**ABSTRACT for CMTC**

# CARBON SEQUESTRATION CASE STUDY: LARGE-SCALE EXPLORATION IN A BASAL SALINE SYSTEM IN CANADA AND THE UNITED STATES

Guoxiang Liu, Wesley D. Peck, Jason R. Braunberger, Robert C.L. Klenner, Charles D. Gorecki,* Edward N. Steadman

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, North Dakota 58202-9018

As one of the U.S. Department of Energy's regional carbon sequestration partnerships, the Plains $CO_2$ Reduction (PCOR) Partnership is performing a case study on the feasibility of large-scale underground $CO_2$ storage in the basal saline system of central North America. The area of investigation encompasses approximately 1,500,000 $km^2$ of the Alberta and Williston Basins located in the provinces of Alberta, Saskatchewan, and Manitoba in Canada and the states of Montana, North Dakota, and South Dakota in the United States. The thickness of the system is up to 300 m, with a permeability range from 10 to 1250 mD and porosity ranging from 1% to 25%. The calculated static storage resource for $CO_2$ in this saline system is 480 billion metric tons. However, the realistic injectivity is highly dependent on the reservoir pressure buildup, which must be considered during the $CO_2$ injection and postinjection for storage resource estimation and risk assessment.

In the study area, there are 16 aggregated large-scale $CO_2$ sources. Eight scenarios were designed to address the dynamic $CO_2$ storage capacity and pressure transient. To increase the injectivity and maximize the storage resource use, various strategies were explored, including injector optimization, injection rate optimization, water extraction during $CO_2$ injection, modifications to the ratio of vertical permeability and horizontal permeability (Kv/Kh), boundary condition plays, and relative permeability changes. Dynamic simulation was set to initiate in 2014 and end in the year 2050. Another 50-year postinjection was followed to check the pressure transient for the whole domain.

The results indicate that the total injected $CO_2$ is 82.2 Mt for the base case, which includes a single injector at each of the 16 $CO_2$ source locations. To improve injectivity, the number of injection wells was increased to 210. The added wells increased the total injected $CO_2$ by 37% to 112.3 Mt. In another scenario, 20 water extractors were placed in conjunction with the injectors at the largest $CO_2$ emission source location, which resulted in the total $CO_2$ injected increasing to 183.1 Mt: 63% higher than the previous scenario. The scenarios exploring various Kv/Kh ratios showed the resulting effect on the dynamic storage capacity to be very small. However, the scenario involving changes to the relative permeability curves showed significant increase of the storage capacity over the base case. A time-stepped injection scenario involving bringing the 16 injection locations online over a series of years and at an increasing annual injection rate over the injection period showed better performance than the case where all of the sources begin injecting

their full output simultaneously. This is because the higher rate in the beginning results in faster reservoir pressure buildup and ultimately constrains the injections. Overall, the pressure difference in the injection area between 2050 and 2014 was increased to ~800 psi, which is lower than the limitation of the reservoir pressure. After the 50-year postinjection period, the pressure difference decreased to ~400 psi.

The successful exploration of this case study for $CO_2$ storage in the basal saline system of central North America provides a basic guideline in performing evaluations of large-scale $CO_2$ storage demonstration projects. Specifically, this effort helps to answer questions regarding reservoir pressure buildup over the injection and postinjection periods and to track the $CO_2$ movement. This effort plays a crucial role in the entire process of $CO_2$ monitoring, verification, and accounting for such a large-scale case study of $CO_2$ storage estimation.