UPDATED NUMERICAL MODELING AND SIMULATION STUDY OF THE AQUISTORE CO_2 STORAGE PROJECT

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ABSTRACT

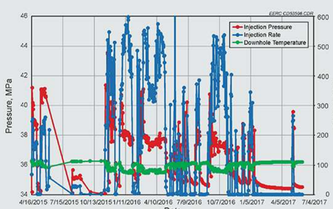
Aquistore, managed by the Petroleum Technology Research Centre (PTRC), is the world's first commercial-scale carbon capture, utilization, and storage project associated with a coal-fired power plant, SaskPower's Boundary Dam Station, located near Estevan, Saskatchewan, Canada. The Energy & Environmental Research Center (EERC), through its Plains CO_2 Reduction (PCOR) Partnership, is collaborating with PTRC and SaskPower to continue PCOR Partnership efforts to numerically model and interpret the performance of the project's injection well and observation well in order to improve the MVA (monitoring, verification, and accounting) strategies based on the history-matching and to provide predictive simulation results.

INTRODUCTION

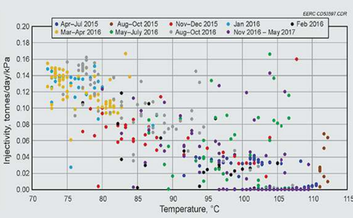
- The Aquistore site includes one injection well and an offset observation well 152 meters distant. Both wells were drilled and completed in the Deadwood and Black Island Formations.
- CO_2 injection was initiated in April 2015.
- Since the start of the injection through June 1, 2017, approximately 100,000 tonnes of CO_2 has been injected at the site.
- CO_2 breakthrough at the observation well has been confirmed by pulsed-neutron logging (PNL) conducted in February 2016.
- The subsurface at the Aquistore CO_2 storage site is one of the most comprehensively monitored and active field labs in the world.

Aquistore geology (figure courtesy PTRC).

CONTINUOUS FIELD DATA



Bottomhole pressure, injection rate, and downhole temperature.

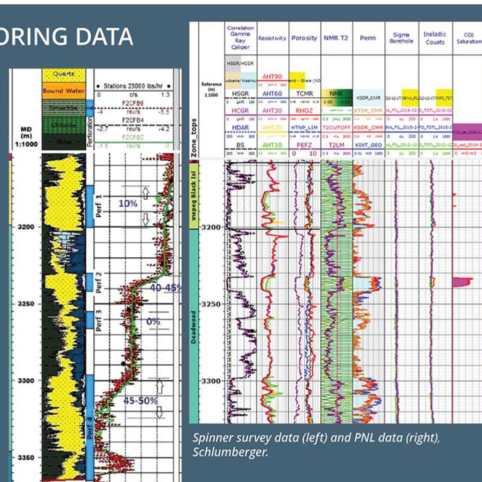


Injectivity data over the course of the injection process.

- The bottomhole pressure response, injection rate, and downhole temperature data have been continuously monitored over 2 years since the start of operation.
- The injection rate varies, and only about 5000 tonnes of CO_2 has been injected since November 2016 because of commercial CO_2 sales or disrupted operation.
- Injectivity data clearly indicate the interdependence of high rates of CO_2 injection, lower downhole temperature, and higher injectivity.

PERIODIC MONITORING DATA

- The spinner logging survey conducted on April 20, 2015, indicated that Perforation 1 takes about 10% of the total flow, 40%–45% goes into Perforation 2, little or no CO_2 goes into Perforation 3, and 45%–50% of the flow goes into the top or upper part of Perforation 4.
- The PNL collected in February 24, 2016, showed that CO_2 had arrived at the observation well in the depth interval, which corresponds to Perforation 2 at the injection well. The CO_2 saturation at the interval averaged around 50% with the top 1 m reaching up to 60%.



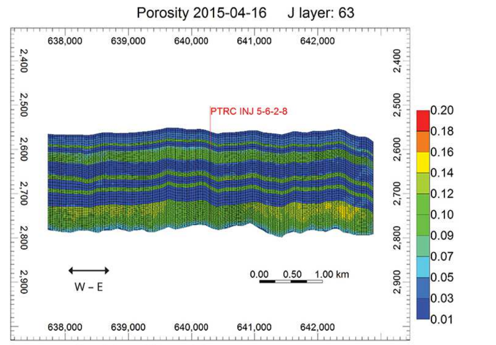
Spinner survey data (left) and PNL data (right), Schlumberger.

THANK YOU PROJECT PARTNERS

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY
ptrc Petroleum Technology Research Centre
SaskPower Powering the future
Schlumberger
CMG COMPUTER MODELLING GROUP LTD.

SIMULATION MODEL DEVELOPMENT

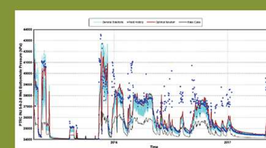
- The current static model adheres to the known geology and structure.
- The horizons of the formations were interpreted and picked from the baseline vibro-seismic data.
- Porosity was distributed based on seismic inversion methods.
- A grid dimension of 36 x 36 m was selected to have the equivalent resolution as seismic monitoring data.
- The average thickness of layers is ~2 m.
- The model comprises ~1.5 million grid cells.



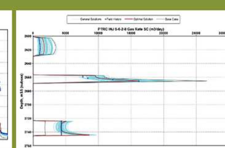
A cross-sectional view of the model.

HISTORY MATCHING

- The historical CO_2 injection performance from the Aquistore site and the subsequent prediction scenario were dynamically simulated using the Computer Modelling Group (CMG) GEM simulator and CMG's CMOST, an assisted history-matching software.



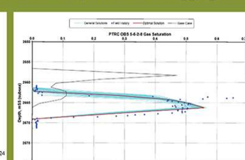
History-matched pressure response.



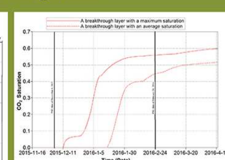
History-matched spinner survey data.

- The current simulation model is now capable of replicating (with a global history-matching error of around 7%) not only the continuous pressure response but also the CO_2 injection flow distribution and breakthrough profile data acquired from the periodic well logging monitoring events.

CO_2 injected volume into four perforations.



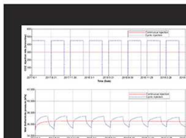
History-matched PNL data.



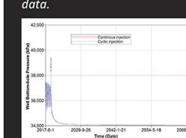
CO_2 breakthrough at the observation well.

PREDICTIVE SIMULATION WORK

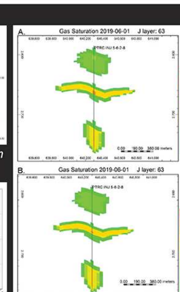
- Simulation scenarios for a 50-year forecast (additional 2 years of injection plus 48 years of monitoring period with no injection) were studied to predict the future injection performance and CO_2 plume evolution through June 1, 2067.
- Two different cases with continuous (A) and cyclic (B) injection modes for the additional 2 years were run to reflect the varying operation at the storage site.
- The predictive simulation results indicated that, regardless of injection mode, the CO_2 plume is similar in size and shape with a diameter of about 1 km in Perforation 2 around the injection well at the end of the additional 2 years of injection.
- During the postinjection period of 48 years, the heterogeneity and geologic structure of the formation controls the plume migration and shape.
- The CO_2 plume extends to 1.4 km in diameter for Perforation 2, and CO_2 appears to migrate slightly more to the west of the injection well because of the updip structure and consequent buoyancy migration in both injection modes.



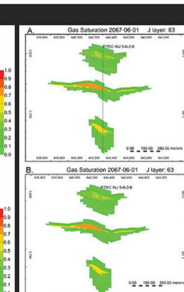
Continuous and cyclic injection data.



Pressure response during the 50-year forecast.



A cross-sectional view of CO_2 saturation at the end of the additional 2 years of injection.



A cross-sectional view of CO_2 saturation at the end of the 48 years of no injection.

SUMMARY AND FUTURE WORK

- The current simulation model at the EERC is now capable of reproducing (with a global history-matching error of around 7%) not only the continuous field data but also the periodic well logging monitoring data.
- According to the history-matched simulation model, CO_2 appears to have first arrived at the observation well around mid-December 2015, after approximately 8 months of injection.
- The predictive simulation results indicate that, regardless of injection mode whether it is continuous or cyclic, the CO_2 plume looks similar in size and shape, when an equivalent CO_2 volume of 200,000 tonnes was injected over 2 additional years.
- During the postinjection period of 48 years, the heterogeneity and geologic structure of the formation controls the plume migration and shape.
- Possible next updating steps: 1) revise the static model using a structural interpretation that reconciles the data from the multiple seismic surveys, 2) update the simulation to match the CO_2 plume signal obtained from the seismic monitoring data, and 3) geomechanical modeling to help explain temperature-dependent injectivity.

ACKNOWLEDGMENT