Assessment of CO_2 Injection Potential in the Copper Ridge Formation at the Mountaineer Power Plant Site

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Introduction

Numerical simulations of CO_2 injection have been conducted as part of a program to assess the potential for geologic sequestration in two deep brine reservoirs at the American Electric Power's (AEP's) Mountaineer Power Plant in New Haven, West Virginia. The results of the simulations will provide design guidance for injection and monitoring strategies, protocols, and permits for a demonstration project for CO_2 injection in these deep saline reservoirs, which are representative of a large part of the Ohio River Valley region.

Wireline log data from the Copper Ridge formation shows a higher porosity and permeability zone approximately 50 ft thick, between 8125-8175 ft true depth below ground surface. This high porosity zone, named the B-Zone, also appears with even greater thickness in two other wells that were characterized in the area and in much of the Midwest within the Knox Dolomite (Jagucki et al., 2006).

Simulations of the Copper Ridge formation complement previous work which assessed the Rose Run formation as a potential injection reservoir at the site (Bacon et al., 2006).

Methods

The numerical simulations of CO_2 injection conducted for this investigation were executed with STOMP-WCS-Sc, which simulates coupled hydrologic, chemical, and thermal processes, including multifluid flow and transport, partitioning of CO_2 into the aqueous phase, and precipitation of salt along with the accurate representation of fluid properties (White & Oostrom, 2006). A 260-ft thick interval containing the B-Zone was simulated, between the true depths of 8053-8313 ft below ground surface.

Geostatistical realizations of formation hydraulic properties were generated based wireline log data (Figures 1 & 2) using SGSIM (Deutsch and Journel, 1998). Permeabilities were scaled by a factor of 66 in order to calibrate the model flow field to a measured transmissivity of 60.3 ft^2/day.

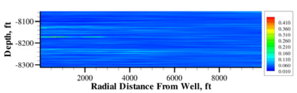


Figure 1. Geostatistical realization of porosity

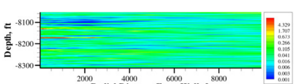


Figure 2. Geostatistical realization of permeability (Darcy)

Pilot Scale Simulation

Pilot scale simulations of CO_2 injection into the Copper Ridge Dolomite at a rate of 50 ktonne/year for 4 years were conducted in an effort to assess the optimum location for a monitoring well. Ambient temperature, pressure and salinity measured in the formation were used as initial and boundary conditions (Figure 3).

Distributions of CO_2 in the gas (Figure 4) and aqueous phase (Figure 5) in the formation show a plume with a radius that is generally less than 1000 ft, with a few stringers out to 3000 ft, indicating that a monitoring well should be placed within 500 to 1000 feet of the injection well.

CO_2 injection raises concerns related to the effect of increased pressures on cap rock integrity, but results of this simulation indicate that increased pressures at the well dissipate rapidly into the formation (Figure 6) and are less than the fracture gradient of 0.8 psi/ft (6650 psi at 8313 ft) measured in the overlying Beekmantown formation.

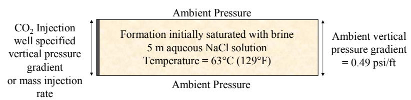


Figure 3. Initial and boundary conditions for pilot scale and production scale simulations

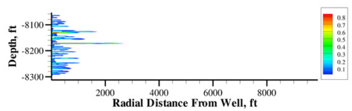


Figure 4. CO_2 gas saturation after 4 years of injection

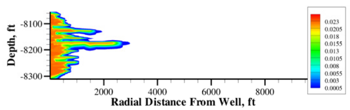


Figure 5. Aqueous CO_2 mass fraction after 4 years of injection

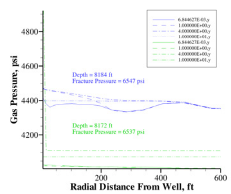


Figure 6. Gas pressure at two depths and several times

Production Scale Simulations

Production scale simulations of CO_2 into the Copper Ridge Dolomite for 3 years were conducted in an effort to assess the rate at which CO_2 could be injected into the formation. A well model in STOMP-WCS was used to simulate the injection of supercritical CO_2 under a constant pressure gradient in the well.

Increasing the injection pressure gradient from 0.55 psi/ft to 0.60 psi/ft increases the amount of CO_2 injected into the Copper Ridge formation over a 3-year period by a factor of 3.5 (Figure 8). Twenty years after the start of injection, 31% of the injected CO_2 has dissolved into the aqueous phase (Figure 9).

At a well pressure gradient of 0.6 psi/ft, stringers of the injected plume extend to a radius of 7000 ft (Figures 10 & 11), but pressure increases in the formation are low, except in the high permeability B-Zone (Figure 12). In all cases the formation pressures are less than the fracture gradient of 0.8 psi/ft, indicating that higher injection pressures are possible.

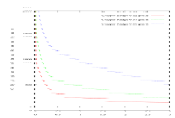


Figure 8. Injection rate increases with increasing well pressure gradient

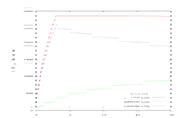


Figure 9. Amount of dissolved CO_2 increases with time after injection

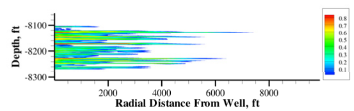


Figure 10. CO_2 gas saturation after 3 years of injection

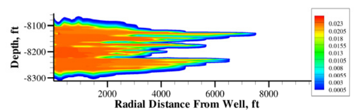


Figure 11. Aqueous CO_2 mass fraction after 3 years of injection

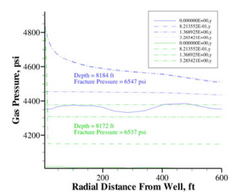


Figure 12. Gas pressure at two depths and several times

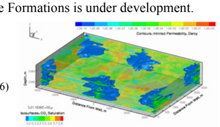
Conclusions

- Simulation of a pilot scale injection of CO_2 into the Copper Ridge formation at a rate of 50 ktonne/year for 4 years indicate that a monitoring well should be placed within 500 to 1000 feet of the injection well.
- At a well injection pressure of 0.60 psi/ft, the Copper Ridge formation shows a declining injection rate at 3 years of 525 ktonne/year, providing a second potential injection reservoir in addition to the Rose Run formation.

Future Work

- AEP recently announced plans for a commercial pilot-scale capture and injection test at the site, scheduled to begin by late 2008 and will include injection in both Rose Run and Copper Ridge zones with an extensive MMV program.
- A 3D simulation of CO_2 injection into the Rose Run (Figure 13) and Copper Ridge Formations is under development.

Figure 13. Multiple-well injection into the Rose Run formation (Bacon et al., 2006)



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Acknowledgments

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For further information

Please contact *dianabacon@battelle.org*. More information on this and related projects can be obtained at *www.battelle.org/environment*.

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