



the **ENERGY** lab

PROJECT FACTS

Carbon Storage - GSRA

Los Alamos National Laboratory – Advancing the State of Geologic Sequestration Technologies towards Commercialization and Pre-Combustion Capture Goals

Background

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) is helping to develop technologies to capture, separate, and store carbon dioxide (CO₂) to aid in reducing greenhouse gas (GHG) emissions without adversely influencing energy use or hindering economic growth. Carbon capture and sequestration (CCS) — the capture of CO₂ from large point sources and subsequent injection into deep geologic formations for permanent storage — is one option that is receiving considerable attention.

NETL is devoted to improving geologic carbon sequestration technology by funding research projects aimed at removing barriers to commercial-scale carbon sequestration deployment. NETL is working with Los Alamos National Laboratory (LANL), one of DOE's multi-program, multi-disciplinary research laboratories, to conduct research studies on key topics critical to the success of geologic sequestration, including CO₂-water-rock interactions; development and deployment of monitoring, verification, and accounting (MVA) tools; systems modeling and science of CO₂ sequestration, national risk assessment research, and advancing CO₂ capture technologies.

Project Description

LANL is working on five tasks aimed at advancing the state of several key geological sequestration technologies :

- **CO₂-Water-Rock Interactions and the Integrity of Hydrodynamic Seals:** LANL will address the stability of the well components interfacing with CO₂ in the subsurface through a combination of field studies, experimental studies, and numerical modeling. An emphasis will be placed on the bond between the cement used in well structures and the natural shale or clay structure because

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PROJECT DURATION

Start Date

01/01/2010

End Date

12/31/2012

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of the importance of achieving an adequate seal to contain the CO₂ plume. The migration and interaction of CO₂ along interfaces between steel and cement (in wells) and between cement and caprock (well/seal formation interfaces) can potentially result in reduced structural stability and integrity. Portland cements typically used to seal wellbores could readily react with injected CO₂ and reduce overall well integrity. The performance and reliability of a geologic CO₂ sequestration site is critically dependent on the integrity of the hydrodynamic seals to prevent migration of buoyant CO₂ plumes.

- **Development and Deployment of Monitoring, Verification, and Accounting (MVA) Tools:** This research will be used to develop monitoring tools to quantify CO₂ within and in the unlikely event of leakage from geologic storage reservoirs. The research aims to target the CO₂ storage reservoir and the soil surface to advance MVA tools to better assess the potential impacts of CO₂ leakage from a reservoir. The primary research focus is to address specific monitoring challenges including quantifying and attributing stored CO₂ within and outside the reservoir, detecting CO₂ movement within the reservoir, and improving the overall accuracy of seepage detection. LANL will develop and field test a Frequency Modulated Spectroscopy Differential Absorption LIDAR instrument (FMS-DIAL). This instrument will be capable of spatially monitoring an entire sequestration site that is at least 1 km by 1 km in area and be capable of quantitatively locating seepage on the surface. Secondly, novel seismic and acoustic imaging analyses will be performed both as a means to non-invasively perform subsurface geologic characterization, as well as locate the CO₂ plume and determine any structural (caprock fracture) or chemical (mineralization or precipitation) changes to the storage reservoir. The remote and non-invasive seismic monitoring techniques developed under this task will play a critical role in safe, effective, and long-term geologic sequestration.
- **Systems Model Development & Science of Geologic CO₂ Sequestration:** Effective deployment of CCS requires understanding the connections between a variety of coupled sub-systems, including CO₂ sources (power plants or industrial sources), CO₂ transportation vehicles (pipelines), and storage reservoirs. Systems-level models can be applied to integrate these sub-systems. In order to develop these analytical models, it is necessary to understand and characterize fundamental physical and chemical processes affecting these sub-systems through numerical simulations, laboratory experiments, or field observations from both analog sites as well as demonstration projects. This project task is being used to develop the first-ever integrated systems modeling capability that can be used for performing simulations of an entire CCS operation, including CO₂ flow in shallow aquifers. The

capability will be primarily based on LANL's CO₂-PENS model and will lead to enhancements of the CO₂ source and transportation sub-modules. The overall focus of this project task is to develop an inclusive systems modeling capability that can be used to perform systems level calculations for feasibility of deployment in an integrated CCS operation.

- **National Risk Assessment Program (NARP) Collaborative Research:** Since large-scale CCS is yet to be widely deployed at full commercial scale, approaches and methods for assessing long-term risks are still being developed and their application to field projects has been limited. Developing a comprehensive approach to assess the long-term risks and feasibility of large-scale geologic sequestration is a priority not only for DOE's sequestration research program but for the nation's overall energy strategy. This effort is a collaborative research project between five national labs, including Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, and Pacific Northwest National Laboratory. Safe and effective CCS technology plays a vital role in fossil-fuel utilization and must be fully understood. Assessing the potential risks associated with long-term CO₂ storage calls for the development and application of a comprehensive approach that can be used to inform the overall decision making and project planning process.
- **Carbon Dioxide Separation Using Thermally Optimized Membranes:** This task is focused on developing thermally, chemically, and mechanically stable polymeric-metallic composite membranes that can provide effective pre-combustion CO₂ capture under a broad range of conditions relevant to the power industry while meeting the Carbon Sequestration Program goals of 90 percent CO₂ capture at less than a 10 percent increase in the cost of energy services. Capturing carbon dioxide from mixed-gas streams is a first and critical step in carbon sequestration. To be technically and economically viable, a successful separation method must be applicable to industrially relevant gas streams at realistic temperatures and volumes. The effectiveness of existing technologies for separating CO₂ is limited. Successful synthesis gas separation using a polymer membrane requires a membrane that is thermally, chemically, and mechanically stable at high temperature and pressure.

The overall focus of the LANL research is to insure that geologic CO₂ storage is safe, effective, and will be a commercially viable solution for industrial use. This requires site specific studies which combine performance assessment of a storage site with an assessment of potential consequences of concern (e.g., environmental, health, economic). DOE's Office of Fossil Energy Carbon Sequestration Program

involves components ranging from applied laboratory research through pilot scale (the Core R&D Program) to Demonstration and Deployment (e.g., the Regional Carbon Sequestration Partnerships, international engagement and other commercial opportunities). For geologic sequestration technology to be cost effective and commercially viable, risk assessment methodologies must be developed, tested, and validated.

Goals/Objectives

The goal of this effort is to gain knowledge of key technologies and processes critical to the geologic sequestration of CO₂ through field investigations and supporting experimental and simulation studies at existing sequestration projects.

Project objectives are to:

- Understand CO₂ interaction with well cement and surrounding geologic structures, including reservoir seal formations
- Determine the mode of CO₂ interaction with cement by obtaining sidetrack cores from existing injection wells and producer wells

- Create surface CO₂ detection systems that can accurately detect CO₂ with high precision in varying environmental conditions
- Work with other national laboratories to perform collaborative and coordinated research to enhance the United States' capabilities to perform science-based risk assessment for geologic sequestration of CO₂
- Develop innovative polymeric-metallic composite membrane structures for carbon dioxide capture with enhanced gas separation properties, while maintaining the desirable chemical, mechanical, and thermal stability

Benefits

The applied research that LANL proposes is intended to enhance the process of geological sequestration using new instruments to monitor and detect any problems with the sequestration site. Benefits gained by this research are paramount to the success of CO₂ sequestration over the long term. This work is focused on investigating the necessary science that will lead towards large-scale deployment of geologic CO₂ sequestration technologies.

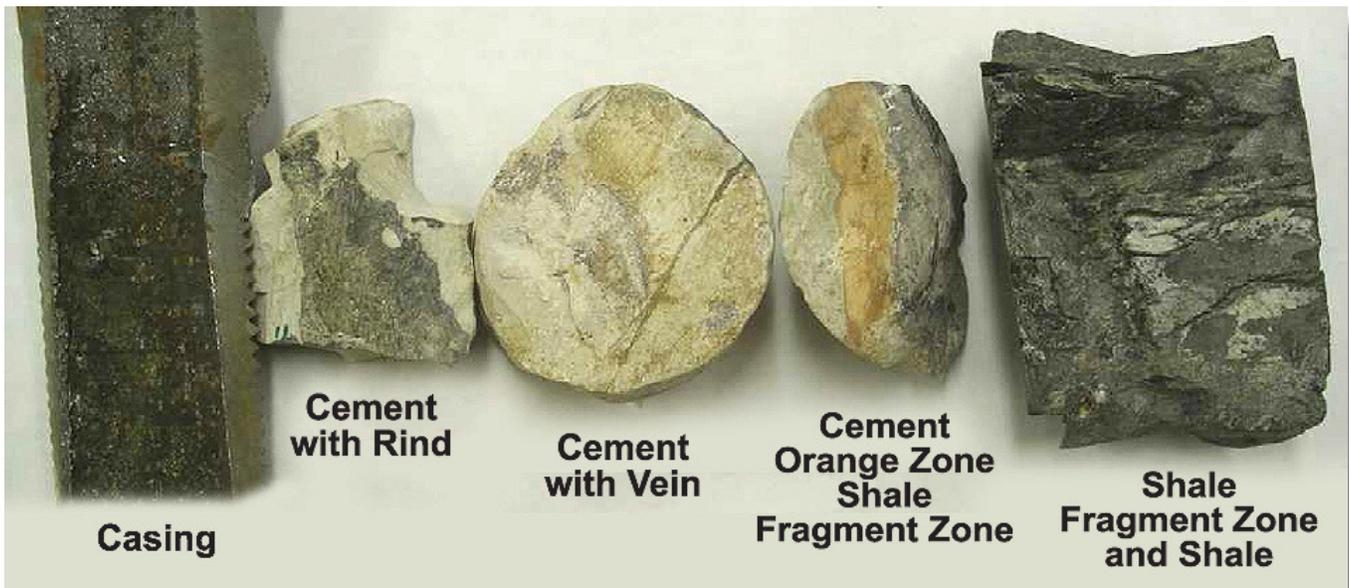


Figure 1: Samples recovered from West Texas SACROC Unit Well 49-6.

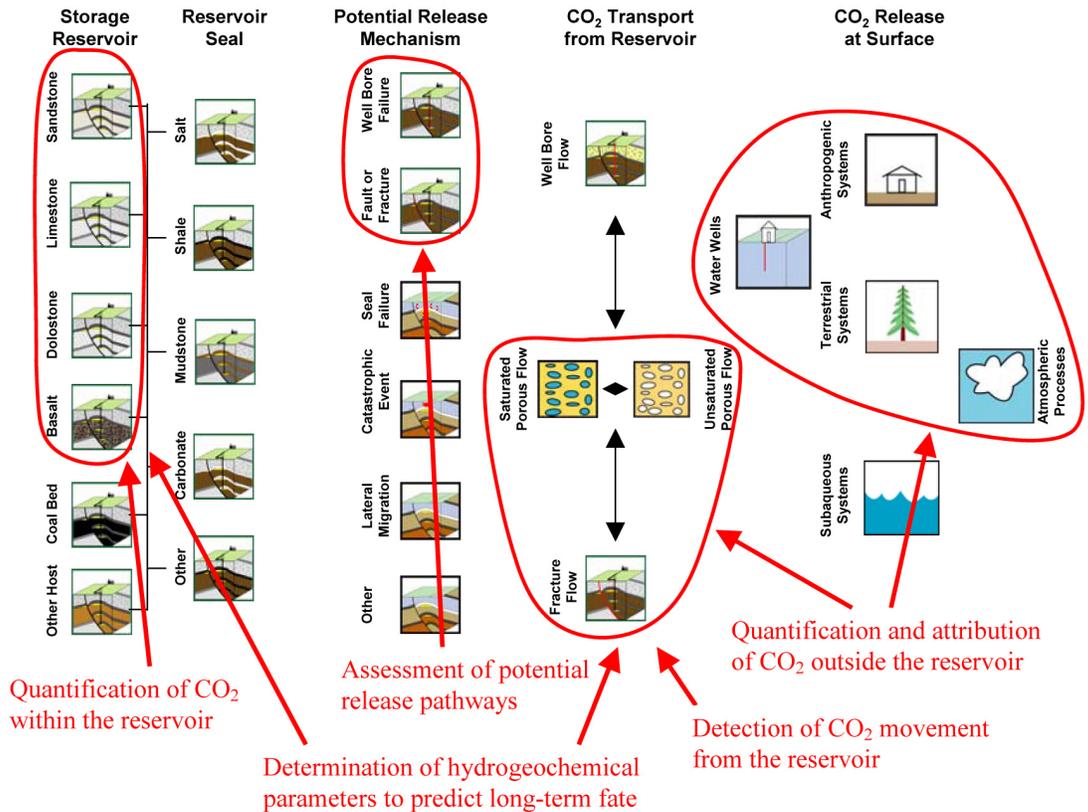


Figure 2: Schematic of CO₂-PENS Framework for understanding geologic storage systems and CO₂ release from these systems. Red circles and text indicate the objectives and target areas of this novel monitoring program and how these objectives can map into the DOE Carbon Sequestration Roadmap.

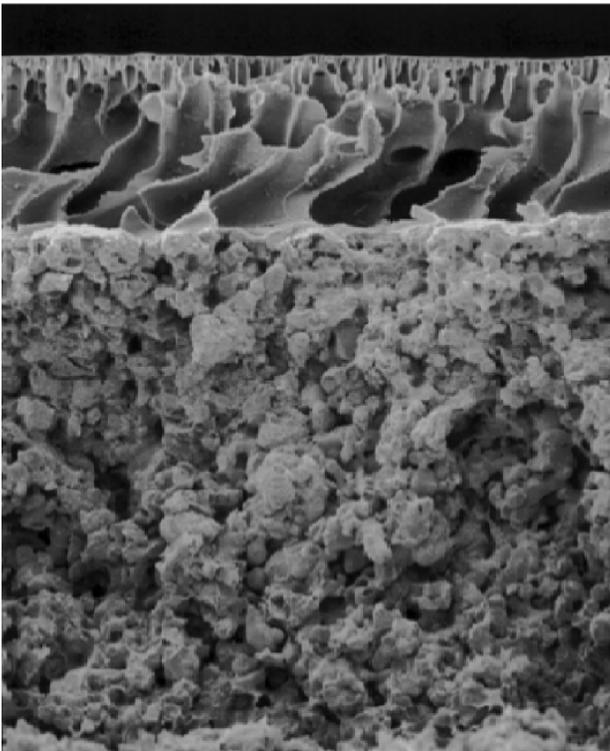


Figure 3: Scanning electron microscopy image of a poly-benzimidazole (PBI) based polymeric-metallic composite membrane cross-section. PBI membranes will be enhanced under this LANL effort to achieve high selectivity, permeability, chemical stability, and mechanical stability at elevated temperatures (> 150 °C).

COST

Total Project Value

\$9,813,001

DOE/Non-DOE Share

\$9,813,001/ \$0

PARTNERS

Colorado School of Mines
 Lawrence Berkeley National Laboratory
 Lawrence Livermore National Laboratory
 Pacific Northwest National Laboratory

