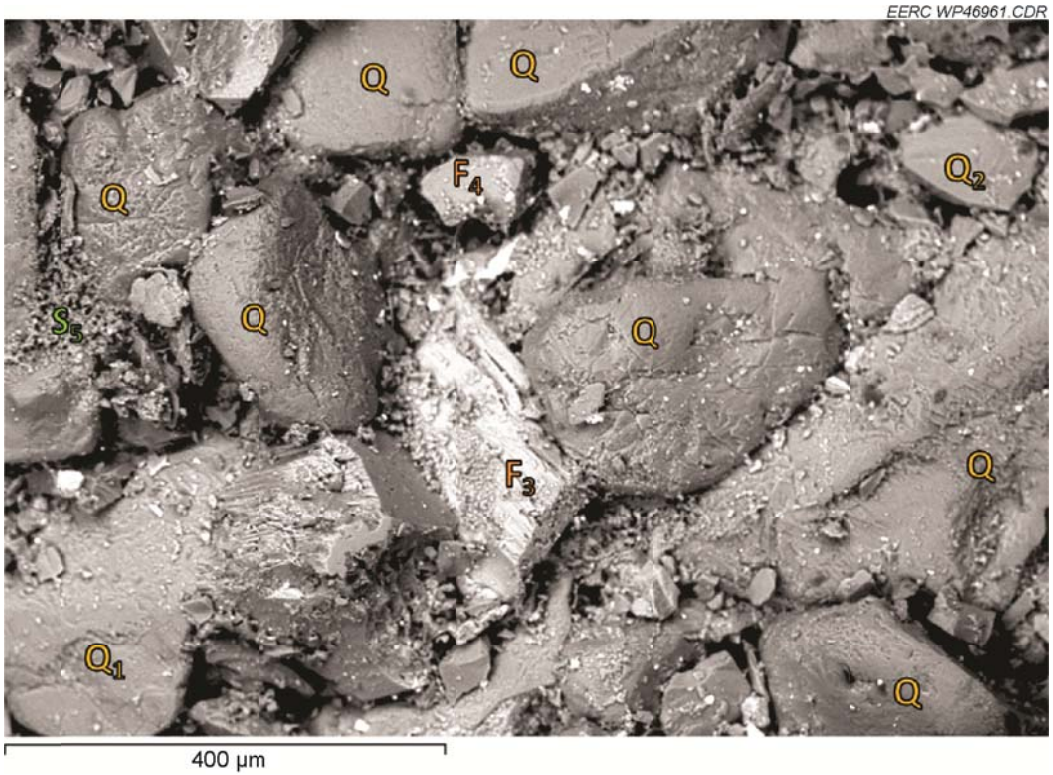



Figure C-21. Preexposure SEM image of ND 6264-BI-6086.

**Table C-5. SEM Point Analysis Data from Figure C-21**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.39 | 0.92 | 1.75 | 94.60 | 0.00 | 0.72 | 0.00 | 0.42 | 0.40 | 0.00 | 0.00 | 0.00 | 0.79 | 0.00 | Quartz |
| 2 | 0.00 | 1.08 | 0.91 | 95.30 | 0.00 | 0.65 | 0.00 | 0.30 | 1.11 | 0.00 | 0.00 | 0.00 | 0.66 | 0.00 | Quartz |
| 3 | 9.85 | 0.00 | 13.26 | 57.83 | 0.00 | 7.91 | 0.00 | 10.27 | 0.51 | 0.00 | 0.00 | 0.00 | 0.37 | 0.00 | K-feldspar |
| 4 | 0.74 | 0.00 | 15.29 | 68.02 | 0.00 | 0.80 | 0.00 | 13.91 | 0.68 | 0.00 | 0.00 | 0.00 | 0.55 | 0.00 | K-feldspar |
| 5 | 20.36 | 0.00 | 0.96 | 29.78 | 0.00 | 44.72 | 0.00 | 0.44 | 0.62 | 0.00 | 0.00 | 0.00 | 1.24 | 1.88 | Thenardite |

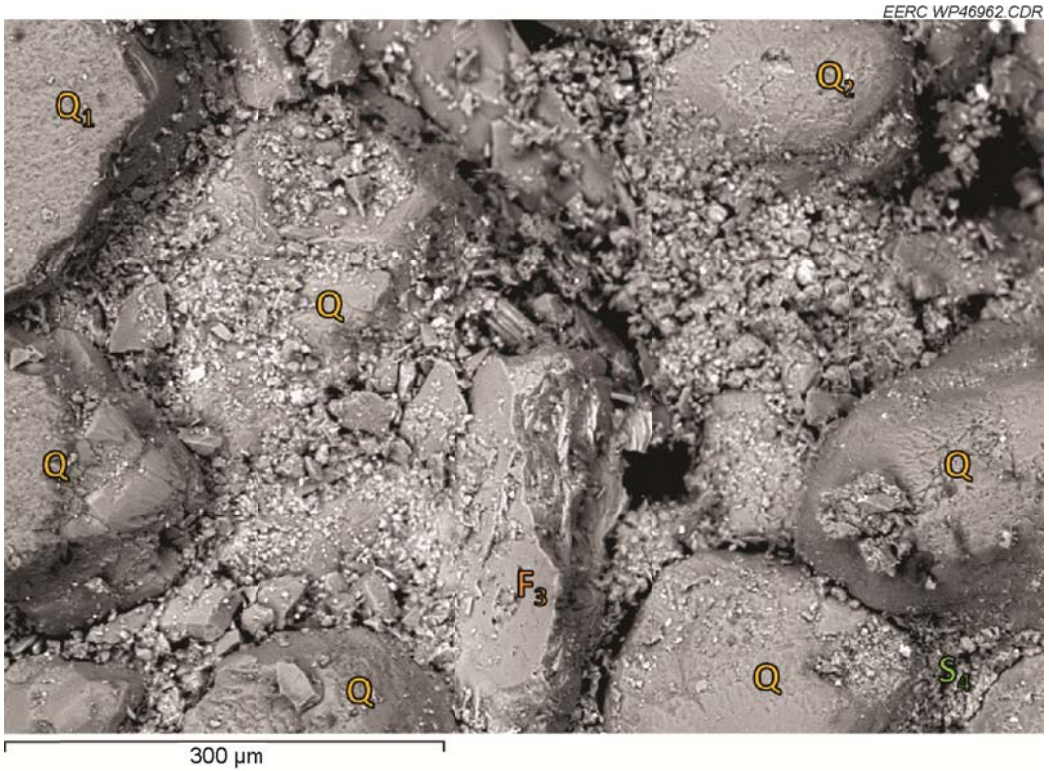



Figure C-22. Preexposure SEM Image 2 of ND 6264-BI-6086.

**Table C-6. SEM Point Analysis Data from Figure C-22**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.45 | 97.33 | 0.00 | 0.96 | 0.00 | 0.27 | 0.55 | 0.00 | 0.00 | 0.00 | 0.44 | 0.00 | Quartz |
| 2 | 3.93 | 0.00 | 1.82 | 88.71 | 0.00 | 3.09 | 0.00 | 0.72 | 1.15 | 0.00 | 0.00 | 0.00 | 0.57 | 0.00 | Quartz |
| 3 | 0.00 | 0.00 | 16.88 | 70.62 | 0.00 | 0.00 | 0.00 | 11.82 | 0.68 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | K-feldspar |
| 4 | 9.36 | 1.36 | 2.28 | 69.47 | 0.00 | 13.47 | 0.00 | 0.58 | 2.10 | 0.00 | 0.00 | 0.00 | 1.39 | 0.00 | Thenardite |

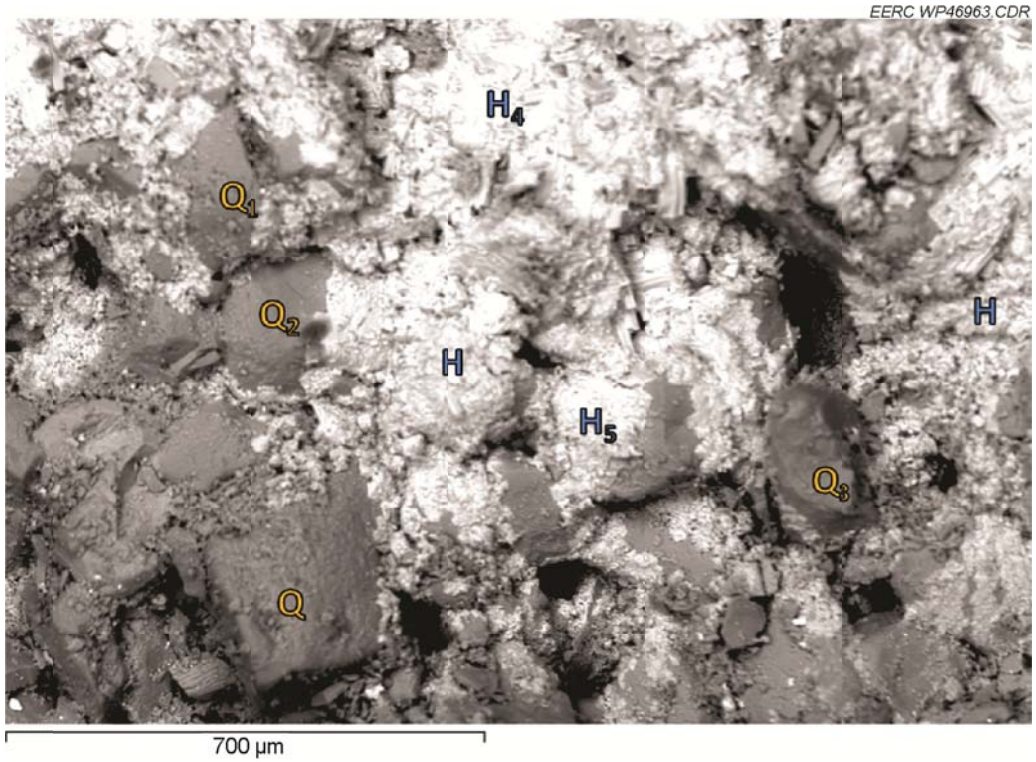



Figure C-23. Postexposure SEM image of ND 6264-BI-6086.

**Table C-7. SEM Point Analysis Data from Figure C-23**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.70 | 0.28 | 1.08 | 81.39 | 0.00 | 0.00 | 8.24 | 0.36 | 0.43 | 0.00 | 0.00 | 0.00 | 0.52 | 0.00 | Quartz |
| 2 | 5.44 | 0.27 | 1.06 | 85.86 | 0.00 | 0.00 | 5.76 | 0.34 | 0.55 | 0.00 | 0.00 | 0.00 | 0.73 | 0.00 | Quartz |
| 3 | 5.88 | 0.38 | 1.83 | 82.63 | 0.00 | 0.00 | 5.89 | 0.30 | 1.92 | 0.00 | 0.00 | 0.00 | 1.17 | 0.00 | Quartz |
| 4 | 44.58 | 0.00 | 1.03 | 6.35 | 0.00 | 0.00 | 46.9 | 0.24 | 0.42 | 0.00 | 0.00 | 0.00 | 0.49 | 0.00 | Halite |
| 5 | 45.91 | 0.00 | 1.42 | 7.98 | 0.00 | 0.00 | 43.4 | 0.13 | 0.40 | 0.00 | 0.11 | 0.00 | 0.61 | 0.00 | Halite |

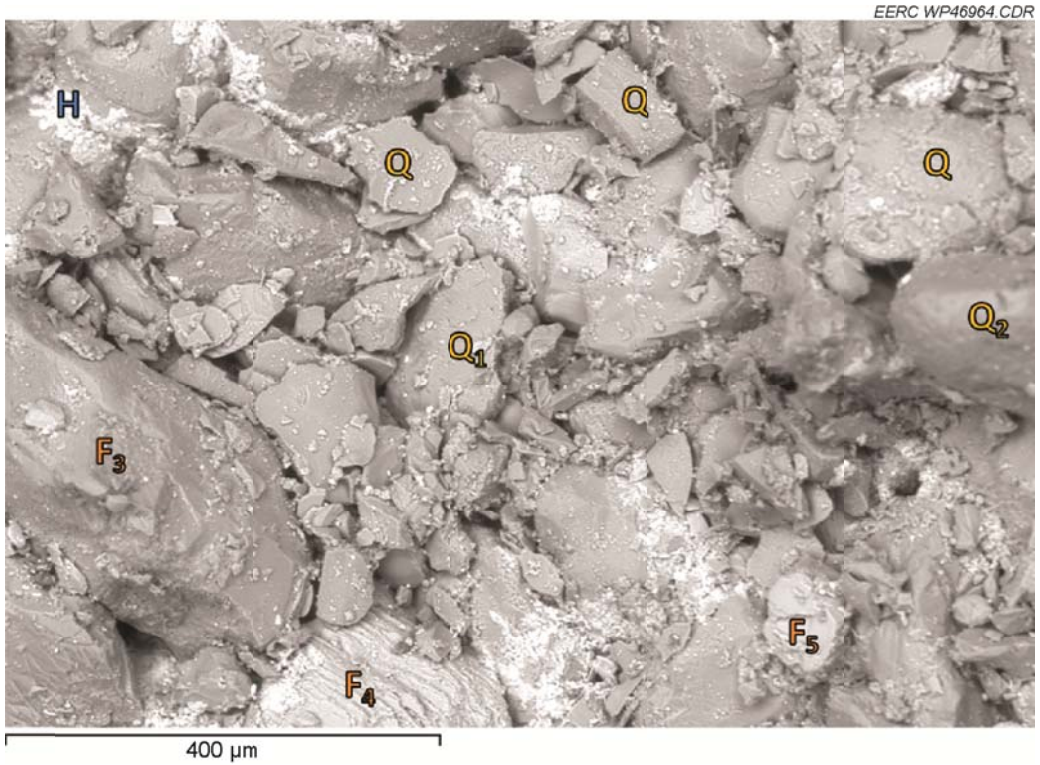



Figure C-24. Postexposure SEM image of ND 6264-BI-6086.

**Table C-8. SEM Point Analysis Data from Figure C-24**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 0.49 | 1.50 | 87.96 | 0.00 | 0.37 | 1.00 | 0.45 | 4.56 | 0.00 | 0.00 | 0.00 | 2.67 | 0.00 | Quartz |
| 2 | 1.32 | 0.33 | 2.33 | 92.49 | 0.00 | 0.00 | 0.88 | 0.35 | 0.70 | 0.00 | 0.00 | 0.00 | 1.60 | 0.00 | Quartz |
| 3 | 1.98 | 2.02 | 6.04 | 76.13 | 0.00 | 0.32 | 2.00 | 1.16 | 3.20 | 0.46 | 0.00 | 0.00 | 6.70 | 0.00 | Feldspar |
| 4 | 1.73 | 0.69 | 15.51 | 66.41 | 0.00 | 0.21 | 1.66 | 11.39 | 1.20 | 0.00 | 0.00 | 0.00 | 1.19 | 0.00 | K-feldspar |
| 5 | 1.45 | 0.25 | 15.50 | 68.96 | 0.00 | 0.00 | 0.90 | 10.90 | 0.92 | 0.17 | 0.00 | 0.00 | 0.96 | 0.00 | K-feldspar |

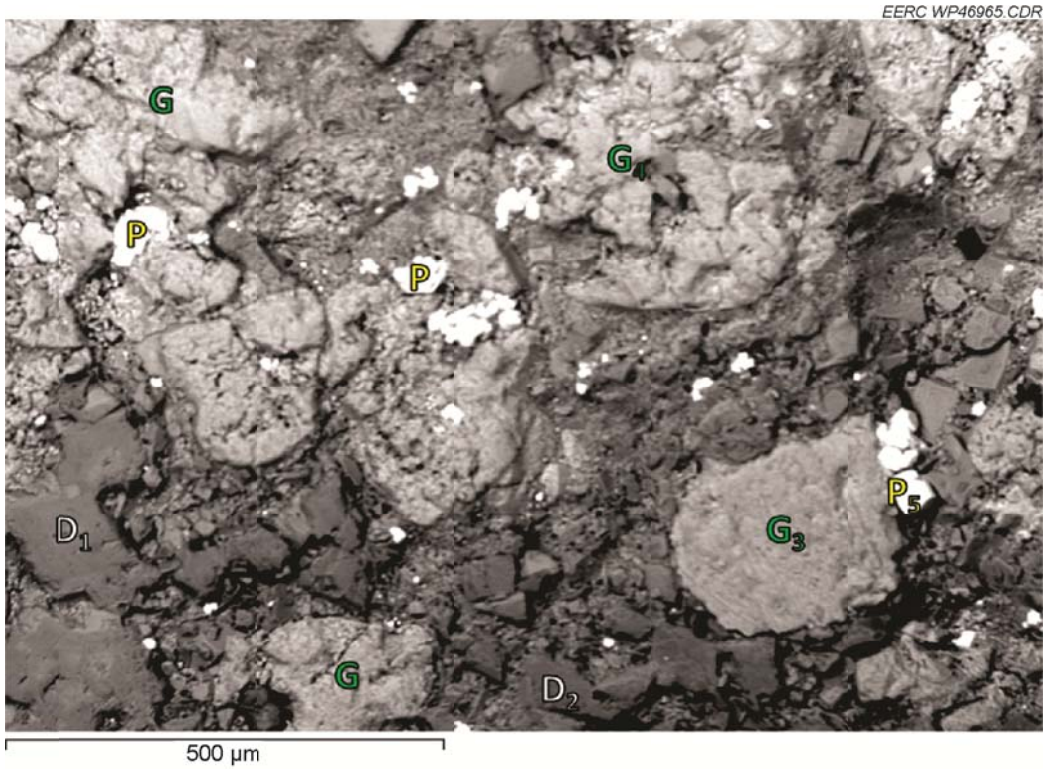



Figure C-25. Preexposure SEM image of ND 6264-DW-6113.

**Table C-9. SEM Point Analysis Data from Figure C-25**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 29.86 | 2.87 | 13.01 | 0.00 | 1.00 | 0.00 | 1.77 | 45.5 | 0.00 | 0.00 | 0.29 | 5.70 | 0.00 | Dolomite |
| 2 | 0.00 | 28.07 | 3.56 | 17.35 | 0.00 | 0.99 | 0.00 | 2.12 | 42.6 | 0.00 | 0.00 | 0.24 | 5.03 | 0.00 | Dolomite |
| 3 | 0.00 | 6.11 | 7.19 | 52.32 | 0.00 | 0.97 | 0.09 | 8.43 | 2.33 | 0.00 | 0.00 | 0.00 | 22.57 | 0.00 | Glauconite |
| 4 | 0.00 | 6.04 | 7.03 | 51.92 | 0.00 | 1.43 | 0.00 | 8.45 | 2.09 | 0.00 | 0.00 | 0.00 | 23.05 | 0.00 | Glauconite |
| 5 | 0.00 | 1.55 | 1.27 | 6.25 | 0.00 | 55.80 | 0.00 | 1.01 | 1.80 | 0.00 | 0.00 | 0.00 | 30.97 | 1.35 | Pyrite |

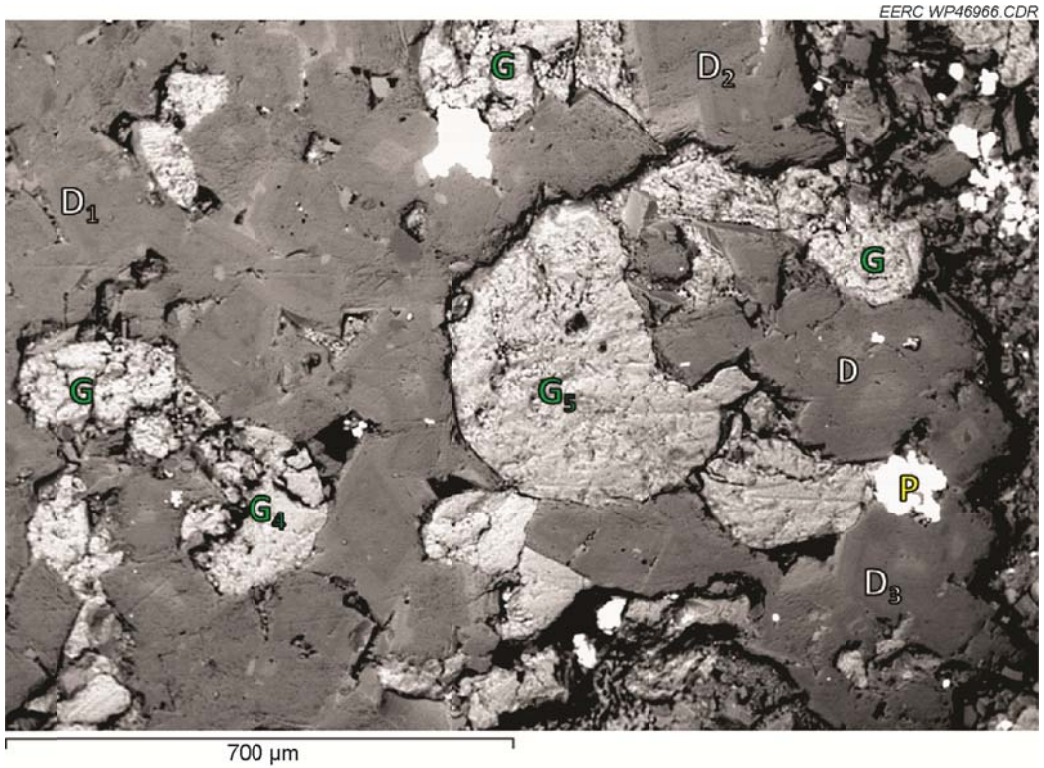



Figure C-26. Preexposure SEM Image 2 of ND 6264-DW-6113.

**Table C-10. SEM Point Analysis Data from Figure C-26**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.41 | 30.86 | 2.17 | 9.72 | 0.00 | 0.88 | 0.00 | 1.31 | 49.2 | 0.00 | 0.00 | 0.31 | 5.18 | 0.00 | Dolomite |
| 2 | 0.53 | 29.43 | 2.07 | 9.35 | 0.00 | 1.33 | 0.00 | 1.43 | 46.5 | 0.00 | 0.00 | 0.36 | 8.97 | 0.00 | Dolomite |
| 3 | 0.56 | 29.89 | 2.49 | 11.17 | 0.00 | 2.45 | 0.00 | 1.29 | 45.4 | 0.00 | 0.00 | 0.36 | 6.42 | 0.00 | Dolomite |
| 4 | 0.00 | 7.86 | 6.61 | 50.60 | 0.00 | 0.68 | 0.00 | 7.52 | 5.26 | 0.00 | 0.00 | 0.00 | 21.47 | 0.00 | Glauconite |
| 5 | 0.00 | 7.20 | 10.06 | 50.94 | 0.00 | 0.92 | 0.00 | 7.43 | 4.43 | 0.00 | 0.00 | 0.00 | 19.01 | 0.00 | Glauconite |

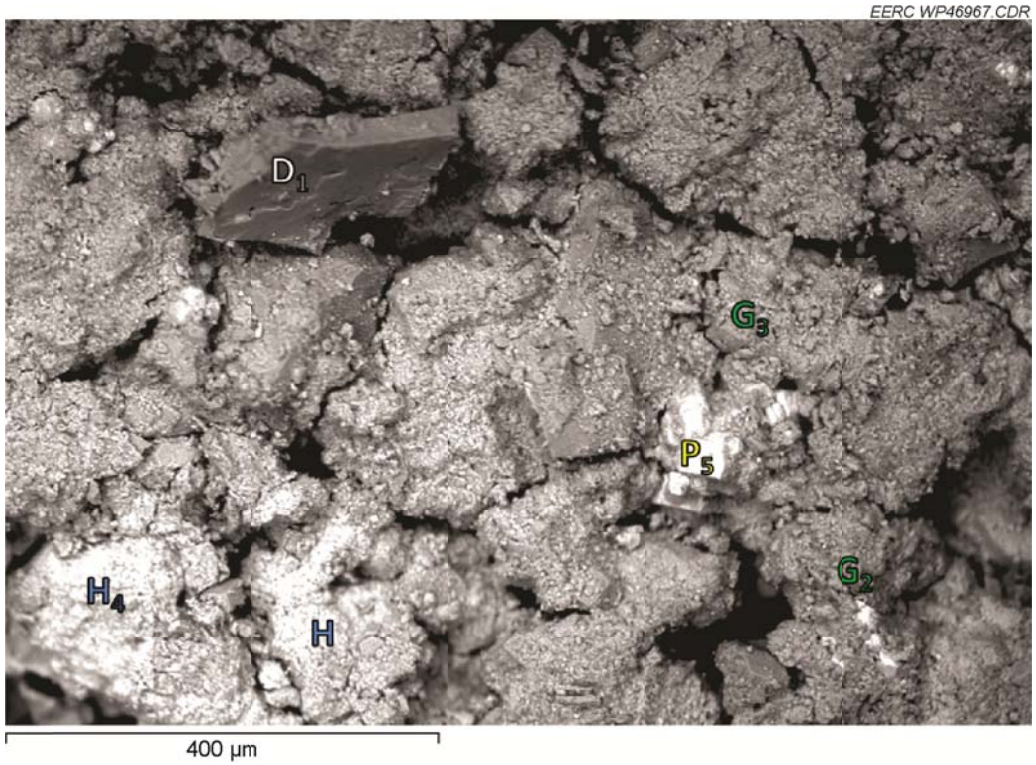



Figure C-27. Postexposure SEM image of ND 6264-DW-6113.

**Table C-11. SEM Point Analysis Data from Figure C-27**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.34 | 17.42 | 7.25 | 32.92 | 0.35 | 0.52 | 0.84 | 4.07 | 23.9 | 0.00 | 0.00 | 0.38 | 11.03 | 0.00 | Dolomite |
| 2 | 2.54 | 1.98 | 9.26 | 57.70 | 0.49 | 5.01 | 2.18 | 8.09 | 1.47 | 0.00 | 0.00 | 0.00 | 11.28 | 0.00 | Glauconite |
| 3 | 2.04 | 4.32 | 10.63 | 55.72 | 0.37 | 0.84 | 0.98 | 7.06 | 2.28 | 0.41 | 0.00 | 0.00 | 15.35 | 0.00 | Glauconite |
| 4 | 24.05 | 1.58 | 3.53 | 18.06 | 0.00 | 0.40 | 39.2 | 3.28 | 1.35 | 0.00 | 0.00 | 0.00 | 8.58 | 0.00 | Halite |
| 5 | 0.77 | 1.20 | 2.63 | 10.65 | 0.00 | 53.83 | 0.41 | 1.62 | 0.57 | 0.00 | 0.00 | 0.13 | 27.03 | 1.16 | Pyrite |

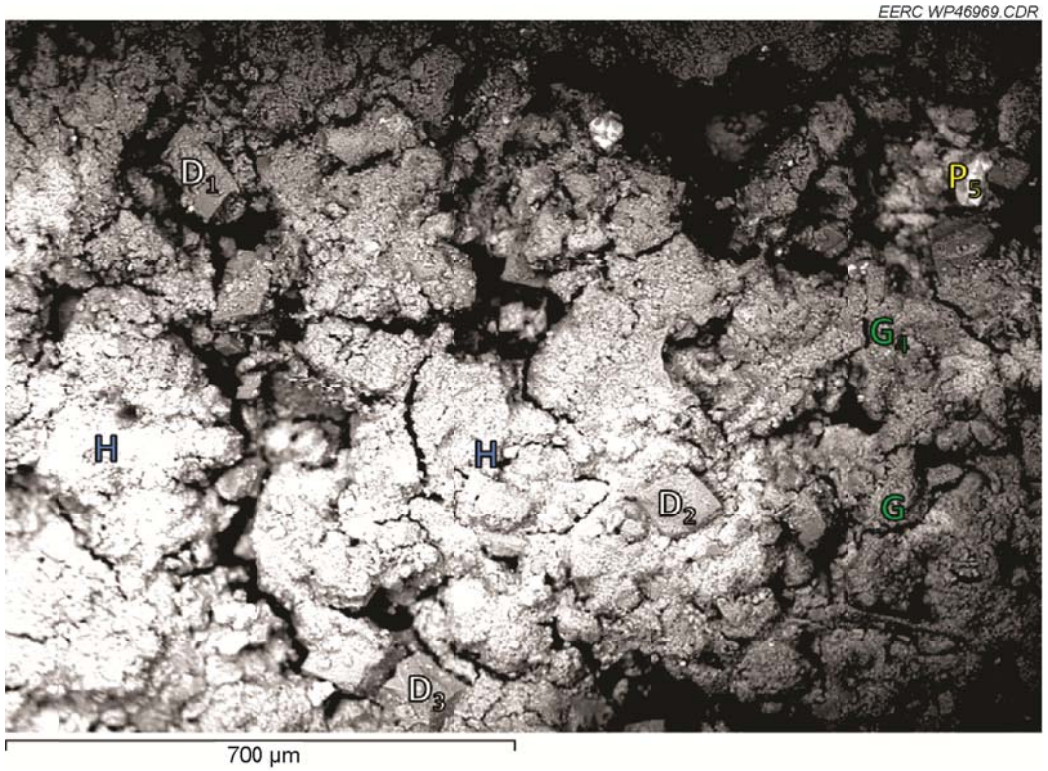



Figure C-28. Postexposure SEM Image 2 of ND 6264-DW-6113.

**Table C-12. SEM Point Analysis Data from Figure C-28**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.14 | 13.39 | 6.27 | 29.54 | 0.00 | 0.67 | 1.59 | 4.29 | 26.9 | 0.32 | 0.00 | 0.41 | 14.45 | 0.00 | Dolomite |
| 2 | 3.12 | 16.60 | 7.39 | 32.55 | 1.01 | 0.57 | 2.28 | 4.20 | 21.6 | 0.00 | 0.00 | 0.00 | 10.74 | 0.00 | Dolomite |
| 3 | 1.50 | 17.49 | 4.79 | 22.44 | 0.00 | 0.67 | 1.17 | 2.93 | 29.5 | 0.00 | 0.00 | 0.56 | 18.94 | 0.00 | Dolomite |
| 4 | 1.94 | 3.49 | 8.98 | 49.06 | 1.53 | 0.61 | 1.81 | 7.77 | 3.41 | 0.00 | 0.00 | 0.00 | 21.41 | 0.00 | Glauconite |
| 5 | 2.56 | 1.40 | 2.14 | 9.12 | 0.00 | 53.87 | 2.13 | 1.36 | 1.40 | 0.00 | 0.00 | 0.00 | 24.65 | 1.38 | Pyrite |

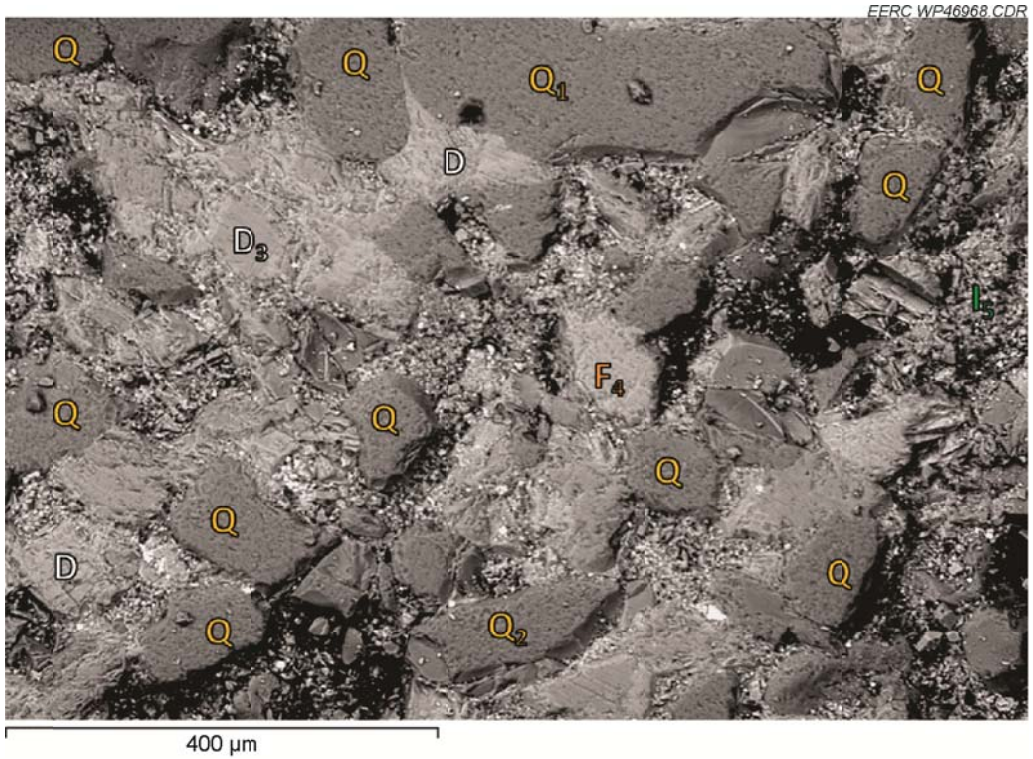



Figure C-29. Preexposure SEM image of ND 6264-DW-6114.5.

**Table C-13. SEM Point Analysis Data from Figure C-29**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 1.27 | 0.80 | 93.78 | 0.00 | 0.00 | 0.00 | 0.57 | 2.77 | 0.00 | 0.00 | 0.00 | 0.80 | 0.00 | Quartz |
| 2 | 0.00 | 1.03 | 1.25 | 93.62 | 0.00 | 0.33 | 0.09 | 1.01 | 2.04 | 0.00 | 0.00 | 0.00 | 0.63 | 0.00 | Quartz |
| 3 | 0.57 | 26.11 | 3.34 | 23.32 | 0.00 | 0.36 | 0.23 | 1.64 | 41.4 | 0.00 | 0.00 | 0.26 | 2.76 | 0.00 | Dolomite |
| 4 | 0.43 | 1.26 | 15.68 | 65.81 | 0.00 | 0.00 | 0.11 | 13.76 | 2.27 | 0.00 | 0.00 | 0.00 | 0.69 | 0.00 | K-feldspar |
| 5 | 1.16 | 3.45 | 16.64 | 59.15 | 0.00 | 2.73 | 0.67 | 9.08 | 2.77 | 0.68 | 0.00 | 0.00 | 3.68 | 0.00 | Illite |

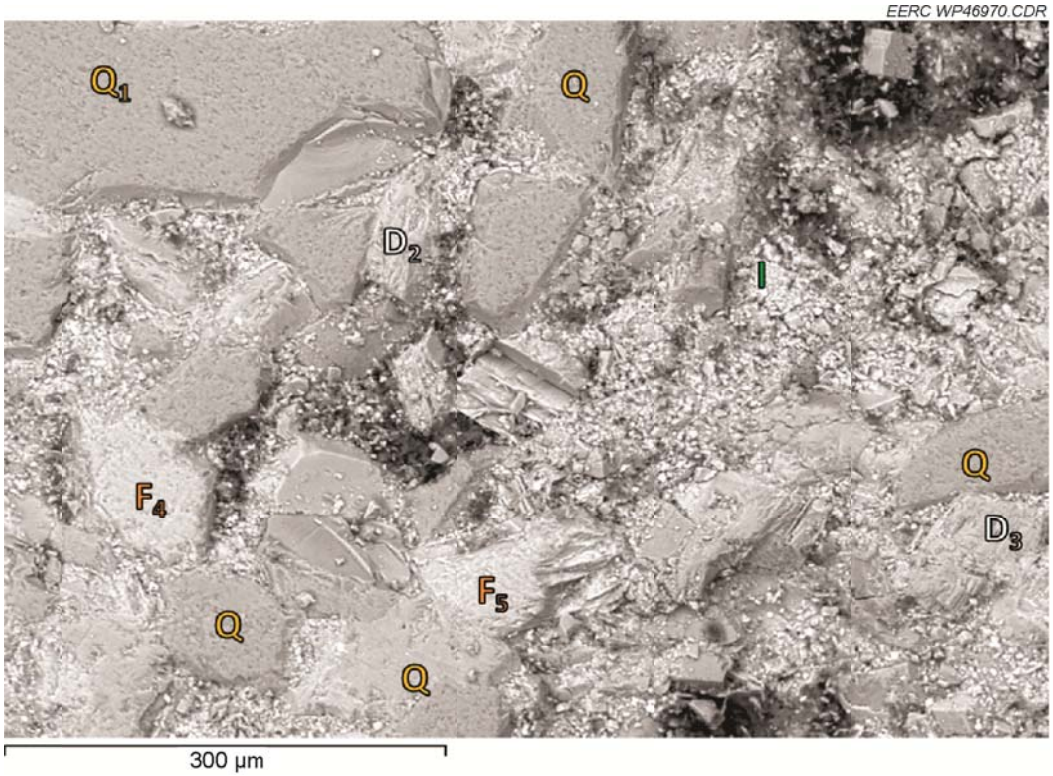



Figure C-30. Preexposure SEM Image 2 of ND 6264-DW-6114.5.

**Table C-14. SEM Point Analysis Data from Figure C-30**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 1.35 | 0.85 | 93.84 | 0.00 | 0.00 | 0.00 | 0.56 | 2.64 | 0.00 | 0.00 | 0.00 | 0.75 | 0.00 | Quartz |
| 2 | 0.43 | 17.74 | 2.57 | 30.91 | 0.00 | 0.34 | 0.15 | 1.26 | 35.46 | 0.00 | 0.00 | 0.28 | 10.86 | 0.00 | Dolomite |
| 3 | 0.60 | 19.89 | 3.97 | 27.46 | 0.00 | 1.59 | 0.30 | 2.25 | 36.82 | 0.00 | 0.00 | 0.54 | 6.57 | 0.00 | Dolomite |
| 4 | 0.44 | 1.17 | 15.80 | 65.57 | 0.00 | 0.35 | 0.10 | 13.57 | 2.12 | 0.20 | 0.00 | 0.00 | 0.68 | 0.00 | K-feldspar |
| 5 | 0.61 | 1.59 | 15.89 | 64.95 | 0.00 | 0.25 | 0.09 | 12.88 | 2.49 | 0.24 | 0.00 | 0.00 | 1.00 | 0.00 | K-feldspar |

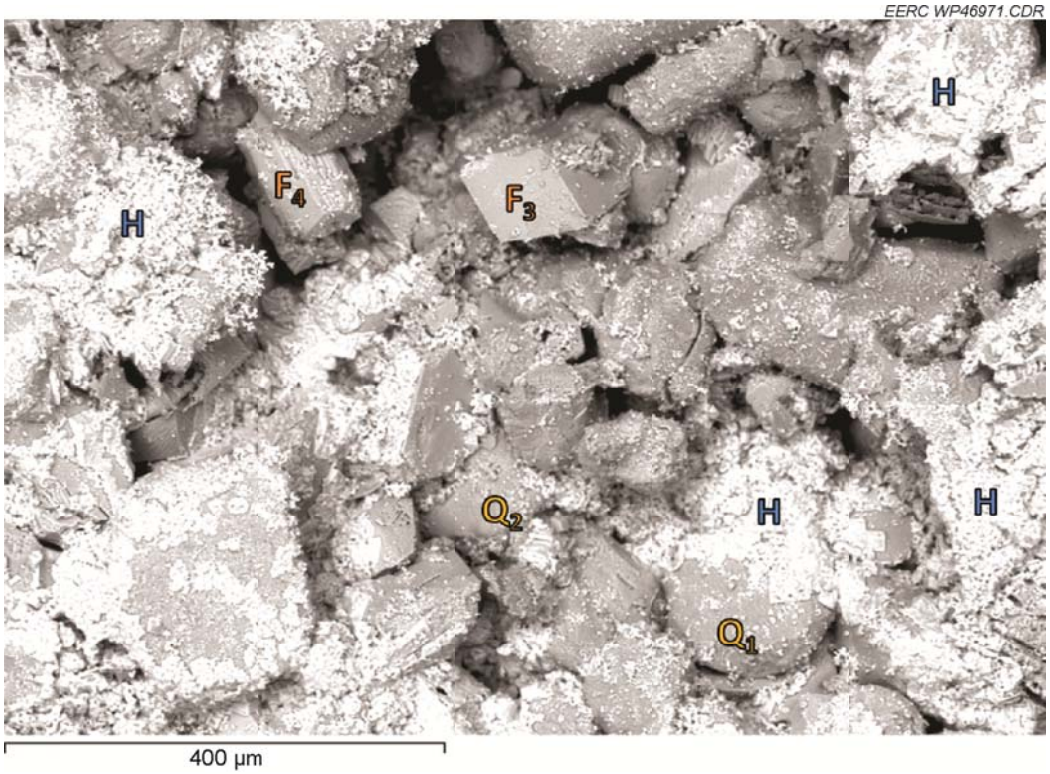



Figure C-31. Postexposure SEM image of ND 6264-DW-6114.5.

**Table C-15. SEM Point Analysis Data from Figure C-31**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.38 | 0.22 | 0.95 | 75.52 | 0.00 | 0.00 | 6.82 | 0.43 | 1.12 | 0.00 | 0.00 | 0.00 | 7.55 | 0.00 | Quartz |
| 2 | 6.71 | 0.76 | 3.67 | 70.31 | 0.00 | 0.40 | 6.54 | 1.87 | 0.99 | 0.00 | 0.00 | 0.00 | 8.74 | 0.00 | Quartz |
| 3 | 3.13 | 0.00 | 16.25 | 61.49 | 0.00 | 0.21 | 2.97 | 12.39 | 0.56 | 0.00 | 0.00 | 0.00 | 3.00 | 0.00 | K-feldspar |
| 4 | 5.85 | 0.00 | 13.87 | 55.68 | 0.00 | 0.00 | 4.95 | 11.81 | 0.60 | 0.00 | 0.00 | 0.00 | 7.24 | 0.00 | K-feldspar |




Figure C-32. Postexposure SEM Image 2 of ND 6264-DW-6114.5.

**Table C-16. SEM Point Analysis Data from Figure C-32**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.34 | 0.59 | 0.63 | 83.13 | 0.24 | 0.00 | 3.87 | 0.44 | 1.75 | 0.00 | 0.00 | 0.00 | 6.01 | 0.00 | Quartz |
| 2 | 9.17 | 23.29 | 1.05 | 8.79 | 0.00 | 0.00 | 6.51 | 0.52 | 38.3 | 0.00 | 0.00 | 0.56 | 11.78 | 0.00 | Dolomite |
| 3 | 8.01 | 0.57 | 13.19 | 51.19 | 0.00 | 0.30 | 7.61 | 12.23 | 1.48 | 0.00 | 0.00 | 0.00 | 5.42 | 0.00 | K-feldspar |

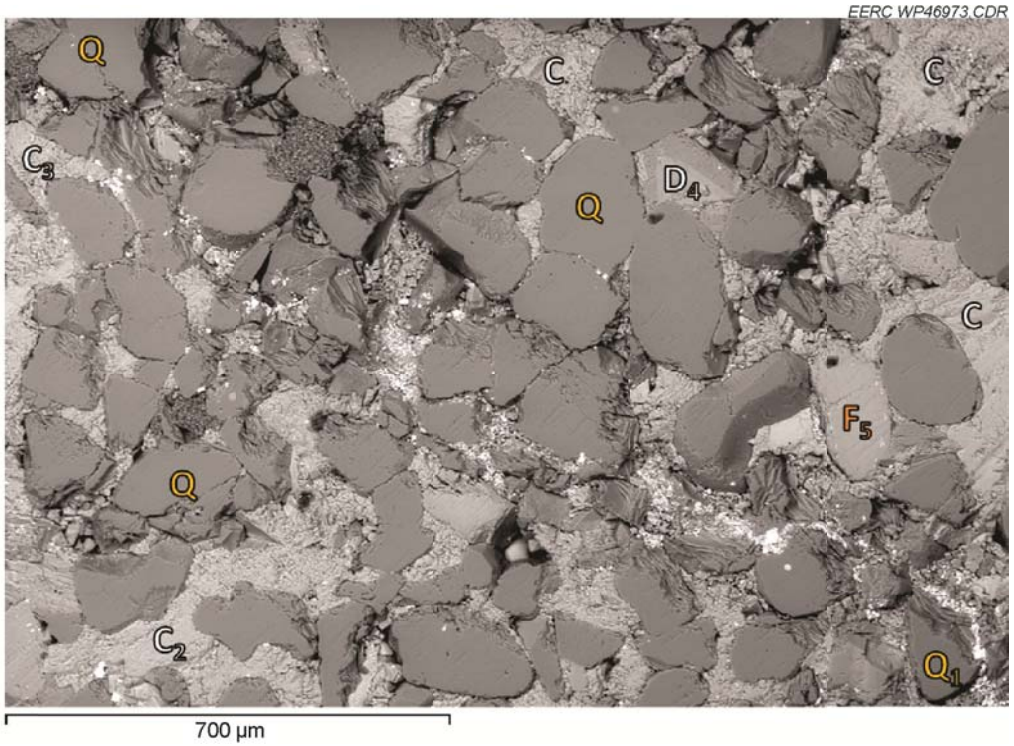



Figure C-33. Preexposure SEM image of ND 6264-DW-6126.5.

**Table C-17. SEM Point Analysis Data from Figure C-33**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.29 | 0.47 | 92.33 | 0.32 | 0.93 | 0.11 | 0.50 | 3.51 | 0.00 | 0.00 | 0.00 | 1.54 | 0.00 | Quartz |
| 2 | 0.00 | 0.57 | 0.74 | 24.22 | 0.00 | 0.51 | 0.00 | 0.55 | 73.1 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | Calcite |
| 3 | 0.00 | 0.83 | 0.30 | 23.64 | 0.00 | 1.07 | 0.00 | 0.26 | 73.2 | 0.00 | 0.00 | 0.00 | 0.69 | 0.00 | Calcite |
| 4 | 0.00 | 16.72 | 0.63 | 30.07 | 0.00 | 0.00 | 0.00 | 0.22 | 39.4 | 0.00 | 0.00 | 0.43 | 12.58 | 0.00 | Dolomite |
| 5 | 0.98 | 0.45 | 15.78 | 65.41 | 0.28 | 0.42 | 0.11 | 11.82 | 4.30 | 0.00 | 0.00 | 0.00 | 0.45 | 0.00 | K-feldspar |

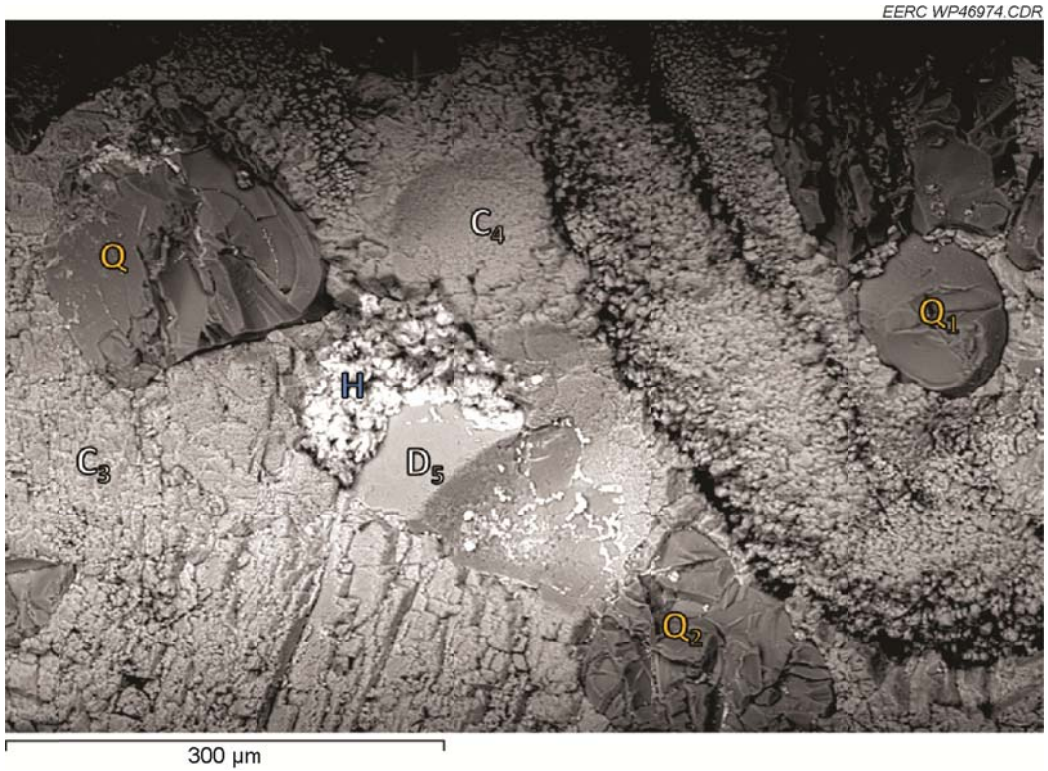



Figure C-34. Preexposure SEM Image 2 of ND 6264-DW-6126.5.

**Table C-18. SEM Point Analysis Data from Figure C-34**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.82 | 0.49 | 93.14 | 0.00 | 0.00 | 0.00 | 0.42 | 4.83 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 | Quartz |
| 2 | 0.00 | 1.96 | 1.08 | 16.31 | 0.00 | 0.53 | 0.00 | 0.55 | 79.0 | 0.00 | 0.00 | 0.00 | 0.59 | 0.00 | Calcite |
| 3 | 0.00 | 26.18 | 1.08 | 21.33 | 0.00 | 0.00 | 0.00 | 0.59 | 49.4 | 0.00 | 0.00 | 0.00 | 1.38 | 0.00 | Dolomite |
| 4 | 0.00 | 20.19 | 1.07 | 19.82 | 0.00 | 0.57 | 0.00 | 0.68 | 48.5 | 0.00 | 0.00 | 0.00 | 9.17 | 0.00 | Dolomite |
| 5 | 0.42 | 0.87 | 14.48 | 61.89 | 0.00 | 2.51 | 0.00 | 12.13 | 7.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | K-feldspar |

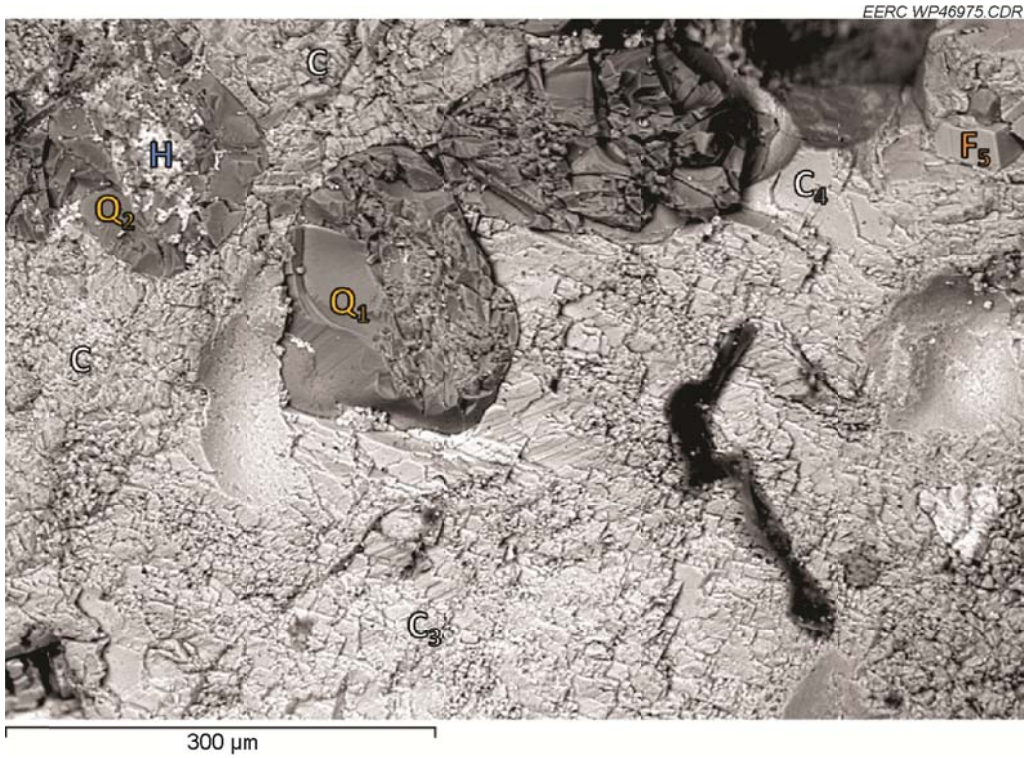



Figure C-35. Postexposure SEM image of ND 6264-DW-6126.5.

**Table C-19. SEM Point Analysis Data from Figure C-35**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 89.10 | 0.00 | 0.00 | 0.64 | 0.00 | 10.1 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 2 | 1.51 | 0.30 | 0.39 | 84.54 | 0.00 | 0.00 | 1.87 | 0.20 | 11.0 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | Quartz |
| 3 | 6.18 | 0.86 | 0.00 | 4.81 | 0.00 | 1.08 | 3.25 | 0.00 | 83.8 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Calcite |
| 4 | 0.00 | 1.15 | 0.00 | 10.44 | 0.00 | 0.53 | 0.43 | 0.24 | 87.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Calcite |
| 5 | 0.00 | 0.00 | 14.70 | 57.77 | 0.00 | 0.00 | 0.31 | 11.69 | 15.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | K-feldspar |

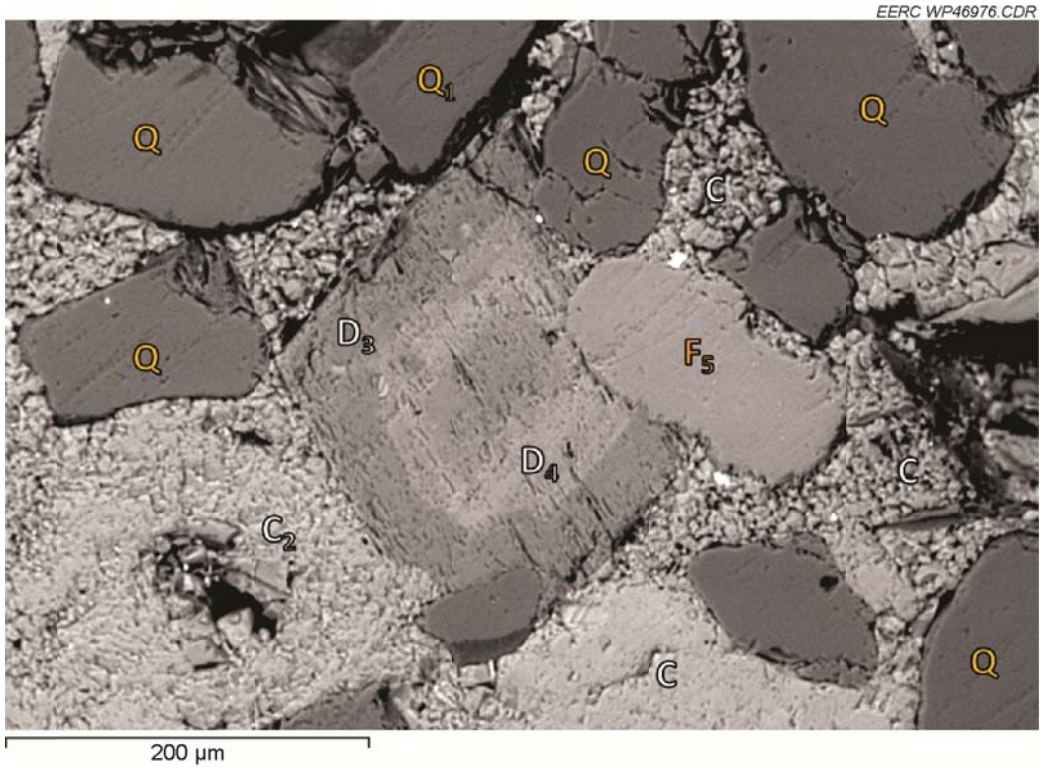



Figure C-36. Postexposure SEM Image 2 of ND 6264-DW-6126.5.

**Table C-20. SEM Point Analysis Data from Figure C-36**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.42 | 0.00 | 0.00 | 88.01 | 0.00 | 0.00 | 0.41 | 0.00 | 10.7 | 0.00 | 0.00 | 0.00 | 0.48 | 0.00 | Quartz |
| 2 | 0.96 | 0.51 | 0.00 | 86.52 | 0.00 | 0.24 | 0.73 | 0.00 | 10.8 | 0.00 | 0.00 | 0.00 | 0.28 | 0.00 | Quartz |
| 3 | 5.22 | 0.83 | 0.48 | 12.48 | 0.00 | 1.32 | 1.99 | 0.00 | 77.2 | 0.00 | 0.00 | 0.00 | 0.43 | 0.00 | Calcite |
| 4 | 3.39 | 0.93 | 0.00 | 9.87 | 0.00 | 1.68 | 1.69 | 0.00 | 81.4 | 0.00 | 0.00 | 0.00 | 1.03 | 0.00 | Calcite |
| 5 | 6.09 | 23.19 | 0.31 | 9.08 | 0.00 | 0.32 | 3.97 | 0.00 | 46.9 | 0.00 | 0.00 | 0.71 | 9.46 | 0.00 | Dolomite |




Figure C-37. Preexposure SEM image of ND 6264-DW-6165.

**Table C-21. SEM Point Analysis Data from Figure C-37**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 1.00 | 97.66 | 0.78 | 0.00 | 0.00 | 0.56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 2 | 0.00 | 0.00 | 6.23 | 85.80 | 0.00 | 1.15 | 0.00 | 3.90 | 1.01 | 0.00 | 0.00 | 0.00 | 1.91 | 0.00 | Quartz |
| 3 | 0.00 | 0.00 | 16.51 | 69.78 | 0.00 | 0.00 | 0.00 | 13.40 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | K-feldspar |
| 4 | 0.00 | 0.00 | 16.24 | 70.26 | 0.00 | 0.00 | 0.00 | 13.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | K-feldspar |
| 5 | 0.00 | 0.65 | 15.63 | 69.68 | 0.00 | 0.70 | 0.00 | 12.90 | 0.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | K-feldspar |




Figure C-38. Preexposure SEM image of ND 6264-DW-6165.

**Table C-22. SEM Point Analysis Data from Figure C-38**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 1.50 | 97.06 | 0.00 | 0.00 | 0.00 | 1.14 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 2 | 0.00 | 0.00 | 1.19 | 97.38 | 0.00 | 0.00 | 0.00 | 1.05 | 0.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 3 | 0.00 | 0.00 | 15.28 | 67.21 | 0.00 | 0.92 | 0.22 | 15.05 | 0.73 | 0.00 | 0.00 | 0.00 | 0.59 | 0.00 | K-feldspar |
| 4 | 0.00 | 0.00 | 16.51 | 68.63 | 0.00 | 0.00 | 0.00 | 14.42 | 0.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | K-feldspar |

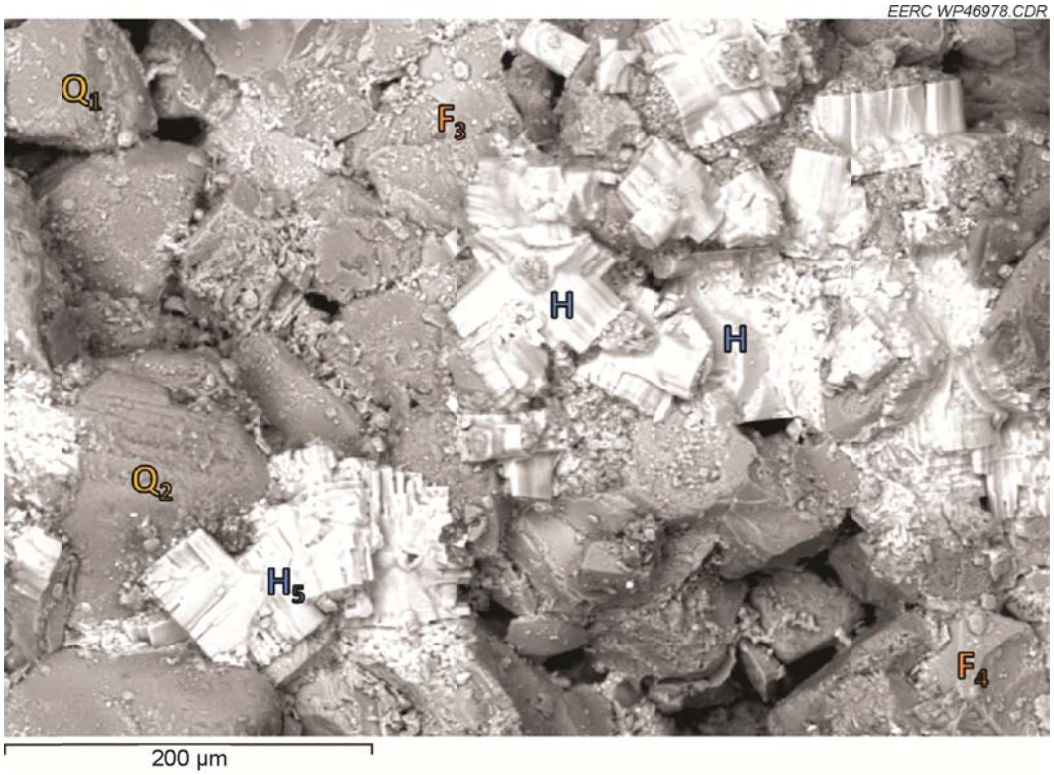



Figure C-39. Postexposure SEM image of ND 6264-DW-6165.

**Table C-23. SEM Point Analysis Data from Figure C-39**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.65 | 0.00 | 1.51 | 90.62 | 0.00 | 0.21 | 2.39 | 1.18 | 0.46 | 0.00 | 0.00 | 0.00 | 0.98 | 0.00 | Quartz |
| 2 | 4.21 | 0.27 | 2.27 | 84.99 | 0.00 | 0.00 | 4.44 | 1.31 | 0.46 | 0.14 | 0.00 | 0.00 | 1.90 | 0.00 | Quartz |
| 3 | 4.38 | 0.00 | 15.47 | 63.03 | 0.00 | 0.19 | 3.86 | 11.32 | 0.68 | 0.00 | 0.00 | 0.00 | 1.07 | 0.00 | K-feldspar |
| 4 | 2.68 | 0.33 | 15.84 | 63.92 | 0.00 | 0.00 | 2.62 | 11.78 | 0.64 | 0.00 | 0.00 | 0.00 | 2.19 | 0.00 | K-feldspar |
| 5 | 36.31 | 0.00 | 1.44 | 13.92 | 0.00 | 0.18 | 46.2 | 0.92 | 0.35 | 0.15 | 0.00 | 0.00 | 0.59 | 0.00 | Halite |

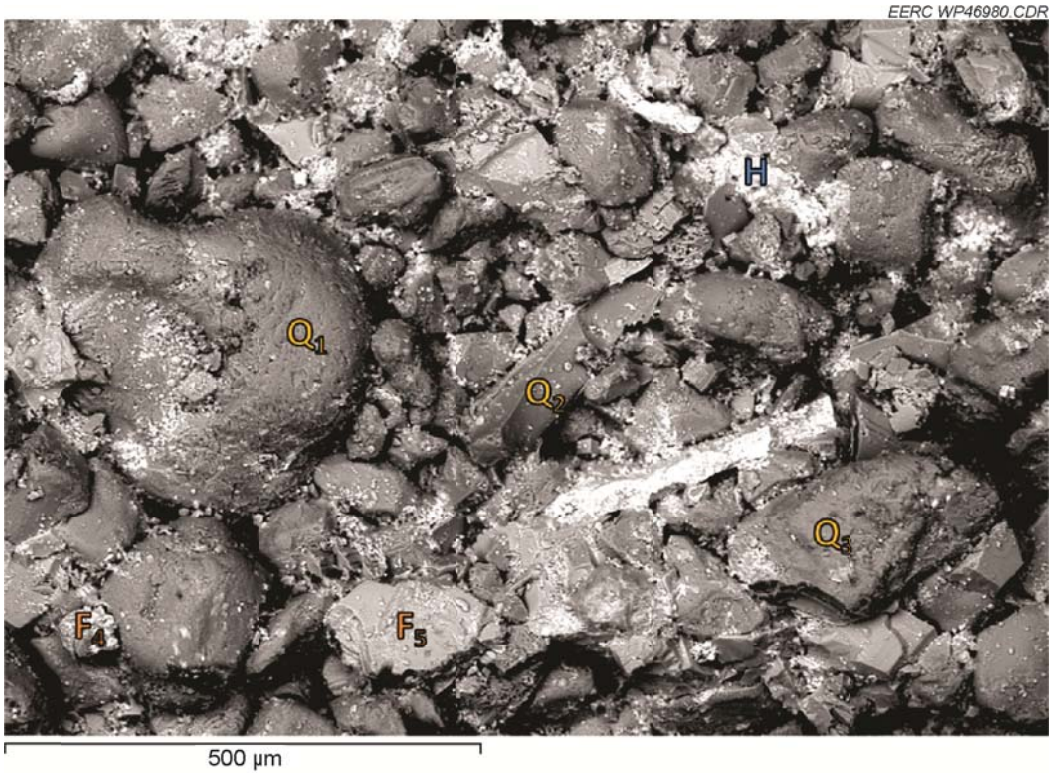



Figure C-40. Postexposure SEM Image 2 of ND 6264-DW-6165.

**Table C-24. SEM Point Analysis Data from Figure C-40**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.21 | 0.00 | 1.23 | 94.19 | 0.00 | 0.00 | 1.32 | 0.83 | 0.35 | 0.00 | 0.00 | 0.00 | 0.87 | 0.00 | Quartz |
| 2 | 2.30 | 0.00 | 1.52 | 90.15 | 0.00 | 0.00 | 2.32 | 1.27 | 0.64 | 0.00 | 0.00 | 0.00 | 1.80 | 0.00 | Quartz |
| 3 | 2.12 | 0.31 | 2.05 | 89.92 | 0.00 | 0.41 | 2.08 | 1.09 | 0.93 | 0.15 | 0.00 | 0.00 | 0.94 | 0.00 | Quartz |
| 4 | 2.39 | 1.81 | 14.61 | 63.89 | 0.00 | 0.42 | 2.82 | 9.67 | 0.96 | 0.35 | 0.00 | 0.00 | 3.06 | 0.00 | K-feldspar |
| 5 | 1.35 | 0.25 | 15.99 | 67.08 | 0.00 | 0.00 | 1.13 | 12.88 | 0.57 | 0.00 | 0.00 | 0.00 | 0.76 | 0.00 | K-feldspar |

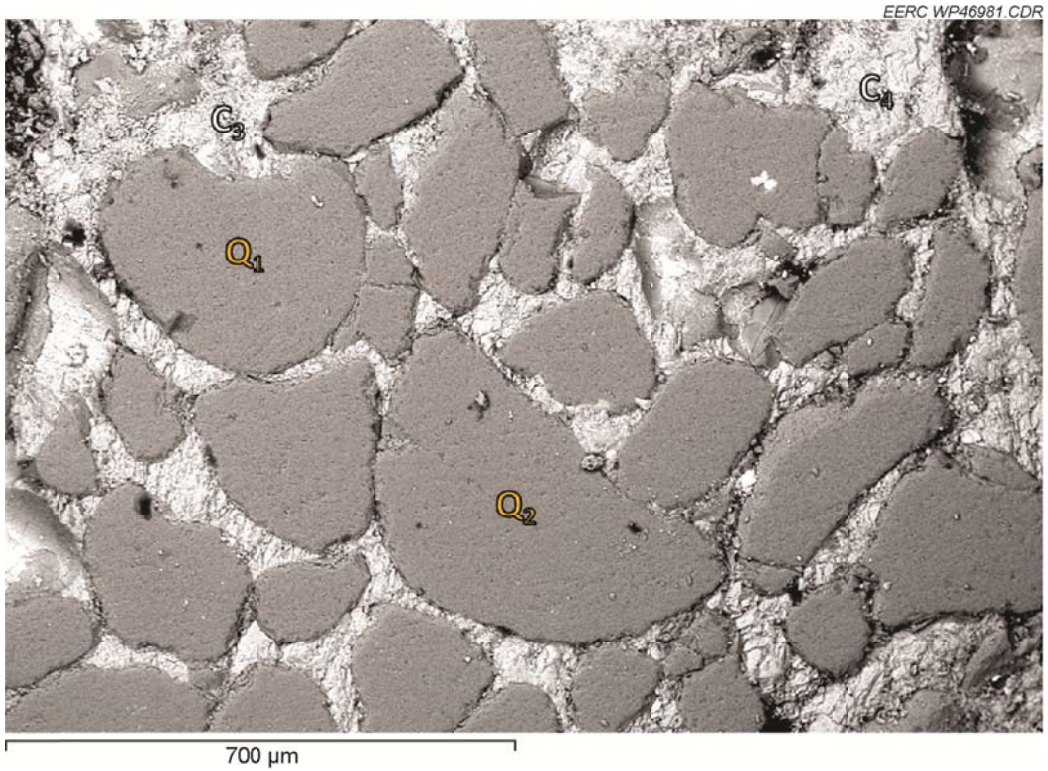



Figure C-41. Preexposure SEM image of ND 9257-BI-11789.5.

**Table C-25. SEM Point Analysis Data from Figure C-41**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.58 | 96.66 | 0.00 | 0.00 | 0.00 | 0.26 | 2.51 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 2 | 0.00 | 0.00 | 0.49 | 97.48 | 0.00 | 0.00 | 0.00 | 0.27 | 1.76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 3 | 0.00 | 0.00 | 2.41 | 29.76 | 0.00 | 0.00 | 0.77 | 0.74 | 65.0 | 0.00 | 0.00 | 0.00 | 1.26 | 0.00 | Calcite |
| 4 | 0.00 | 0.00 | 1.50 | 24.91 | 0.00 | 0.00 | 0.41 | 0.46 | 72.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Calcite |

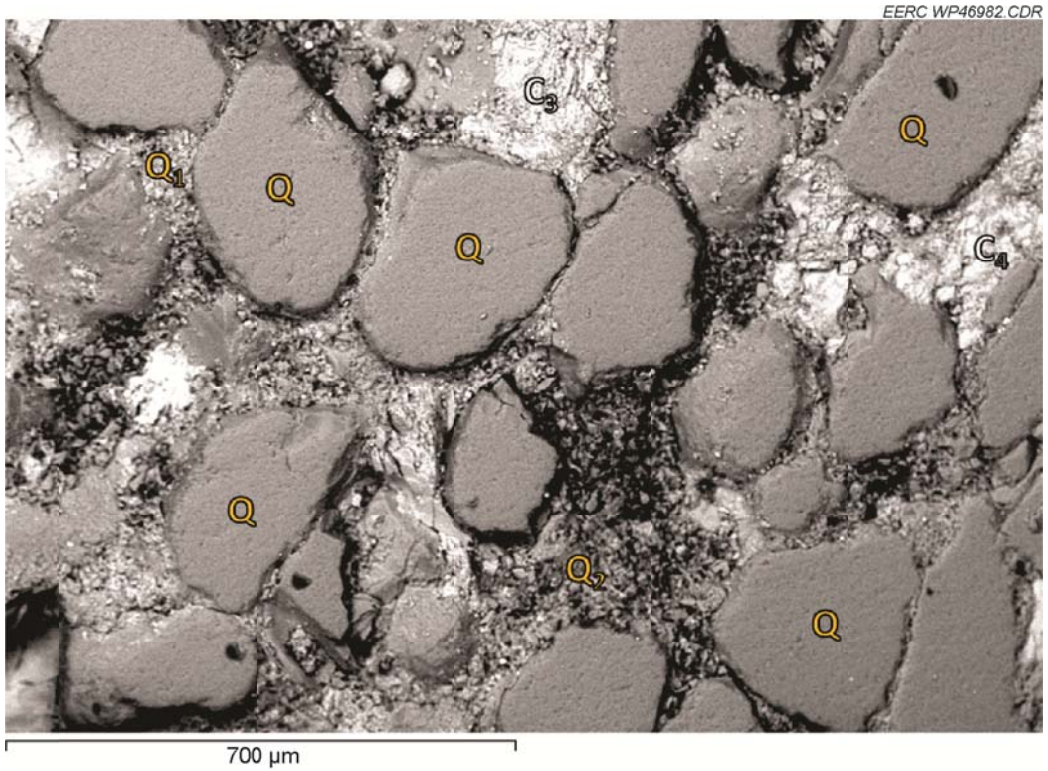



Figure C-42. Preexposure SEM Image 2 of ND 9257-BI-11789.5

**Table C-26. SEM Point Analysis Data from Figure C-42**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.98 | 0.00 | 4.93 | 84.72 | 0.00 | 0.00 | 2.90 | 1.56 | 2.29 | 0.58 | 0.00 | 0.00 | 1.06 | 0.00 | Quartz |
| 2 | 1.17 | 0.72 | 4.88 | 79.98 | 0.00 | 0.00 | 1.51 | 1.41 | 8.82 | 0.00 | 0.00 | 0.00 | 1.51 | 0.00 | Quartz |
| 3 | 0.84 | 0.00 | 2.18 | 27.17 | 0.00 | 0.00 | 0.55 | 0.62 | 68.6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Calcite |
| 4 | 0.89 | 0.00 | 1.29 | 32.86 | 0.00 | 0.00 | 0.62 | 0.00 | 63.6 | 0.00 | 0.00 | 0.00 | 0.70 | 0.00 | Calcite |

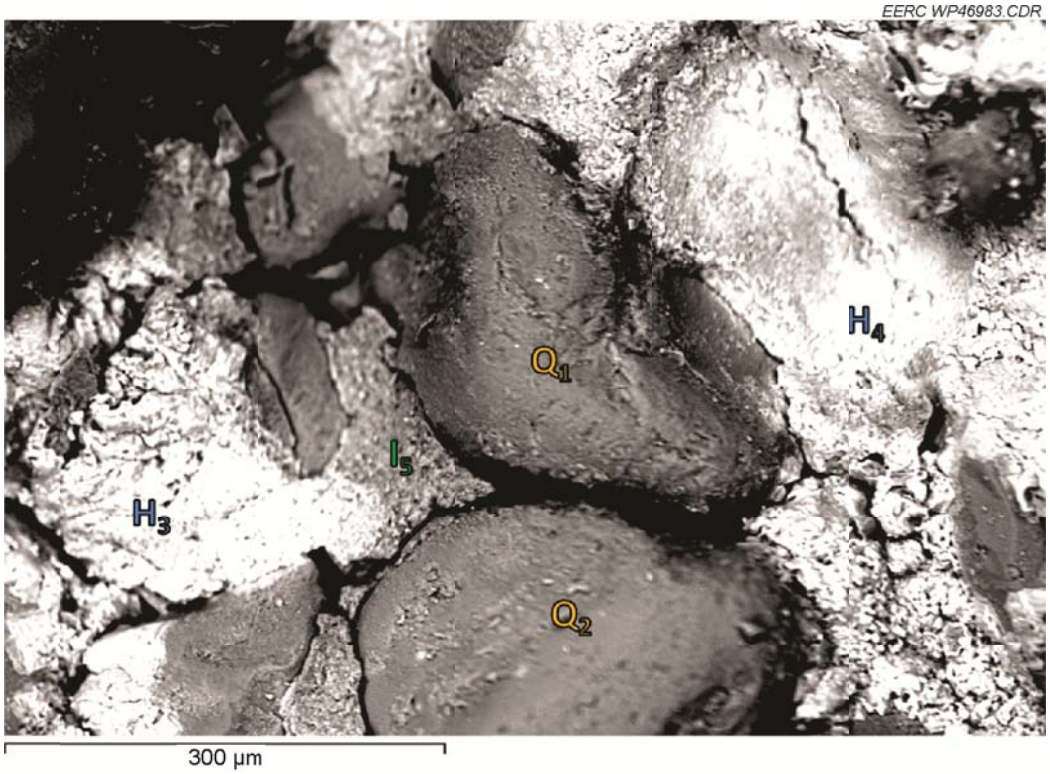



Figure C-43. Postexposure SEM image of ND 9257-BI-11789.5.

**Table C-27. SEM Point Analysis Data from Figure C-43**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.60 | 0.62 | 4.27 | 83.99 | 0.00 | 0.00 | 4.26 | 1.01 | 0.45 | 0.16 | 0.00 | 0.00 | 0.63 | 0.00 | Quartz |
| 2 | 4.29 | 0.51 | 3.54 | 85.83 | 0.00 | 0.00 | 3.90 | 0.91 | 0.33 | 0.22 | 0.00 | 0.00 | 0.46 | 0.00 | Quartz |
| 3 | 36.37 | 0.00 | 2.25 | 10.75 | 0.00 | 0.00 | 49.3 | 0.64 | 0.40 | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 | Halite |
| 4 | 30.49 | 0.36 | 2.59 | 34.75 | 0.00 | 0.00 | 29.6 | 0.79 | 0.79 | 0.15 | 0.00 | 0.00 | 0.47 | 0.00 | Halite |
| 5 | 5.59 | 2.36 | 22.16 | 54.90 | 0.00 | 0.34 | 4.92 | 5.06 | 2.34 | 0.41 | 0.00 | 0.00 | 1.91 | 0.00 | Illite |

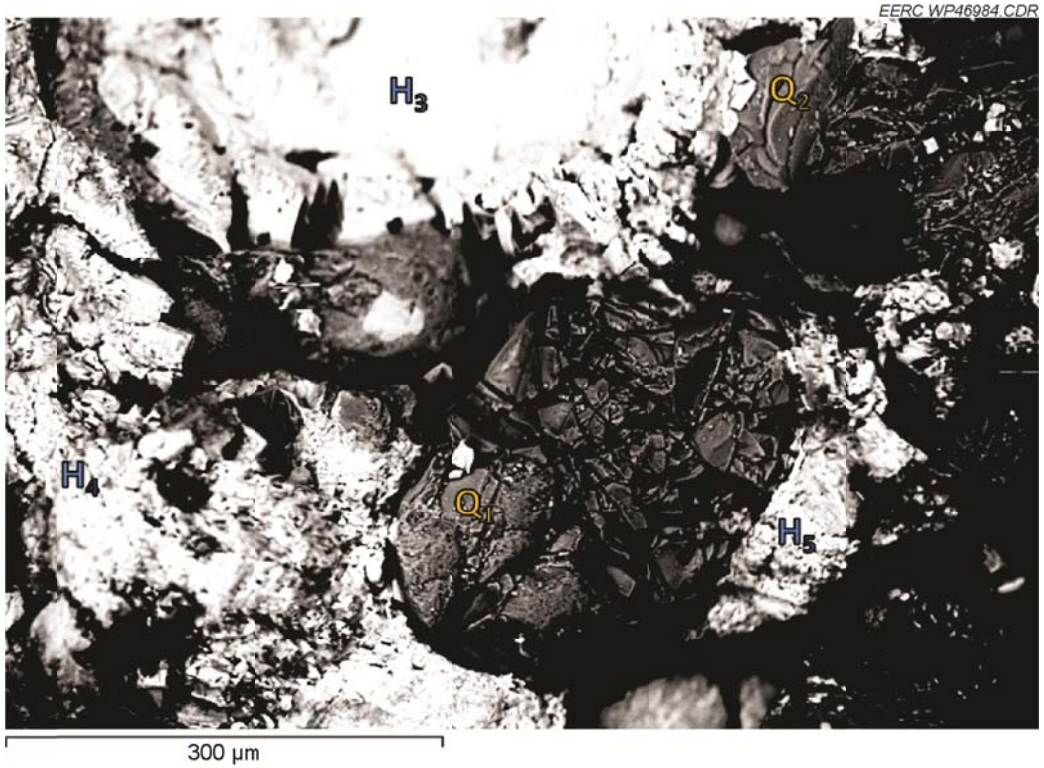



Figure C-44. Postexposure SEM Image 2 of ND 9257-BI-11789.5.

**Table C-28. SEM Point Analysis Data from Figure C-44**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.80 | 0.00 | 1.50 | 85.64 | 0.00 | 0.00 | 6.04 | 0.52 | 0.31 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | Quartz |
| 2 | 10.55 | 0.00 | 1.11 | 77.86 | 0.00 | 0.00 | 9.46 | 0.35 | 0.50 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | Quartz |
| 3 | 45.36 | 0.00 | 1.33 | 5.52 | 0.00 | 0.00 | 47.1 | 0.40 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Halite |
| 4 | 39.77 | 0.00 | 2.14 | 9.46 | 0.00 | 0.25 | 46.7 | 0.70 | 0.52 | 0.00 | 0.00 | 0.00 | 0.49 | 0.00 | Halite |
| 5 | 44.15 | 0.00 | 1.93 | 10.84 | 0.00 | 0.21 | 41.9 | 0.46 | 0.29 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | Halite |




Figure C-45. Preexposure SEM image of ND 9257-DW-11832.5.

**Table C-29. SEM Point Analysis Data from Figure C-45**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 3.19 | 2.96 | 87.27 | 0.00 | 0.00 | 0.00 | 1.51 | 4.19 | 0.00 | 0.00 | 0.00 | 0.88 | 0.00 | Quartz |
| 2 | 0.00 | 26.60 | 4.27 | 22.00 | 0.00 | 0.00 | 0.00 | 1.64 | 43.4 | 0.00 | 0.00 | 0.00 | 2.09 | 0.00 | Dolomite |
| 3 | 0.00 | 24.39 | 5.71 | 22.32 | 0.00 | 0.00 | 0.00 | 1.75 | 37.6 | 0.00 | 0.00 | 0.56 | 7.71 | 0.00 | Dolomite |
| 4 | 0.00 | 3.66 | 16.39 | 61.07 | 0.00 | 0.00 | 0.00 | 12.56 | 5.20 | 0.00 | 0.00 | 0.00 | 1.13 | 0.00 | K-feldspar |
| 5 | 0.00 | 6.26 | 18.68 | 59.14 | 0.00 | 0.00 | 0.23 | 6.89 | 5.60 | 0.38 | 0.00 | 0.00 | 2.82 | 0.00 | Illite |

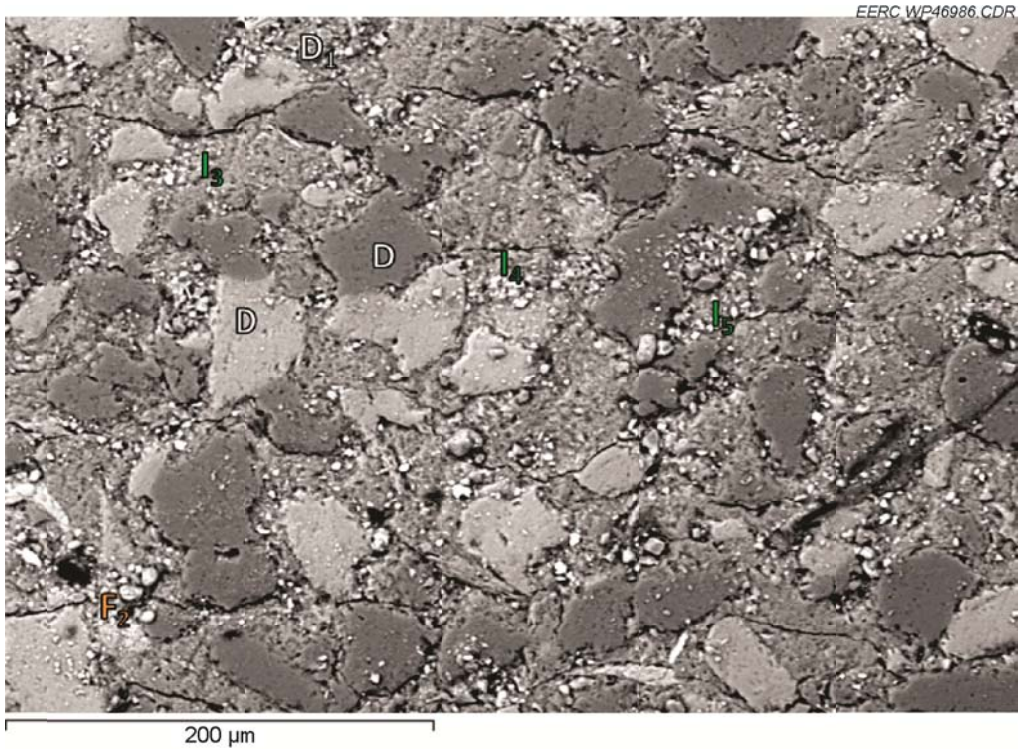



Figure C-46. Pre exposure SEM Image 2 of ND 9257-DW-11832.5.

**Table C-30. SEM Point Analysis Data from Figure C-46**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 13.31 | 8.51 | 47.29 | 0.00 | 0.79 | 0.21 | 4.58 | 19.9 | 0.00 | 0.00 | 0.00 | 5.42 | 0.00 | Dolomite |
| 2 | 0.00 | 5.02 | 11.49 | 56.67 | 0.47 | 1.63 | 0.22 | 8.43 | 4.52 | 0.00 | 0.00 | 0.00 | 11.56 | 0.00 | K-feldspar |
| 3 | 0.77 | 2.89 | 14.99 | 68.22 | 0.00 | 0.00 | 0.85 | 6.75 | 1.76 | 0.00 | 0.00 | 0.00 | 3.76 | 0.00 | Illite |
| 4 | 0.64 | 3.73 | 17.18 | 63.92 | 0.00 | 0.67 | 0.54 | 6.98 | 2.08 | 0.00 | 0.00 | 0.00 | 4.26 | 0.00 | Illite |
| 5 | 0.46 | 5.12 | 17.17 | 62.65 | 0.00 | 0.00 | 0.26 | 7.09 | 2.62 | 0.25 | 0.00 | 0.00 | 4.37 | 0.00 | Illite |

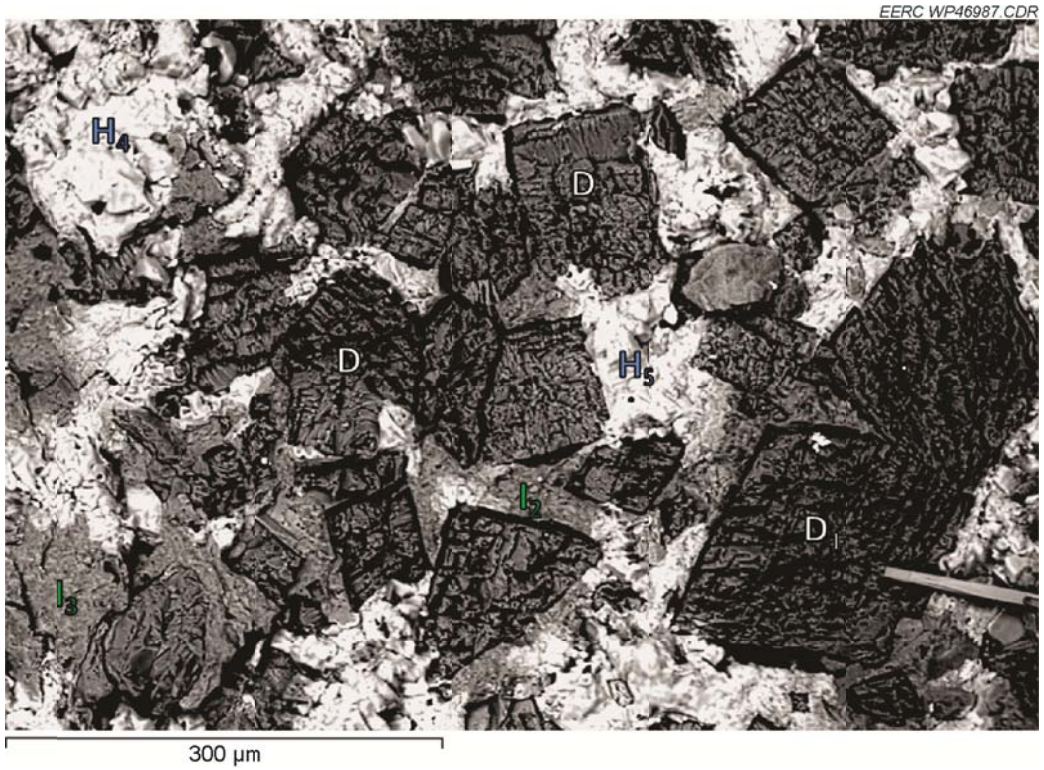



Figure C-47. Postexposure SEM image of ND 9257-DW-11832.5

**Table C-31. SEM Point Analysis Data from Figure C-47**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.28 | 27.56 | 3.37 | 10.77 | 0.00 | 0.39 | 5.19 | 1.06 | 40.5 | 0.00 | 0.00 | 0.35 | 3.52 | 0.00 | Dolomite |
| 2 | 4.66 | 4.57 | 15.39 | 57.52 | 0.00 | 0.00 | 4.71 | 5.91 | 5.13 | 0.23 | 0.00 | 0.00 | 1.87 | 0.00 | Illite |
| 3 | 3.45 | 2.81 | 19.38 | 55.74 | 2.69 | 0.32 | 4.56 | 6.09 | 3.50 | 0.00 | 0.00 | 0.00 | 1.46 | 0.00 | Illite |
| 4 | 32.47 | 1.65 | 6.24 | 18.09 | 0.00 | 0.00 | 35.9 | 2.41 | 1.41 | 0.46 | 0.00 | 0.00 | 1.33 | 0.00 | Halite |
| 5 | 30.76 | 4.08 | 3.39 | 9.98 | 0.00 | 0.00 | 43.4 | 1.33 | 6.33 | 0.00 | 0.00 | 0.00 | 0.77 | 0.00 | Halite |

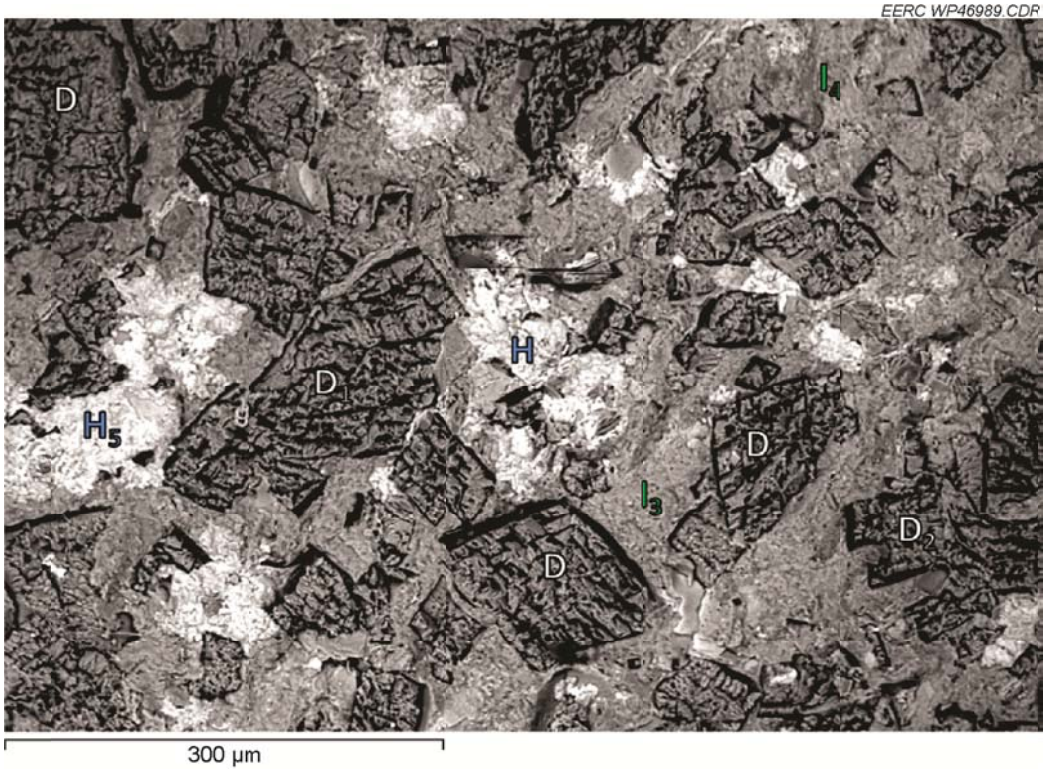



Figure C-48. Postexposure SEM Image 2 of ND 9257-DW-11832.5.

**Table C-32. SEM Point Analysis Data from Figure C-48**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.80 | 19.37 | 5.80 | 16.41 | 0.00 | 0.00 | 3.11 | 1.60 | 44.5 | 0.00 | 0.00 | 0.32 | 4.06 | 0.00 | Dolomite |
| 2 | 3.11 | 27.49 | 6.53 | 18.72 | 0.00 | 0.38 | 2.09 | 1.99 | 38.7 | 0.00 | 0.00 | 0.00 | 0.95 | 0.00 | Dolomite |
| 3 | 2.23 | 4.16 | 19.20 | 58.25 | 0.00 | 0.00 | 2.00 | 7.48 | 4.19 | 0.39 | 0.00 | 0.00 | 2.12 | 0.00 | Illite |
| 4 | 3.13 | 4.64 | 18.72 | 53.12 | 0.00 | 0.00 | 2.83 | 8.62 | 5.03 | 0.56 | 0.00 | 0.00 | 3.35 | 0.00 | Illite |
| 5 | 28.04 | 2.99 | 8.10 | 24.34 | 0.00 | 0.00 | 28.0 | 3.55 | 3.73 | 0.26 | 0.00 | 0.00 | 1.01 | 0.00 | Halite |

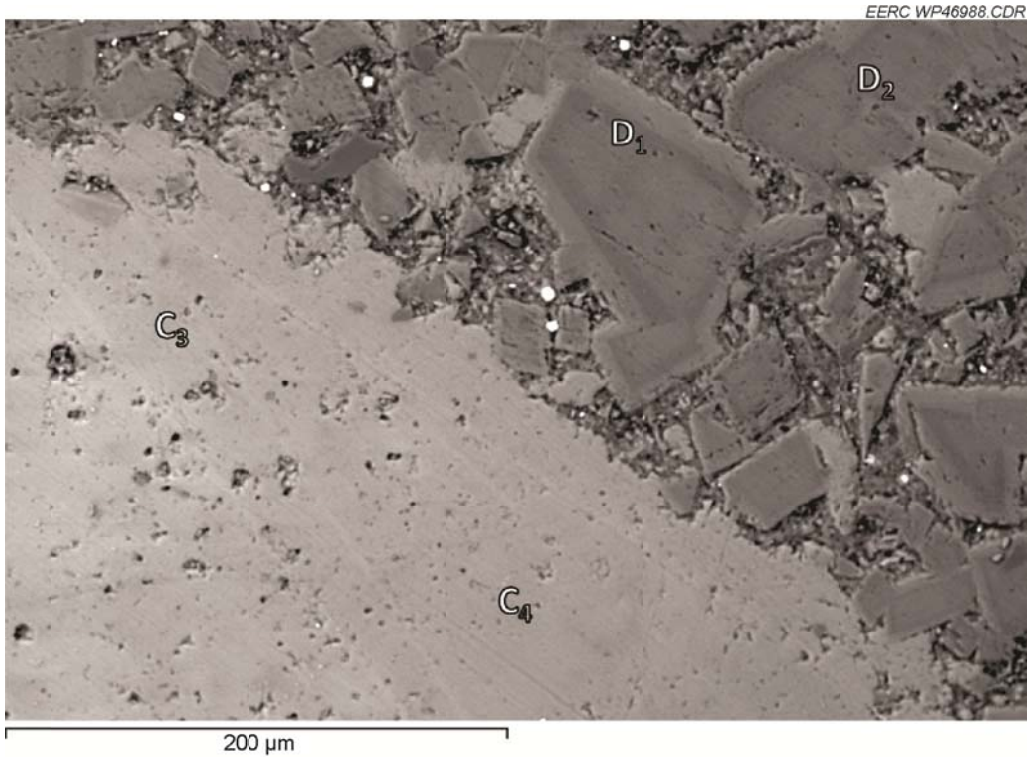



Figure C-49. Preexposure SEM image of ND 9257-DW-11858.5.

**Table C-33. SEM Point Analysis Data from Figure C-49**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 24.70 | 2.38 | 8.87 | 0.00 | 0.00 | 0.14 | 0.86 | 56.3 | 0.00 | 0.00 | 0.85 | 5.90 | 0.00 | Dolomite |
| 2 | 0.00 | 27.53 | 2.32 | 7.64 | 0.00 | 0.47 | 0.17 | 0.73 | 56.9 | 0.00 | 0.00 | 0.34 | 3.95 | 0.00 | Dolomite |
| 3 | 0.00 | 3.71 | 0.76 | 3.29 | 0.00 | 0.00 | 0.00 | 0.31 | 91.0 | 0.00 | 0.00 | 0.00 | 0.98 | 0.00 | Calcite |
| 4 | 0.00 | 3.39 | 0.51 | 2.92 | 0.47 | 0.00 | 0.00 | 0.25 | 91.7 | 0.00 | 0.00 | 0.00 | 0.77 | 0.00 | Calcite |

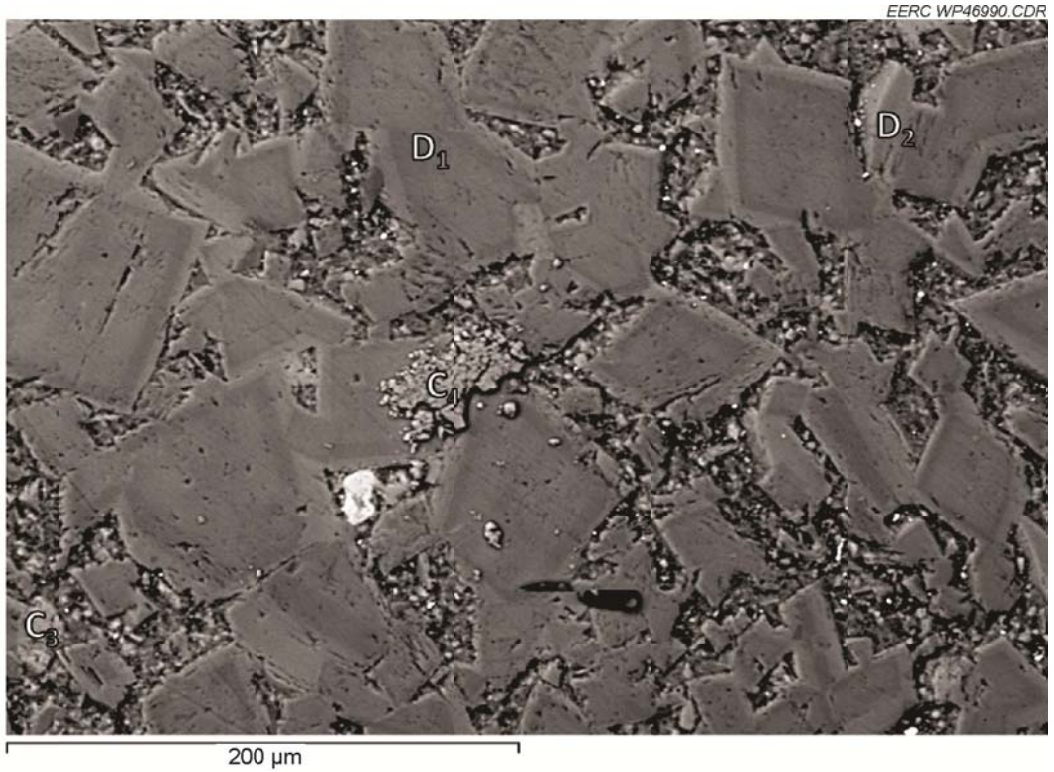



Figure C-50. Preexposure SEM Image 2 of ND 9257-DW-11858.5.

**Table C-34. SEM Point Analysis Data from Figure C-50**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 29.09 | 2.13 | 7.57 | 0.00 | 0.00 | 0.00 | 0.94 | 56.8 | 0.00 | 0.00 | 0.00 | 3.49 | 0.00 | Dolomite |
| 2 | 0.42 | 25.34 | 2.46 | 9.63 | 0.00 | 0.00 | 0.00 | 1.05 | 54.7 | 0.00 | 0.00 | 0.78 | 5.61 | 0.00 | Dolomite |
| 3 | 0.00 | 9.38 | 3.01 | 12.07 | 0.00 | 0.00 | 0.12 | 1.40 | 71.4 | 0.00 | 0.00 | 0.28 | 2.39 | 0.00 | Calcite |
| 4 | 0.00 | 9.42 | 1.66 | 7.02 | 0.00 | 0.37 | 0.25 | 0.78 | 78.1 | 0.00 | 0.00 | 0.38 | 2.04 | 0.00 | Calcite |

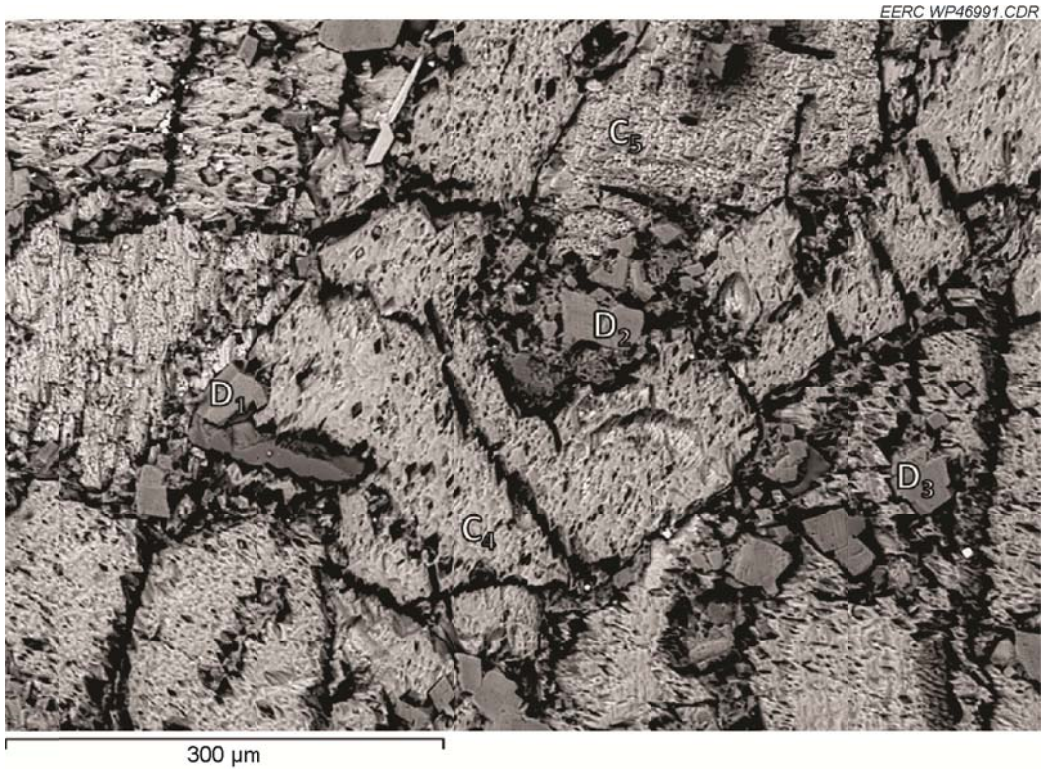



Figure C-51. Postexposure SEM image of ND 9257-DW-11858.5.

**Table C-35. SEM Point Analysis Data from Figure C-51**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 21.53 | 1.80 | 10.74 | 0.40 | 0.00 | 0.14 | 0.59 | 59.6 | 0.00 | 0.00 | 0.61 | 4.57 | 0.00 | Dolomite |
| 2 | 0.00 | 23.64 | 2.60 | 10.84 | 0.00 | 0.35 | 0.20 | 0.89 | 58.4 | 0.00 | 0.00 | 0.00 | 3.13 | 0.00 | Dolomite |
| 3 | 0.40 | 24.48 | 2.12 | 7.56 | 0.00 | 0.47 | 0.14 | 0.67 | 60.9 | 0.00 | 0.00 | 0.26 | 3.02 | 0.00 | Dolomite |
| 4 | 0.00 | 2.58 | 1.28 | 5.86 | 0.00 | 0.00 | 0.27 | 0.43 | 88.8 | 0.00 | 0.00 | 0.00 | 0.82 | 0.00 | Calcite |
| 5 | 0.00 | 2.11 | 1.10 | 4.52 | 0.00 | 0.40 | 0.21 | 0.45 | 90.4 | 0.00 | 0.00 | 0.00 | 0.81 | 0.00 | Calcite |




Figure C-52. Postexposure SEM Image 2 of ND 9257-DW-11858.5.

**Table C-36. SEM Point Analysis Data from Figure C-52**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 25.38 | 2.52 | 10.04 | 0.00 | 0.51 | 0.30 | 0.89 | 56.0 | 0.00 | 0.00 | 0.30 | 4.06 | 0.00 | Dolomite |
| 2 | 0.34 | 24.90 | 2.13 | 12.52 | 0.00 | 0.43 | 0.33 | 0.77 | 55.7 | 0.00 | 0.00 | 0.00 | 2.93 | 0.00 | Dolomite |
| 3 | 0.00 | 3.91 | 1.55 | 6.55 | 0.00 | 0.54 | 0.18 | 0.60 | 85.1 | 0.00 | 0.00 | 0.00 | 1.53 | 0.00 | Calcite |

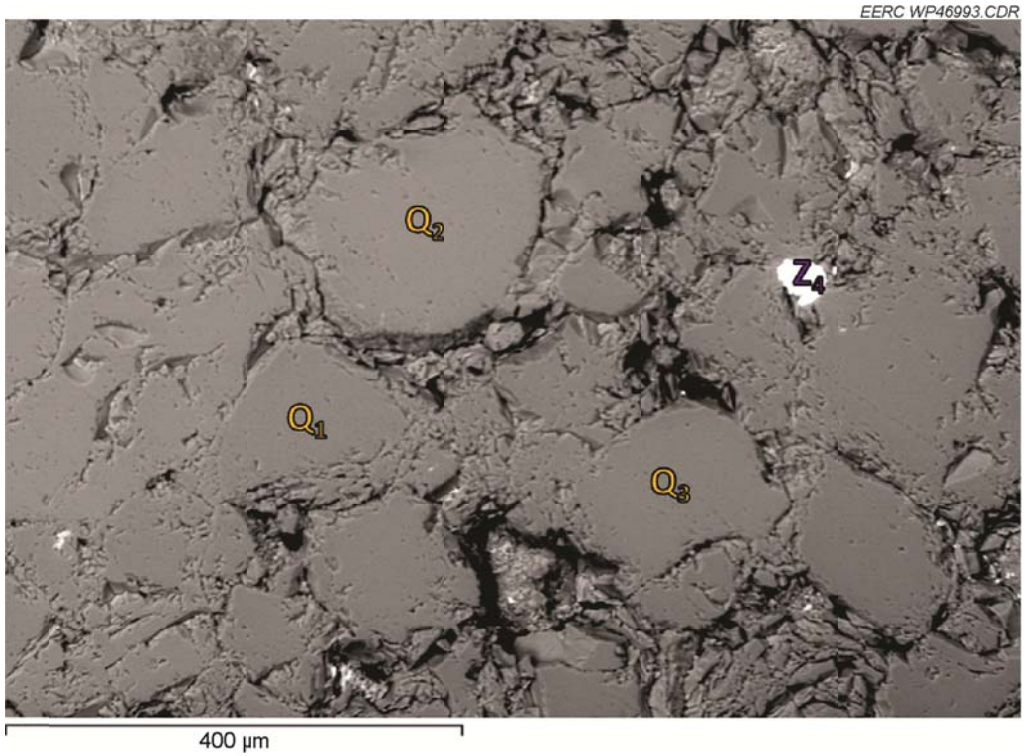



Figure C-53. Preexposure SEM image of ND 12596-BI-14802.

**Table C-37. SEM Point Analysis Data from Figure C-53**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 100.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 2 | 0.00 | 0.00 | 0.00 | 100.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 3 | 0.00 | 0.00 | 0.00 | 99.77 | 0.00 | 0.00 | 0.12 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 4 | 0.00 | 0.00 | 0.79 | 54.20 | 0.00 | 0.00 | 0.36 | 0.00 | 0.59 | 0.00 | 0.00 | 0.00 | 0.62 | 43.4 | Zircon |

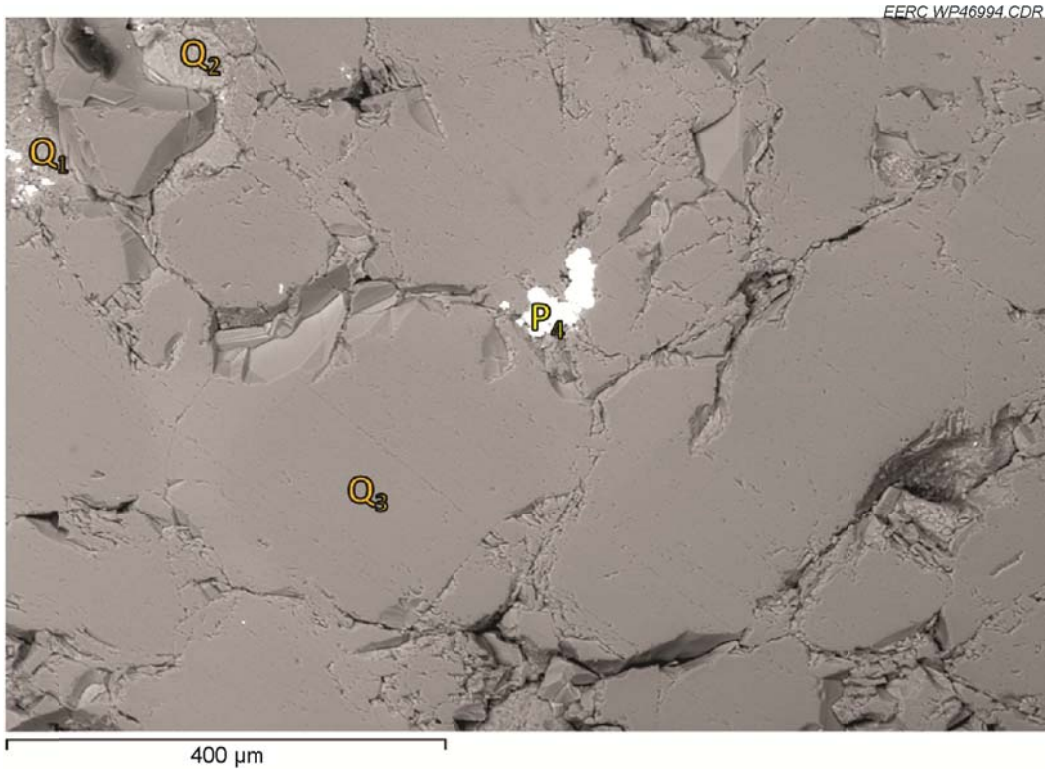



Figure C-54. Preexposure SEM image of ND 12596-BI-14802.

**Table C-38. SEM Point Analysis Data from Figure C-54**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 1.40 | 96.11 | 0.00 | 1.07 | 0.25 | 0.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | Quartz |
| 2 | 0.00 | 0.00 | 0.76 | 98.15 | 0.00 | 0.00 | 0.20 | 0.19 | 0.00 | 0.53 | 0.00 | 0.00 | 0.17 | 0.00 | Quartz |
| 3 | 0.00 | 0.00 | 0.00 | 100.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 4 | 0.00 | 0.00 | 0.11 | 19.96 | 0.00 | 55.00 | 0.16 | 0.00 | 0.22 | 0.00 | 0.00 | 0.00 | 23.30 | 1.26 | Pyrite |

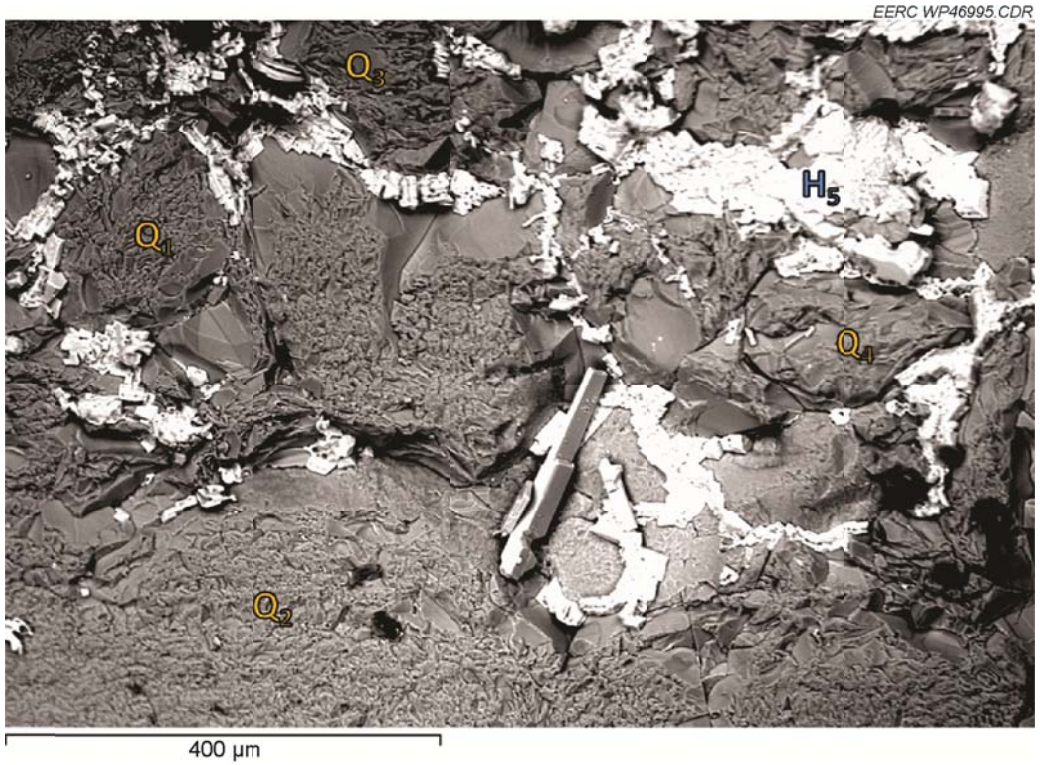



Figure C-55. Postexposure SEM image of ND 12596-BI-14802.

**Table C-39. SEM Point Analysis Data from Figure C-55**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.53 | 0.00 | 0.00 | 90.63 | 0.00 | 0.00 | 4.68 | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 2 | 2.17 | 0.00 | 0.00 | 94.97 | 0.00 | 0.00 | 2.45 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.22 | 0.00 | Quartz |
| 3 | 5.66 | 0.00 | 0.00 | 88.04 | 0.00 | 0.00 | 6.18 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 4 | 4.26 | 0.00 | 0.00 | 89.02 | 0.00 | 0.49 | 4.62 | 0.00 | 1.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 5 | 37.29 | 0.00 | 2.16 | 19.66 | 0.00 | 0.30 | 39.5 | 0.56 | 0.25 | 0.00 | 0.00 | 0.00 | 0.28 | 0.00 | Halite |

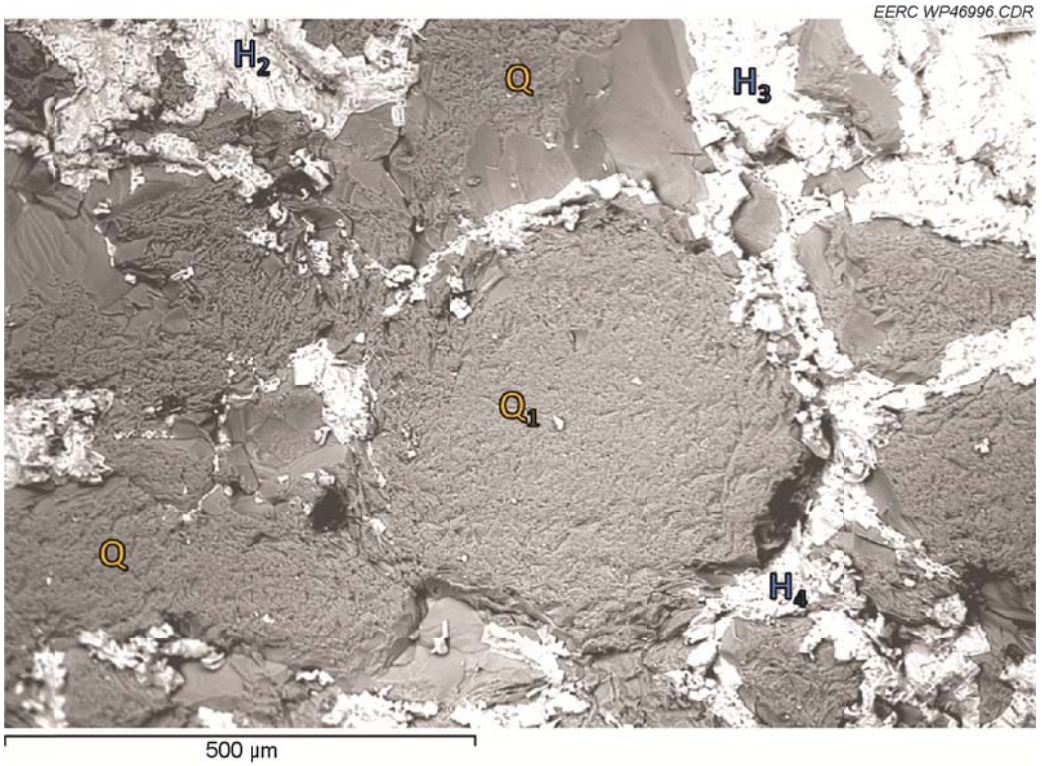



Figure C-56. Postexposure SEM Image 2 of ND 12596-BI-14802.

**Table C-40. SEM Point Analysis Data from Figure C-56**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.95 | 0.00 | 0.00 | 93.75 | 0.00 | 0.00 | 3.18 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Quartz |
| 2 | 42.18 | 0.00 | 0.42 | 13.63 | 0.00 | 0.00 | 43.6 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Halite |
| 3 | 38.75 | 0.00 | 0.16 | 16.17 | 0.00 | 1.05 | 43.2 | 0.00 | 0.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Halite |
| 4 | 36.01 | 0.00 | 0.38 | 19.52 | 0.00 | 0.32 | 43.4 | 0.16 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Halite |

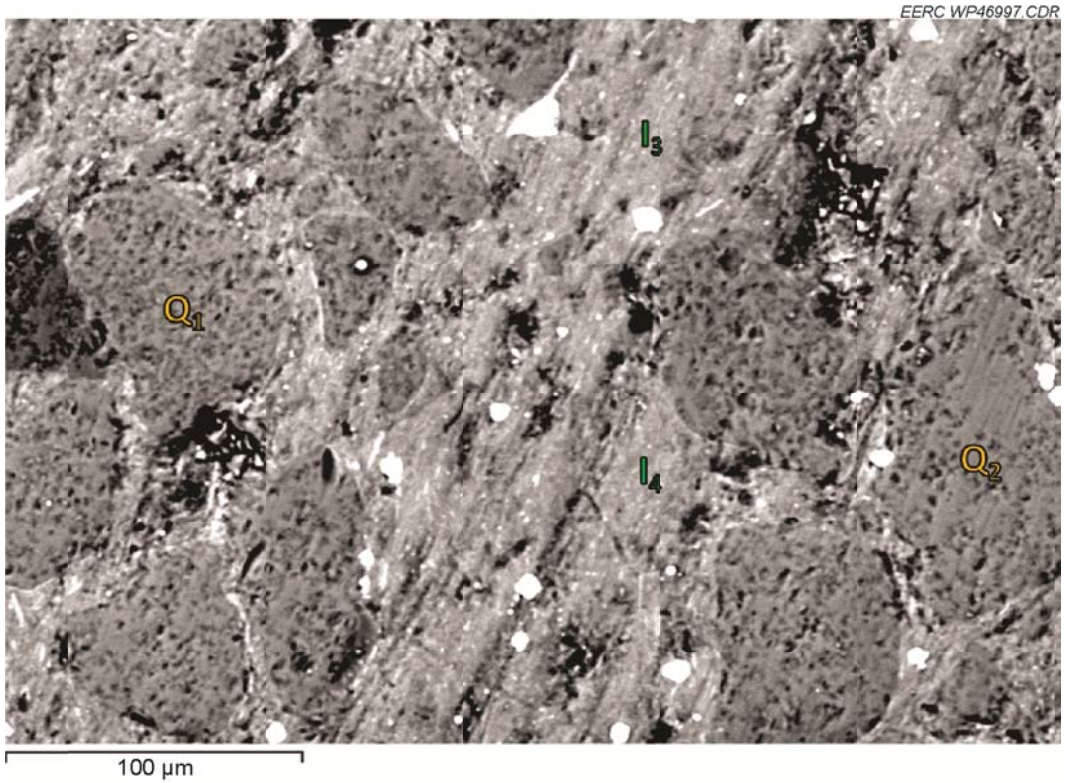



Figure C-57. Preexposure SEM image of ND 12596-BI-14831.

**Table C-41. SEM Point Analysis Data from Figure C-57**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.51 | 5.03 | 91.82 | 0.00 | 0.00 | 0.00 | 1.01 | 0.00 | 0.35 | 0.00 | 0.00 | 1.28 | 0.00 | Quartz |
| 2 | 0.00 | 0.51 | 4.56 | 92.20 | 0.00 | 0.29 | 0.00 | 0.90 | 0.00 | 0.32 | 0.00 | 0.00 | 1.22 | 0.00 | Quartz |
| 3 | 0.36 | 3.03 | 27.39 | 55.41 | 0.00 | 0.61 | 0.33 | 5.78 | 0.25 | 1.53 | 0.00 | 0.00 | 5.33 | 0.00 | Illite |
| 4 | 0.38 | 2.94 | 27.26 | 56.39 | 0.00 | 0.36 | 0.32 | 4.84 | 0.27 | 1.62 | 0.00 | 0.00 | 5.62 | 0.00 | Illite |

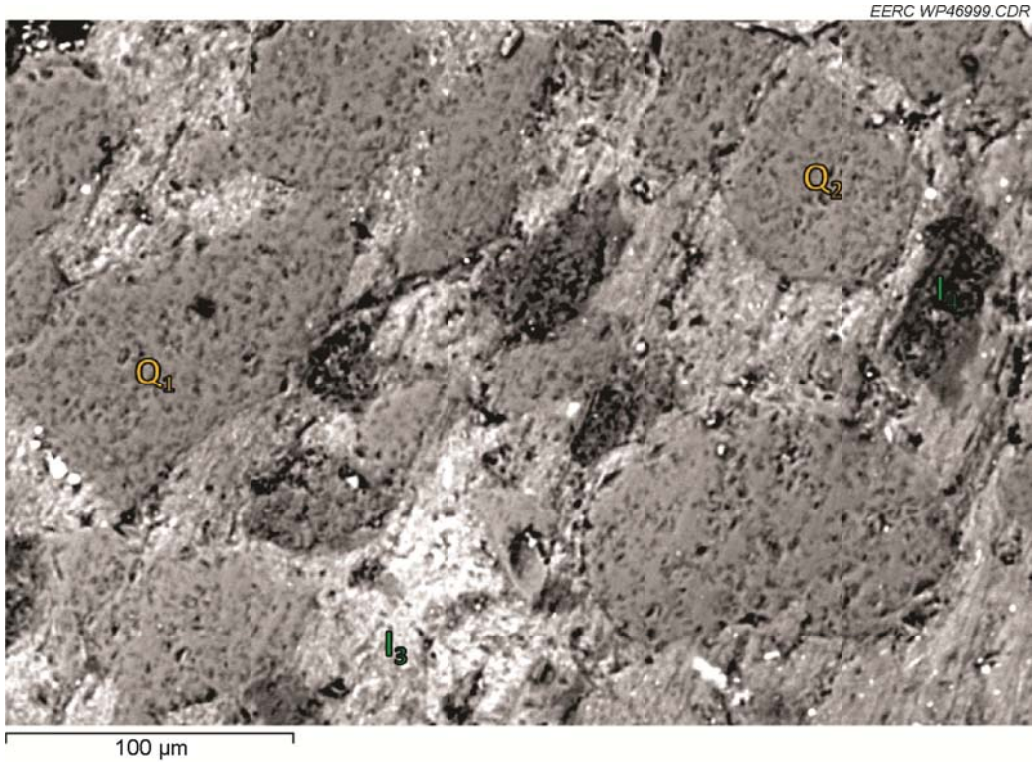



Figure C-58. Preexposure SEM image of ND 12596-BI-14831.

**Table C-42. SEM Point Analysis Data from Figure C-58**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.46 | 4.05 | 93.40 | 0.00 | 0.19 | 0.00 | 0.79 | 0.12 | 0.16 | 0.00 | 0.00 | 0.84 | 0.00 | Quartz |
| 2 | 0.00 | 0.49 | 4.31 | 93.05 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.26 | 0.00 | 0.00 | 0.90 | 0.00 | Quartz |
| 3 | 0.28 | 2.57 | 28.93 | 56.87 | 0.00 | 0.22 | 0.20 | 4.26 | 0.21 | 0.63 | 0.00 | 0.00 | 5.84 | 0.00 | Illite |
| 4 | 0.00 | 1.07 | 33.42 | 60.27 | 0.00 | 0.25 | 0.17 | 1.66 | 0.25 | 0.52 | 0.00 | 0.00 | 2.39 | 0.00 | Illite |

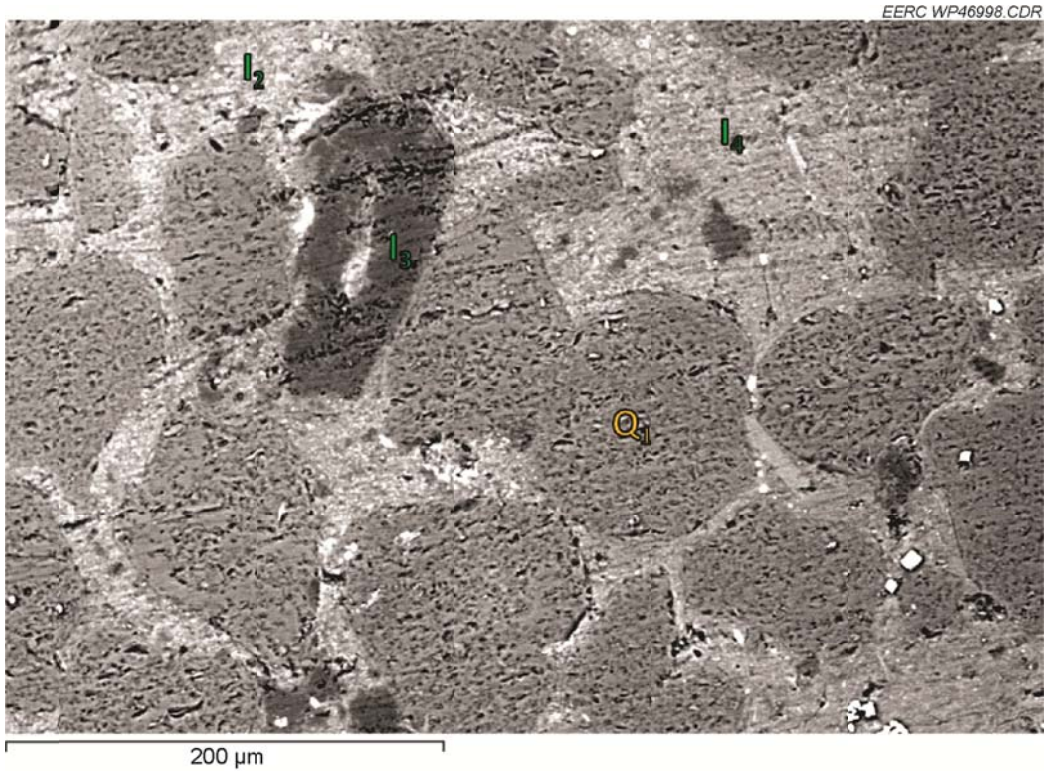



Figure C-59. Postexposure SEM image of ND 12596-BI-14831.

**Table C-43. SEM Point Analysis Data from Figure C-59**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.08 | 0.47 | 3.35 | 90.78 | 0.00 | 0.00 | 1.98 | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | Quartz |
| 2 | 2.28 | 2.19 | 26.60 | 53.59 | 0.00 | 0.00 | 1.94 | 4.14 | 0.11 | 4.24 | 0.00 | 0.00 | 4.91 | 0.00 | Illite |
| 3 | 2.28 | 0.69 | 33.60 | 59.07 | 0.00 | 0.00 | 1.89 | 1.23 | 0.00 | 0.16 | 0.00 | 0.00 | 1.08 | 0.00 | Illite |
| 4 | 2.26 | 2.25 | 28.07 | 55.71 | 0.00 | 0.23 | 2.01 | 4.61 | 0.00 | 0.72 | 0.00 | 0.00 | 4.16 | 0.00 | Illite |

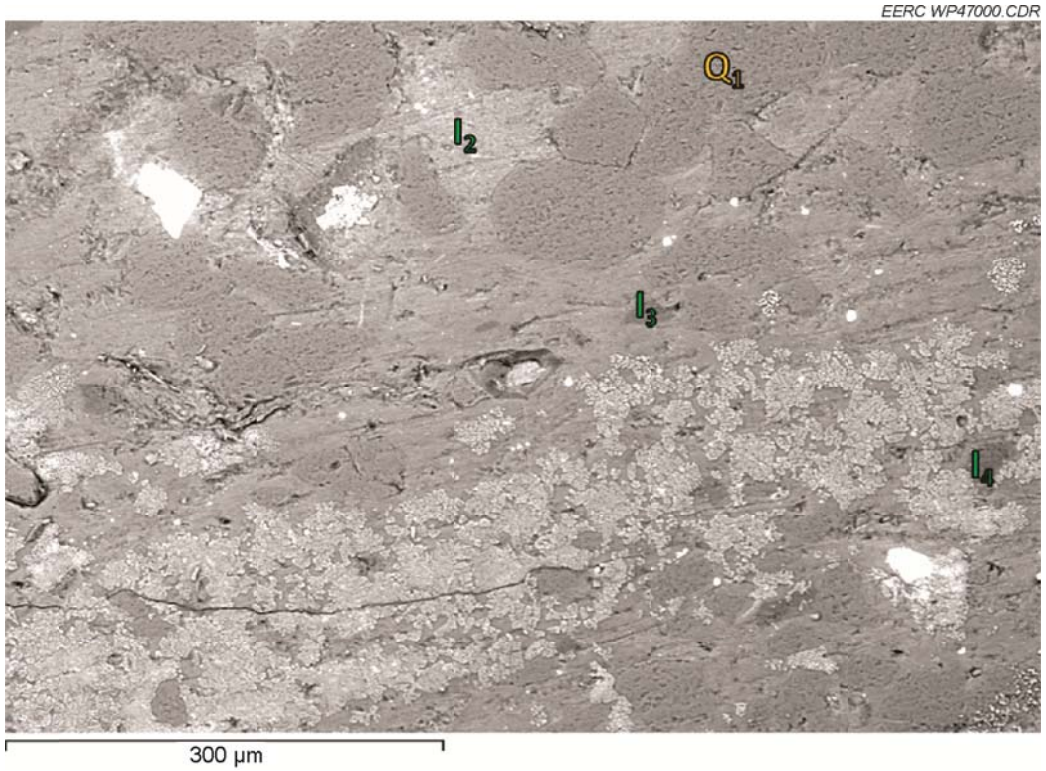



Figure C-60. Postexposure SEM image of ND 12596-BI-14831.

**Table C-44. SEM Point Analysis Data from Figure C-60**

| Point | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_2O_5$ | $SO_3$ | Cl | $K_2O$ | CaO | $TiO_2$ | CrO | MnO | $Fe_2O_3$ | $ZrO_2$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.34 | 0.39 | 4.71 | 90.61 | 0.00 | 0.00 | 1.11 | 0.72 | 0.00 | 0.18 | 0.00 | 0.00 | 0.95 | 0.00 | Quartz |
| 2 | 1.86 | 2.74 | 29.27 | 54.20 | 0.00 | 0.00 | 1.33 | 3.82 | 0.00 | 0.42 | 0.00 | 0.00 | 6.34 | 0.00 | Illite |
| 3 | 2.21 | 1.24 | 34.57 | 56.69 | 0.00 | 0.00 | 1.56 | 1.56 | 0.00 | 0.49 | 0.00 | 0.00 | 1.68 | 0.00 | Illite |
| 4 | 3.74 | 1.08 | 36.96 | 51.55 | 0.00 | 0.44 | 2.58 | 1.48 | 0.26 | 0.43 | 0.00 | 0.00 | 1.47 | 0.00 | Illite |