

## CO<sub>2</sub> Sequestration

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### Research Objective

Research for this project focuses on estimating the capacity and identifying near-term opportunities for geological CO<sub>2</sub> storage (CCS and CCUS) in the Ordos Basin, China, and also applicable to formations in the United States. This effort includes the following:

- Simulation technology for CO<sub>2</sub> storage in saline formations
- Research and application of monitoring technology of CO<sub>2</sub> storage in saline formations
- Assessment of safety and risk of CO<sub>2</sub> storage in saline formations
- Geological characterization
- Through combined research on the above issues and successful execution of demonstration projects, this effort will improve understanding, provide verification of key technologies for CO<sub>2</sub> storage in saline formations, and provide the scientific evidence to implement large-scale CCS and CCUS in China and in the United States.
- The project has two primary objectives:
- To build the scientific, technological, and engineering framework necessary for CO<sub>2</sub> utilization through enhanced oil recovery and the safe, permanent storage of commercial quantities of anthropogenic CO<sub>2</sub> in the Majiagou Limestone of the Ordos Basin, Shaanxi Province, China
- To assess the safety and risk of CO<sub>2</sub> storage in saline formations

### Technical Approach

In this project, UWY, WVU, IGS, LANL, LLNL, and Chinese partners undertake the work necessary to move from preliminary characterization to commercial development of a premier CO<sub>2</sub> storage site in the Shaanxi Province of China. The team's technical approach to CO<sub>2</sub> storage characterization in the Ordos Basin emphasizes the following five steps:

- Quick procession from the recently completed general inventory of CO<sub>2</sub> storage potential in the Ordos Basin to detailed, site-specific characterization studies of individual targeted storage sites
- Experience with the Wyoming Carbon Underground Storage Project and other U.S. Department of Energy characterization projects supports the use of two-dimensional and 3-D seismic surveys, stratigraphic test wells, and existing well bore information



as basic elements to the retrieval, evaluation, and interpretation of data vital to project success

- These data allow the best decisions possible regarding characterization, prioritization, and selection of specific storage sites
- Numerical simulation techniques, which are vital to the delineation of 3-D geological heterogeneity at selected storage sites, and to the evaluation of caprock distribution, sealing capacity, trap configuration, reservoir storage capacity, reasonable injection rates, optimal injection well patterns, various pressure configurations, potential CO<sub>2</sub> plume distributions, and displaced fluid domains at potential storage sites (i.e., risk reduction)
- Planning before CO<sub>2</sub> injection for customized fluid production and treatment of displaced fluids, or to develop some other displaced fluid management strategy
- Assuming success in steps 1 through 4, step 5 involves planning, designing, and implementing a sub-commercial CO<sub>2</sub> storage demonstration (1 Mt per year) to test the validity of the numerical simulation scenarios, and to construct credible monitoring and performance assessment plans

## Recent Progress

The team has developed a regional geologic/structural model for the Ordos Basin based on the geologic, geophysical, geochemical, petrophysical, and petrographic data available in the public domain for the Shaanxi portion of the Ordos Basin.

The Shaanxi-Wyoming team is inventorying and prioritizing the highest-priority storage sites and reservoirs in the Ordos Basin. The team has implemented plans to share data in order to effectively characterize and prioritize potential geological CO<sub>2</sub> storage reservoirs in the Ordos Basin. They also used the technology developed by Aines et al. (2010) at LLNL and the Wyoming/SPIERCE team evaluated displaced fluid management strategies for the Majiagou Limestone in the basin. Results suggest that more than 90% of the produced Majiagou formation water (total dissolved solids of approximately 20,000 ppm) could be treated and used beneficially.

To better utilize CO<sub>2</sub> for enhanced oil recovery, the research team made two visits to the Yanchang Oil Company owned by Shaanxi Province. The UWY team is working alongside the Yanchang Oil Company in prioritizing these oil fields according to their potential for EOR using CO<sub>2</sub> flooding. The partnership has developed an assessment strategy that includes screening criteria for Ordos Basin oil fields. Preliminary screening results suggest that in the Yanchang oil fields, the Triassic Yanchang Formation—particularly the Chang 4, 5, and 6 reservoirs, and Yan 8 and 9 reservoirs—have the greatest potential for CO<sub>2</sub> EOR in Shaanxi Province.

The researchers also assessed the risks and safety of CO<sub>2</sub> storage in the Ordos Basin. They collected data from a potential demonstration project site and conducted a risk analysis. The resulting work was turned into a paper that has been submitted to *Energy and Environmental Science* that describes a pore-scale to regional-scale analysis of CCS in the southern United States. A new site-scale pipeline optimization algorithm was developed for this work and this algorithm will be demonstrated and communicated to interested parties. Researchers finalized several numerical simulations of CO<sub>2</sub> plume evolution for a project in the United States. These simulations are designed to reveal details and uncertainty in storage capacity, injectivity, and leakage that are at the cutting edge of current simulation capability. The work incorporates heterogeneity in rock properties and has led to new insights into defining storage reservoirs and will be submitted for publication in 2012. The results will play an important role in demonstrating the value of cutting-edge numerical techniques.

## Expected Outcomes

The significant opportunity for storage and utilization of CO<sub>2</sub> in the Ordos Basin in China complements opportunities that are being explored in the United States. The research team is looking at the Ordos Basin parallel to similar research on basins in the United States, such as in Wyoming and Illinois.

The lessons learned will be invaluable to CCS projects particularly in Rocky Mountain basins; the Majiagou Limestone and Ordos Basin are very similar to the Paleozoic Madison Limestone and the Powder River Basin of Wyoming and Montana.

This work ultimately improves global understanding of how to safely and effectively store CO<sub>2</sub> in saline formations or to use the CO<sub>2</sub> for EOR.



Illustrative simulation model output for supercritical CO<sub>2</sub> volume fraction

