Findings of the Storage Potential Assessment in Deep Saline Formations in the Ohio River Valley Region

Battelle

Neeraj Gupta[1], Phil Jagucki[1], Jim Dooley[2], Mike Mudd[3], and Charlie Byrer[4]

[1]Battelle, Columbus, Ohio; [2]Battelle, Joint Global Change Research Institute, Maryland; [3]American Electric Power, Columbus, Ohio; [4]DOE, NETL, Morgantown, West Virginia

Introduction

Abstract

An extensive program of drilling, sampling, and testing of a deep well at the state-of-the-art Mountaineer Plant coal-fired power plant combined with a seismic survey has been used to develop a regional geologic sequestration framework. Assessment of injection potential in several zones at the site through reservoir testing and simulations has been completed. The studies show that the Rose Run Sandstone and several high permeability zones in the adjacent dolomite layers are suitable for injection. The results also highlight the potential importance of carbonate formations and the use of multilateral/horizontal wells for large-scale injection in the region. These observations are also supported through characterization of other nearby deep wells conducted in collaboration with the oil and gas industry.

Following a successful site assessment, the project's focus is now on an assessment of CO_2 source, handling, and design issues. In addition, regulatory and stakeholder issues related to capture and injection are being evaluated.

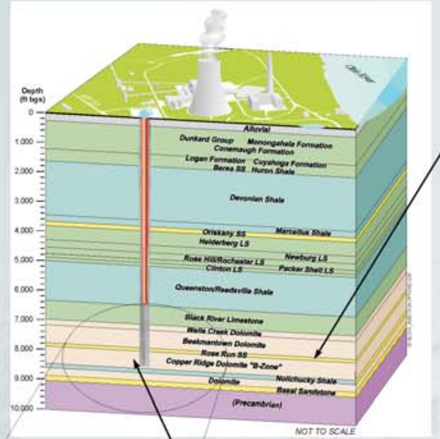
The final decision to move to an injection and monitoring phase will be made during the next year based on the findings of design feasibility studies and approval of the project sponsors.

Location

The site is located at AEP's 1,300 MW Mountaineer Power Plant near New Haven, West Virginia. It is located in a region with a large number of current and planned power plants.

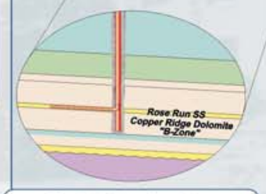
The site is located in the Appalachian Basin, where up to 15,000-ft thick sequences of Paleozoic sedimentary rocks are present.

There were no wells that fully penetrated Paleozoic strata within 40 km of the site and very few other deep wells in the region. Thus the hydrogeologic setting of the area was poorly understood.



NOT TO SCALE

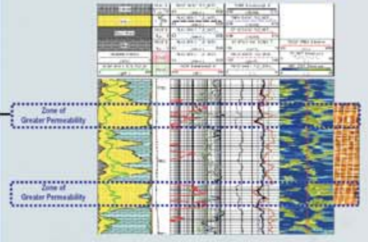
Detailed Testing of Copper Ridge "B- Zone" Injection Zone is Planned



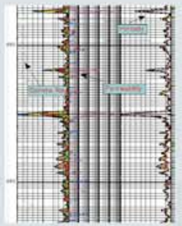
Possible Future Completion for CO_2 Injection Tests

- A ~9,200-ft-deep well was drilled to characterize CO_2 storage and containment potential at the Mountaineer Site and surrounding region
- The well was designed so that it could be converted to an experimental CO_2 injection well in the future

Advanced Wireline Logging to Locate Injection Zones



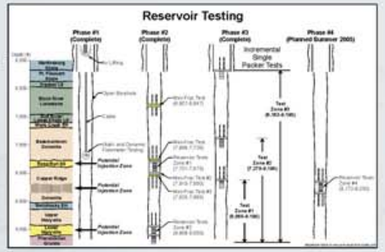
Multiple logs showed permeability and porosity variation within the Rose Run Sandstone



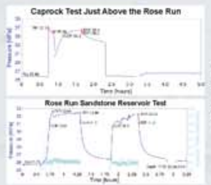
Logging also indicated other potential CO_2 storage intervals in less characterized zones like the Copper Ridge Dolomite

Reservoir Testing and In Situ Stress Analysis

- Reservoir Tests were used to validate injection parameters and locate injection zones.
- Injectivity in Rose Run Sandstone was confirmed
- Initial testing showed significant potential in Copper Ridge Dolomite permeability zones. This will be verified with further tests.
- Mini-frac tests show presence of competent caprock above the injection reservoirs and potential for reservoir stimulation through fracturing for enhanced injectivity

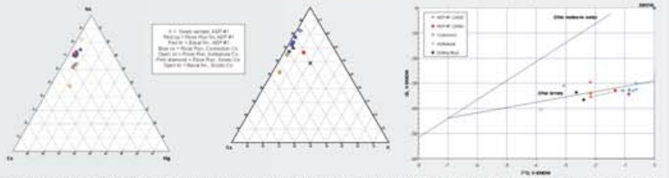


The orientation of S_{Hmax} (maximum horizontal stress) is consistent with that of the regional stress field. The regional S_{Hmax} is oriented approximately NE-SW near the site.



The fracture pressure or minimum horizontal stress (S_{hmin}) for Rose Run (31-32 MPa) is less than the caprock (35-36 MPa), indicating that Rose Run can be fractured without affecting caprock.

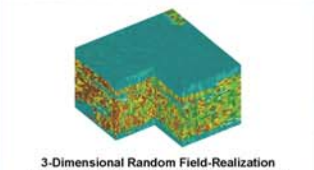
Geochemical Analysis



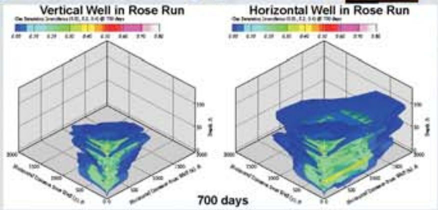
- Brine samples were collected from AEP #1 at the time the well was completed (August 2003) and again during reservoir tests (March 2004)
- Composition and stable isotope ratios match those of other deep well brines in the region
- High salinity (>300,000 ppm) indicates that solubility of CO_2 in brine will be low
- Geochemical modeling indicates that the Rose Run brine, when equilibrated, is undersaturated with respect to carbonate and sulfate minerals and is unlikely to cause precipitation of solids that would inhibit formation porosity and permeability

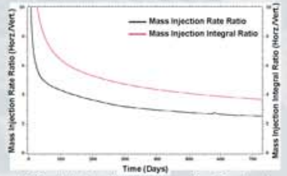
Reservoir Simulations for Injection and Monitoring System Design

- Objective – evaluate the injection and containment scenarios in several formations to support design, permitting, risk assessment, and monitoring
- STOMP-CO_2 - a multiphase, scalable-parallel processor with capabilities for solubility, thermal, geochemical effects is being used.
- Eclipse simulations to be conducted by Schlumberger
- Rose Run Formation – an interbedded sandstone and dolomite layer – has been simulated using geostatistical models with 2-D and 3-D settings



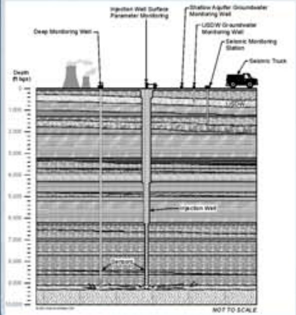
3-Dimensional Random Field-Realization of Intrinsic Permeability, ln(mD) in Rose Run





A Single Lateral Well in Rose Run Can Lead to ~3x Increase in Injection Rate

Development of a Monitoring Strategy



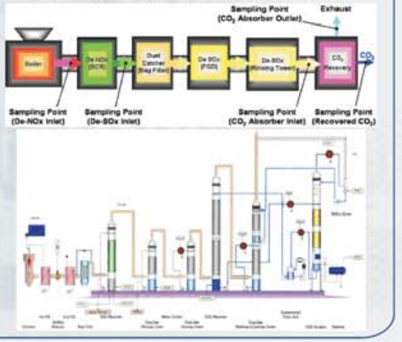
A comprehensive monitoring strategy is being evaluated, including options such as:

- Using existing network of shallow wells
- Deeper observation wells including multilevel wells
- Surface or borehole geophysical techniques
- Geochemical sampling
- Tracer tests
- Continuous pressure, temperature, chemical sensors
- Continuous geophysical sensors – passive seismic
- Periodic well logging
- Reservoir tests

Design Feasibility Analysis for a Small-Scale Modular Capture System is Underway

- Mountaineer Plant already has an SCR; an FGD system is under construction and is expected to be on-line in 2007
- Design feasibility for a small-scale capture system is underway in collaboration with various vendors
- As part of this effort, 4 tons of high sulfur coal were tested in a 1 t/day capture test facility to optimize the system
- Results indicate that an output CO_2 purity of 99.95% with 0.05% of N_2 and O_2. Other impurities are below detection limits.
- Post FGD removal of residual sulfur is required to prevent amine loss
- Basic and detailed designs and cost analysis for a modular capture system will be completed during 2005-06

Setup for CO_2 Capture Test from High-Sulfur Coal



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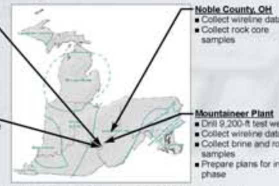
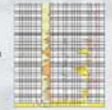
Ohio Coal Development Office

Developing a Regional Sequestration Framework

- A Regional Characterization Strategy was developed to leverage new exploratory drilling in the region for logging and sampling to characterize CO_2 storage candidate reservoirs at low cost
- Three (in addition to AEP #1) regional characterization wells have been completed in collaboration with the regional oil and gas industry
- DOE has awarded an additional contract to Battelle to expand the effort
- Opportunities are evaluated case-by-case to determine the most beneficial efforts that will fill critical data gaps





Collaboration with Oil and Gas Industry to Build Geologic Framework

Key Steps in Developing CO_2 Storage Demonstration – Where do we Stand?

Conclusions

- All objectives of the initial site characterization phase have been successfully completed
- Based on core analyses, wireline logs, and reservoir tests representing sequentially larger areas of testing there is injection potential in the sandy zones in Rose Run interval and possibly greater potential in a very high permeability zone within the Copper Ridge Dolomite
- The basal sand, known as the Mt. Simon Sandstone in the rest of the region has very low potential in this area. However, the high injection potential in Mt. Simon Sandstone elsewhere in the region is already proven.
- As suggested by the pre-drilling investigation, sufficient and multiple containment layers are present in this area. There was no indication of extensive fracturing that would affect containment.
- The geologic framework developed here is being used for reservoir simulations, risk assessment, and development of CO_2 injection and monitoring options at this site
- The characterization work at Mountaineer is being expanded to development of regional geologic framework developed in collaboration with oil and gas industry