3-D Geochemical Modeling of Co_2-Based Huff 'N' Puff Oil Recovery at the Northwest McGregor Oil Field

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ABSTRACT

The Plains CO_2 Reduction Partnership, one of the seven U.S. Department of Energy National Energy Technology Laboratory regional partnerships, has conducted a project in the Northwest McGregor oil field in North Dakota to determine the effects CO_2 will have on the productivity of the reservoir, wellbore integrity, and the carbonate formation into which CO_2 was injected. The method used in this project is called huff 'n' puff, whereby 400 tons of supercritical CO_2 was injected into a well over a 2-day period and allowed to "soak" for a 2-week period. The well was subsequently put back into production for incremental oil recovery.

The purpose of this paper is to outline the approach for the 3-D reservoir-scale geochemical modeling in correlation with current field observations and laboratory experiments. The main objective of this work was to identify potential geochemical reactions in an effort to evaluate the short-term risks for operations (e.g., porosity and permeability decrease) and long-term implications for CO_2 storage via mineralization. The main challenges of this project were 1) to perform an optimal problem-specific model, which would correlate sufficiently well with field historical data and laboratory observations, and 2) to investigate the feasibility of geochemical modeling in a carbonate-fractured reservoir where the matrix flow is limited.

The mineralogy of the reservoir was determined using well logs, traditional core sample analysis, x-ray diffraction, and QEMSCAN® techniques. Pressurized bottomhole and observation/production well fluid samples were also collected, and their compositions were determined and used as input parameters for the model. Geochemical modeling was performed in four stages: equilibrium modeling, kinetic modeling, simple homogeneous 2-D reservoir modeling, and nonhomogeneous dual porosity/permeability 3-D modeling. The fluid properties and changes in mineralogy were historically matched with the field and laboratory observations.

It was determined that the already acidic and highly saline environment of the Northwest McGregor oil field should not experience significant changes in mineralogy, especially in the

near-term. An insignificant increase in porosity was predicted as a result of carbonate rock dissolution, and precipitation of iron-bearing minerals (e.g., hematite) was modeled.