CO_2 STORAGE RESOURCE POTENTIAL OF THE CAMBRO–ORDOVICIAN SALINE SYSTEM IN THE WESTERN INTERIOR OF NORTH AMERICA

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A bi-national effort between the United States and Canada is under way to characterize the lowermost aquifer in the Williston and Alberta Basins of the northern Great Plains Prairie region of North America, thereby named the Basal Aquifer. This aquifer extends from northern South Dakota in the United States to central Alberta and Saskatchewan in Canada, covering an area of 1.34 million km^2. The goal of this 3-year project, which now is midway through, is to determine the potential for and effects of geological storage of CO_2 in Cambrian-to-Silurian rocks at the base of the sedimentary succession. To date, no other studies have attempted to characterize on a regional scale the storage potential of such large, deep saline systems that span the U.S.–Canada border. This multiprovince/multistate, multiorganizational, and multidisciplinary project is led on the U.S. side by the Plains CO_2 Reduction (PCOR) Partnership at the University of North Dakota Energy & Environmental Research Center (EERC) and on the Canadian side by Alberta Innovates – Technology Futures (AITF).

The Basal Aquifer includes a variety of clastic and carbonate facies deposited across a range of environments. This aquifer, generally containing saline water, lies directly on top of igneous and metamorphic basement rocks and, except for outcrop areas, is confined by sealing formations that include shales, tight carbonates, and evaporitic rocks. The Basal Aquifer, generally devoid of hydrocarbon resources, is penetrated by the lowest number of wells in the two basins, making it an ideal target for CO_2 storage. In the area underlain by the Basal Aquifer, there are 43 large CO_2 sources that individually emit more than 0.75 Mt CO_2/year, for a total of 159 Mt CO_2/year. Assuming all emissions from each of these sources will be stored in the Basal Aquifer, the main questions addressed by this study are 1) what is the storage capacity of the system and how many years' worth of emissions will it be capable of storing? and 2) what will be the fate and effects of the stored CO_2? A comprehensive characterization of the aquifer was completed to date and the volumetric CO_2 storage capacity of the aquifer was determined, which form the subject of this presentation. Work in progress, not presented, focuses on the effects of storing CO_2 in this aquifer.

Well logs, core analyses, drillstem tests, bottomhole temperatures and analyses of formation waters were used in the study. The depth to the top of the Basal Aquifer varies from close to 5000 m in the Alberta Basin at the Rocky Mountain Deformation Front in the west, and more than 4800 m at the depocenter of the Williston Basin in the south, to zero at the basin edges in outcrop areas. In the confined area, the thickness of the aquifer varies between less than 50 m and more than 400 m. Porosity varies from less than 1% in the deepest portion of the aquifer to more than 25% in shallower regions. Aquifer permeability varies greatly, from <10 mD to several thousand mD. Temperature at the aquifer base varies between >150°C in the deepest part of the Alberta Basin, and more than 130°C at its deepest in the Williston Basin, to less than 10°C in outcrop areas. Water salinity is highly variable, ranging from more than 350,000 mg/L in central Alberta and North Dakota to less than 4000 mg/L of freshwater around the aquifer's boundary in Montana, South Dakota, North Dakota, and Manitoba, where aquifer water is used as a source of groundwater. Pressures in the aquifer generally follow a gradient of 10.8 kPa/m.

The area suitable for CO_2 storage in the Basal Aquifer was determined using the following criteria: 1) water salinity must be greater than 10,000 mg/L, 2) CO_2 at the top of the aquifer must be in a dense phase, and 3) local porosity must be greater than 4%. The aquifer area suitable for CO_2 storage was determined to be 717,820 km^2. The completed 2-D model incorporates the geological and hydrogeological data collected in the baseline characterization effort and distributes the various rock properties, mainly porosity, throughout the study region using geostatistical methods. To estimate the volumetric CO_2 storage capacity in the Basal Aquifer, it was assumed that, as a result of CO_2 storage, the pressure in the aquifer will increase on average from the initial gradient of 10.8 kPa/m to 11.5 kPa/m. Data regarding depth, thickness, and porosity were distilled to produce the components needed to compute the CO_2 storage resource of the Basal Aquifer following the methodology and storage efficiency coefficients developed by the U.S. Department of Energy. A significant effort went into matching and integrating the work initially done separately on the U.S. and Canadian sides of the Basal Aquifer. Gridded maps for either side of the U.S–Canadian border were combined using a diffusive aggregation method to form a seamless CO_2 storage volume grid for the entire Basal Aquifer. This aggregation method involved feathering the Canadian data near the border and joining it to the data on the U.S. side, which allowed the interpolation of geostatistical processing functions across the border. This novel approach for smoothly joining the two data sets was successful. The resulting 2-D model indicates a storage capacity of 113 Gt CO_2. This work also provides the basis for the development of a massive 3-D geological model encompassing the entire study area that incorporates the internal architecture of numerous facies changes that occur across the study region and allows for the propagation and distribution of the petrophysical properties of this heterogeneous system for the purpose of injection scenario modeling.

The methodology and results of estimating the CO_2 storage capacity in the Basal Aquifer will be presented.