OHIO COAL DEVELOPMENT OFFICE
ANNUAL PROJECT ABSTRACT
AS OF DECEMBER 2004

1. PROJECT SPONSOR:
Case Western Reserve University

2. PROJECT MANAGER/TITLE:
Beverly Saylor

3. OCDO GRANT NO. __4-04-1.C1.1____

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5. PROJECT TITLE: _CO2-Brine-Rock reactions for carbon sequestration in Ohio's deep saline aquifers.

6. PROJECT TERM FROM: _9/1/04_____ **TO:** ____9/30/05_____

7. PROJECT UPDATE ___X____ --OR-- **FINAL REPORT** _____

8. BUDGET:

CO-SPONSOR'S NAME	CWRU	**COST-SHARE**
OCDO		$_____
_____16417_____		$__9639____
_____16227_____		$__8043____
_____16605_____		$__12066___
_____30736_____		$___0_____
TOTAL PROJECT VALUE:		$__109733__

ABSTRACT

9. OVERVIEW OF PROJECT & OBJECTIVES:

CO_2 collected from the waste streams of point sources, such as power plants, can be injected into deep saline aquifers in order to limit the buildup of greenhouse gases to the atmosphere. The most secure storage of carbon in deep saline aquifers requires gas-brine-rock reactions to convert the injected CO_2 into dissolved phases and solid carbonate minerals. This project continues and expands geochemical modeling and experimental investigations of reactions between CO_2, brine, and the rocks and minerals that make up Ohio's deep saline aquifers. The objectives are to 1) identify the reactions that are most important for trapping carbon in Ohio's deep saline aquifers, 2) constrain experimentally the

rates and products of these reactions and how they vary with aquifer parameters such as pressure, temperature, and salinity, and with progress of reaction (approach to equilibrium) 3) incorporate experimental data into geochemical models to evaluate likely capacity and safety of carbon storage in Ohio's deep saline aquifers and to aid in optimizing injection strategies.

10. WORK TO DATE & CONCLUSIONS:

Geochemical modeling and geological characterization conducted during the past four and a half years as part of OCRC3 and OCRC4 identified the reactions that are most important for trapping CO_2 as carbonate minerals in the Rose Run Sandstone, one of Ohio's deep sandstone aquifers. Specifically, these reactions are the dissolution of albite ($NaAlSi_3O_8$) and orthoclase ($KAlSi_3O_8$) feldspar leading to the precipitation of the carbonate phase dawsonite ($NaAlCO_3(OH)_2$) and, in some layers of the formation, the dissolution of glauconite ($(K,Na)(Fe,Al,Mg)_2(Si,Al)_4O_{10}(OH)_2$) leading to the precipitation of the carbonate phase siderite ($FeCO_3$). Geochemical modeling predicted that the amount of CO_2 trapped as carbonate mineral phases will depend strongly on the fugacity of dissolved CO_2 in the brine and consequently on the rate of dispersion of CO_2 away from the injection site relative to the rates of mineral dissolution and precipitation reactions. Simple models indicate that 30 years of emissions from the five largest power plants in eastern Ohio (all >1000MW) can be injected into the Rose Run Sandstone, dissolved into the brine, and ultimately converted to stable carbonate minerals (Saylor and Zerai, 2004.

Rocking tube reactors were designed and constructed to conduct mineral-brine-CO_2 reaction experiments at deep aquifer pressure and temperature conditions. A suite of CO_2-brine-abite reaction experiments was completed for initial pressures ranging from 500 to 1300 PSI and temperatures ranging from 22˚ to 100˚ C. Far-from-equilibrium albite dissolution rates were calculated from the changes in solute concentration with time yielding good reproducibility among replicate experiments and good agreement for available literature values.

11. PLANS FOR COMING YEAR:

The goal for the next phase of research is to incorporate into models and experiments the full complexity of reactions with natural brine and rock samples. Experiments during the coming year will use ground mineral separates and rock samples representing Ohio's deep sandstone formations to constrain products and rates of CO_2-brine-rock reactions as functions of rock composition, brine composition, temperature, CO_2 fugacity, and approach to equilibrium. Simple and complex natural and artificial brines and natural and artificial rocks will be used.

12. HIGHLIGHTS/ACCOMPLISHMENTS: (of the past year)

• Evaluated recently published equations of state for the solubility of CO_2 in brine. Demonstrated that 1) decreased solubility in highly saline aquifers, such as those

beneath Ohio, reduces estimates of storage capacity by half compared to models that do not consider salting out effects, and 2) available models of the salting out effects vary considerably for the pressure, temperature, and salinity conditions of deep saline aquifers.

• Adjusted equilibrium constants for elevated salinity, temperature, and pressure and incorporated the adjusted constant into geochemical models of CO_2-brine-rock reactions. The impact of these adjustments is small initially, but has a large effect on phase precipitation and dissolution as reactions progress.

• Began CO_2-brine-rock reaction experiments using glauconite and ground samples of the Rose Run Sandstone, higher salinity brines, and brines of varying composition.

13. ARTICLES/PRESENTATIONS: (since 2004)

Peer-reviewed journal articles

In Review - Zerai, B., Saylor, B.Z**.**, and Matisoff, G. Computer Simulation of CO_2 trapped through mineral precipitation in the Rose Run Sandstone, Ohio, Applied Geochemistry.

2004 - Saylor, B. and Zerai, B**.**, Injection and Trapping of CO_2 in Deep Saline Aquifers: In: Gieré R. and Stille P. (eds): Energy, Waste, and the Environment: A Geochemical Approach, Geological Society, London, v. 236, p. 285-296.

Conference presentations

2005 – Zerai, B., Saylor, B.Z. and Adams, D., Geochemical Modeling of Carbon Storage Capacity in Deep Saline Aquifers, Chapman Conference, San Diego, CA

2005- Saylor, B.Z., Zerai, B., Hanson, B., Matisoff, G., Experimental Constraints on Gas-Brine-Rock Reactions under Conditions of Elevated Pressure, Temperature, and Salinity, Chapman Conference, San Diego, CA

2004 - Zerai, B., Saylor, B.Z., and Matisoff, G., Kinetic Modeling and Geochemical Reactions for Sequestration of CO_2 in Deep Saline Aquifer. Third Annual Conference on Carbon Sequestration, DOE-NETL, Alexandria, VA.

Invited talks

2004 - "Injection and Trapping of CO_2 in Deep Saline Aquifers", 11'th International Symposium on Supercritical Fluid Chromatography, Extraction, and Processing", Pittsburgh, PA.

Conferences chaired

Coordinator and Co-Chair for AGU Chapman conference on the Science and Technology of Carbon Sequestration – January, 2005