cement used in well structures and the natural shale or clay structure because of the importance of achieving an adequate seal to contain the CO_2 plume. The migration and interaction of CO_2 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 CO_2 and reduce overall well integrity. The performance and reliability of a geologic CO_2 sequestration site is critically dependent on the integrity of the hydrodynamic seals to prevent migration of buoyant CO_2 plumes.

- **Development and Deployment of Monitoring, Verification, and Accounting (MVA) Tools:** This research will be used to develop monitoring tools to quantify CO_2 within and in the unlikely event of leakage from geologic storage reservoirs. The research aims to target the CO_2 storage reservoir and the soil surface to advance MVA tools to better assess the potential impacts of CO_2 leakage from a reservoir. The primary research focus is to address specific monitoring challenges including quantifying and attributing stored CO_2 within and outside the reservoir, detecting CO_2 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 CO_2 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 CO_2 Sequestration:** Effective deployment of CCS requires understanding the connections between a variety of coupled sub-systems, including CO_2 sources (power plants or industrial sources), CO_2 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 CO_2 flow in shallow aquifers. The capability will be primarily based on LANL's CO_2-PENS model and will lead to enhancements of the CO_2 source and transportation sub-modules. The overall focus of this project task it 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 CO_2 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 precombustion CO_2 capture under a broad range of conditions relevant to the power industry while meeting the Carbon Sequestration Program goals of 90 percent CO_2 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 CO_2 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 CO_2 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 CO_2 through field investigations and supporting experimental and simulation studies at existing sequestration projects.

Project objectives are to:

- Understand CO_2 interaction with well cement and surrounding geologic structures, including reservoir seal formations
- Determine the mode of CO_2 interaction with cement by obtaining sidetrack cores from existing injection wells and producer wells
- Create surface CO_2 detection systems that can accurately detect CO_2 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 CO_2
- 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 CO_2 sequestration over the long term. This work is focused on investigating the necessary science that will lead towards large-scale deployment of geologic CO_2 sequestration technologies.

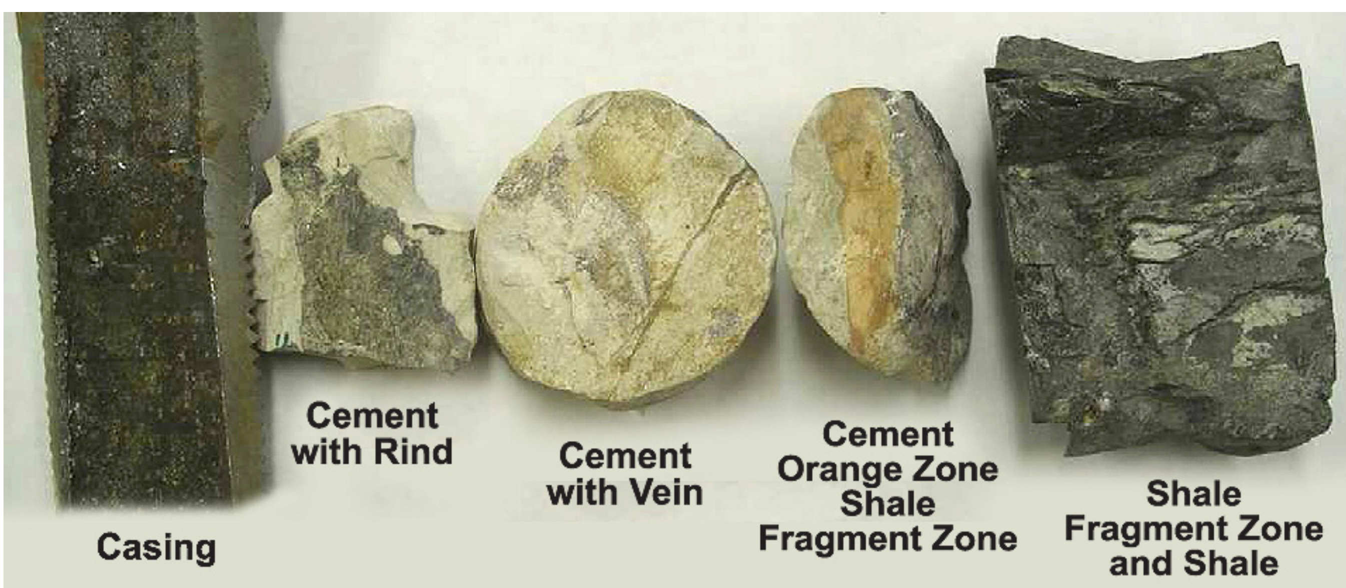

Figure 1: Samples recovered from West Texas SACROC Unit Well 49-6.

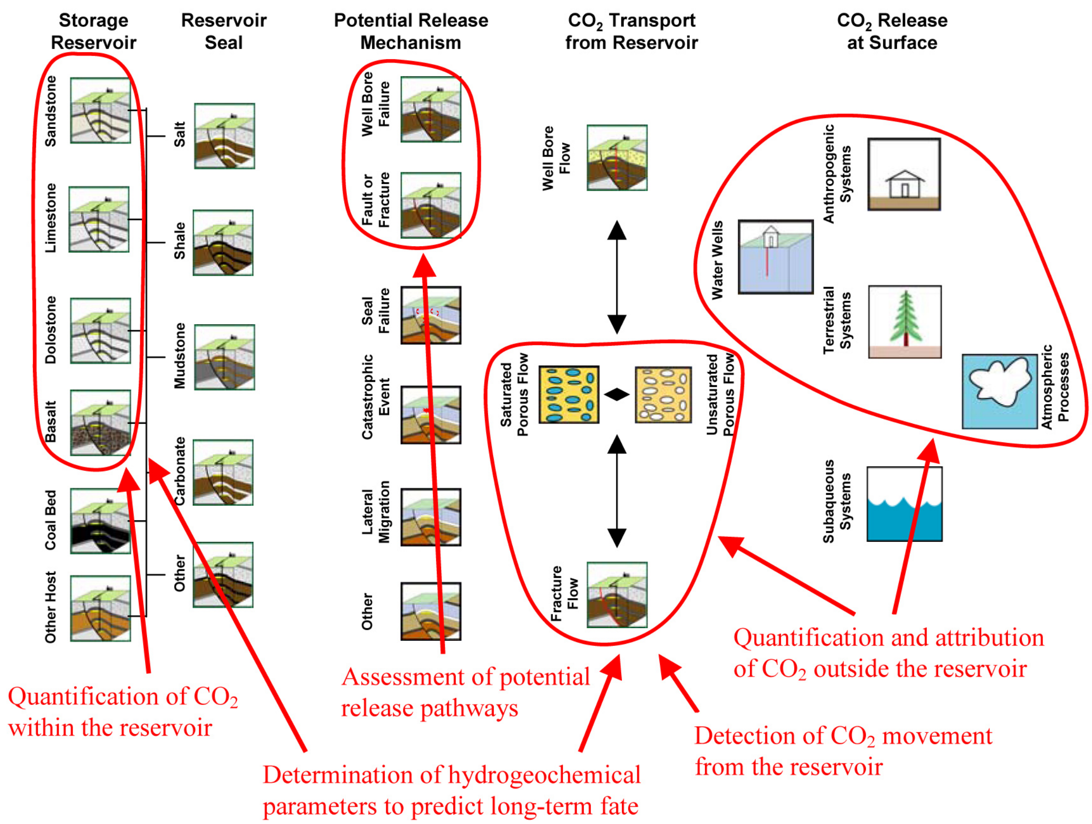

Figure 2: Schematic of CO_2-PENS Framework for understanding geologic storage systems and CO_2 release from these systems. Red circles and text indicate the objectives and target areas of this novel monitoring program and how these objectives can map into the DOE Carbon Sequestration Roadmap.

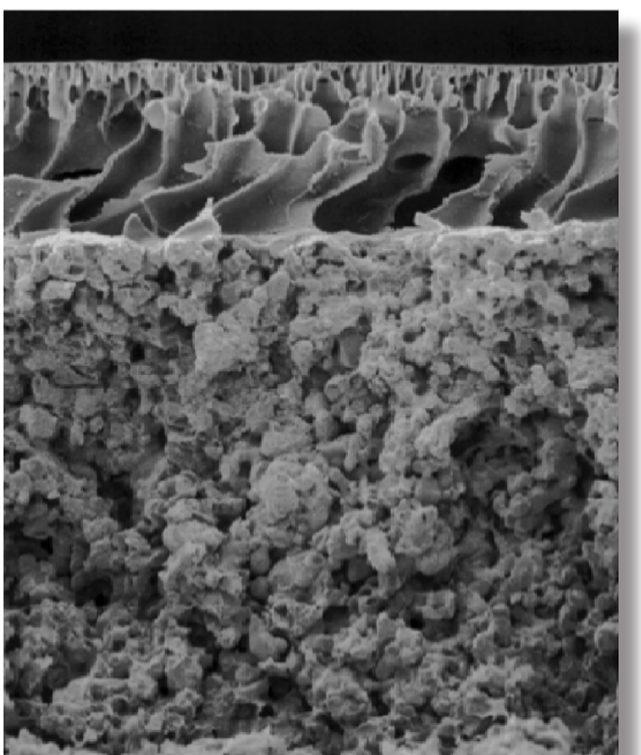

Figure 3: Scanning electron microscopy image of a poly-benzimidazole (PBI) based polymeric-metallic composite membrane cross-section. PBI membranes will be enhanced under this LANL e ort to achieve high selectivity, permeability, chemical stability, and mechanical stability at elevated temperatures (>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