the ENERGY lab

PROJECT FACTS

Carbon Storage – ARRA - GSRA

Training Students to Analyze Spatial and Temporal Heterogeneities in Reservoir and Seal Petrology, Mineralogy, and Geochemistry: Implications for CO_2 Sequestration Prediction, Simulation, and Monitoring

Background

The focus of the Department of Energy's (DOE) Carbon Storage Program is to develop and advance technologies that will significantly improve the effectiveness of geologic carbon storage, reduce the cost of implementation, and prepare for widespread commercial deployment between 2025 and 2035. Research conducted to develop these technologies will ensure safe and permanent storage of carbon dioxide (CO_2) to reduce greenhouse gas (GHG) emissions without adversely affecting energy use or hindering economic growth.

Geologic carbon storage involves the injection of CO_2 into underground formations that have the ability to securely contain the CO_2 permanently. Technologies being developed for geologic carbon storage are focused on five storage types: (1) oil and natural gas reservoirs; (2) saline formation; (3) unmineable coal seams; (4) basalts; and (5) organic-rich shales. These technologies will work towards meeting carbon storage programmatic goals of (1) estimating CO_2 storage capacity +/- 30 percent in geologic formations; (2) ensuring 99 percent storage permanence; (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals. Deploying these technologies in commercial-scale applications will require a drastically expanded workforce trained in carbon capture and storage (CCS)-related disciplines, including geologists, engineers, scientists, and technicians. Training to enhance the existing CCS workforce and to develop new professionals can be accomplished through focused educational initiatives in the CCS technology area.

The National Energy Technology Laboratory (NETL), through funding provided by the American Recovery and Reinvestment Act (ARRA) of 2009, managed 43 projects that received more than $12.7 million in funding that focus on conducting geologic storage training and support fundamental research projects for graduate and undergraduate students throughout the United States. The training and projects can be categorized under one or more of the DOE Carbon Storage Program's five Technology Areas: (1) Geologic Storage and Simulation and Risk Assessment (GSRA), (2) Monitoring, Verification, Accounting (MVA) and Assessment, (3) CO2 Use and Re-Use, (4) Regional Carbon Sequestration Partnerships (RCSP), and (5) Focus Area for Sequestration Science. This project trained students in geological tools that are essential to reservoir characterization and the geologic storage of CO_2.

Project Description

NETL has partnered with Purdue University to conduct training and research to determine the depositional and diagenetic characteristics of CO_2 storage and caprock formations; the low-permeability formations located above the CO_2

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PARTNERS

None

PROJECT DURATION

Start Date	End Date
12/01/2009	09/30/2013

COST

Total Project Value
$303,362
DOE/Non-DOE Share
$299,920 / $3,442

PROJECT NUMBER

DE-FE0001852

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injection zone(s) that prevent the upward migration of CO_2. Depositional characteristics help to determine where sediment was deposited and lithified, such as a beach, lake, or dune. Diagenetic characteristics, such as compaction and cementation, illustrate the physical, chemical, and biological changes that take place in sediments as they become consolidated into rocks. This project also explored methods for predicting changes in the mineralogy (chemical composition) and texture that occur when rocks are exposed to CO_2-saturated brines.

During the project, graduate students conducted original scientific research into topics related to the lithological, textural, and compositional variability in formations that were analyzed as possible CO_2 storage reservoirs and seals. The students focused primarily on analyzing core samples and geophysical well-logs of the Mount Simon Sandstone (Figure 1) and overlying Eau Claire Formation seal.

Goals/Objectives

The objective of this project is to train graduate students in the use of geological tools that are essential to reservoir characterization, including storage capacity estimation and CO_2 storage permanence. This effort focuses on training students through curriculum and research using advanced petrological, mineralogical, and geochemical methods; core analysis; and geophysical well-log interpretation. Specific project objectives included:

- The quantification of the mineralogy, geochemistry, and texture of reservoir and seal units.
- An exploration of new methods of petrographic image analysis for rapid and quantitative assessment of mineralogy, focusing on the minerals that are in contact with pore space.
- The investigation of changes in reservoir mineralogy and texture in samples that have been experimentally exposed to CO_2-saturated brines and compare the observed changes with modeled reactions.

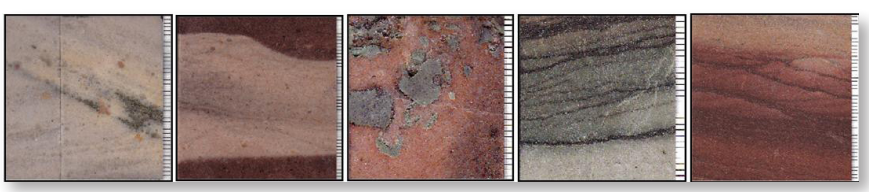

Figure 1. Examples of Mt. Simon Sandstone (a potential CO_2 sink) illustrating its textural and compositional variability.

Accomplishments

- By the end of the project, eight students had accumulated 5,828 training related hours under the program.
- The project team conducted research to understand spatial variations in porosity within the Mount Simon Sandstone (a regionally significant CO_2 storage formation within the Illinois Basin) and to identify the processes that have influenced the observed variation. Samples of Mount Simon Sandstone were obtained basin-wide from representative burial depths and lithofacies. Over 150 individual samples from seven different wells were analyzed petrographically to quantify porosity. The project team also completed analyses of select mineralogies and petrologic textures for characterization of the long-term storage potential of CO_2 in reservoirs and cap rock units.
- Compositional and textural variability within the Eau Claire Formation (a regionally significant sealing formation within the Illinois Basin) was quantified to evaluate the history of fluid-related alteration in this unit and to consider how it might react with future introduction of CO_2-saturation brines. For this work, 60 core-derived Eau Claire Formation samples from seven wells across the Illinois Basin were analyzed visually, petrographically, mineralgically, and geochemically. This work showed that the sealing capabilities of the Eau Claire Formation are quite variable depending on depositional fabric and diagenetic history.
- Compositional and textural changes were examined in samples that were exposed to experimental CCS conditions over a period of six months. Samples were selected to provide a "typical" representative Mount Simon Sandstone sample and to analyze changes in a very low porosity and low permeability sample from deep in the basin. Methods for evaluating the samples included petrographic examination, scanning electron microscopy and energy dispersive chemical analyses, brine geochemical analyses, and geochemical modeling.
- The project team evaluated regional compositional and textural trends within the Mount Simon Sandstone and Eau Claire Formation. Tools for this work included integrated well-log analyses, core descriptions, thin section microscopy and compositional point counting, and geochemical analyses of detrital zircons. This work demonstrated changes in composition and sedimentary provenance through the section, which can then be linked to spatial patterns in reservoir quality.
- Lastly, the project team investigated for evidence of structural textures such as deformation bands or fractures within the Mount Simon Sandstone and to use petrographic and geochemical analyses to evaluate whether these types of structures have been either conduits and/or barriers to fluid flow within this unit. This work demonstrated that deformation bands and grain-scale fracturing are not uncommon in these samples, and that in some cases the fractures seem to have been conduits for diagenetic fluids.

Benefits

Overall the project makes a vital contribution to the scientific, technical, and institutional knowledge base needed to establish frameworks for the development of commercial-scale CCS. This research effort also supports the Carbon Storage Division programmatic goals of estimating carbon storage capacity and ensuring 99 percent storage permanence within the storage formation. This project will improve scientific understanding of the depositional and diagenetic characteristics of regional reservoirs and seals as well as those related to specific storage projects in order to better characterize CO_2 storage capacity and storage permanence in the subsurface. An added benefit of this project is producing a trained workforce with the skills and competencies in geology, geophysics, and geochemistry needed for the implementation of large-scale CCS projects.