the ENERGY lab

R & D FACTS

Carbon Storage

Carbon Storage Research

Carbon capture and storage (CCS) is a key component of the U.S. carbon management portfolio. Numerous studies have shown that CCS can account for up to 55 percent of the emission reductions needed to stabilize and ultimately reduce atmospheric concentrations of CO_2.

The National Energy Technology Laboratory's (NETL) Carbon Storage Program is preparing CCS technologies for widespread laboratory deployment by 2020. The program goals are to:

- Support industries' ability to predict CO_2 storage capacity in geologic formations to within ±30%;
- Demonstrate that 99% of injected CO_2 remains in the injection zones;
- Improve reservoir storage efficiency while ensuring containment effectiveness;
- Support the Department of Energy's (DOE) crossfunctional SubTER technical team in developing laboratory- and bench-scale technologies for identifying and obtaining new subsurface signals, ensuring wellbore integrity, and increasing understanding of stress state and induced seismicity.

Parallel, vertical, orthogonal natural fracture faces (joint sets) in an outcrop of organic-rich Millboro Shale Marcellus equivalent), Clover Creek, VA.

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U.S. DEPARTMENT OF ENERGY

Core R&D Under NETL's Carbon Storage Program

The NETL Office of Research and Development (ORD) provides DOE's Carbon Storage Program with an onsite laboratory to conduct fundamental and applied Research and Development (R&D). This research plan supports DOE Core R&D goals of developing and advancing the CCS technologies necessary for widespread commercial deployment.

Technology Specific Goals and Priorities: Core R&D research will encompass three technical focus areas for CCS technology and protocol development:

- **Geologic Storage Technologies, Simulation, and Risk Assessment:** Understanding the behavior of CO_2 when stored in geologic formations to create and refine capacity estimation methodologies and to determine the geochemical and geomechanical impacts on capacity, injectivity, and storage permanence.
- **Monitoring, Verification, Accounting, (MVA) and Assessment:** Developing reliable and cost-effective monitoring, verification and accounting (MVA) techniques to track CO_2, brine, and pressure plume migration in the deep subsurface, into groundwater aquifers and to the atmosphere.
- **Carbon Use and Reuse:** Developing CO_2 Utilization technologies to convert CO_2 into industrial chemicals.

Pierre Shale core recovered at the surface in South Dakota.

Research

Technical Objectives and Approaches: Carbon Storage research objectives and approaches have been identified through detailed program reviews, systems analyses, review of emerging technologies, R&D activity, and discussions with stakeholders at all levels. This diverse research plan includes laboratory experimentation, field work, and geospatial modeling.

- Energy Data eXchange/National Carbon Sequestration Database and Geographic Information System (NATCARB) Geospatial Resources: Develop and maintain geospatial platforms that support research and assessment and facilitate the preservation and transfer of data DOE-wide.
- Resource Assessments: Refine, develop, and evaluate a suite of methodologies to quantitatively assess storage resource potential in onshore and offshore reservoirs including saline formations, oil and gas reservoirs, coal seams, and organic-rich shales. Method updates will be based on key parameters for high priority depositional environments targeted for CO_2 storage measured by Reservoir Performance. Development and reviews of methods will be coordinated with the Regional Carbon Sequestration Partnerships (RCSPs) and experts in the carbon storage field.
- Reservoir Performance: Improve assessments of CO_2 storage for key reservoir classes through experimental measurements of critical properties at in situ conditions and characterizing critical property changes as CO_2 interacts with the reservoirs using unique imaging and core flow capabilities and modeling programs. Work will be focused on measuring relative permeability, residual saturation, and wettability for high priority depositional environments targeted for CO_2 storage.
- Shales as Seals and Unconventional Reservoirs: Improve characterization of shales as seals for CO_2 containment and shales as reservoirs for geologic storage of CO_2.
- Wellbore Integrity and Mitigation: Evaluate the geochemical and geomechanical impact of CO_2 interaction with foamed cement to provide guidance on wellbore security in offshore and onshore storage environments, explore the risk associated with uncertainty and failure of wellbore materials and validate parameters for risk assessments for cement use.
- SubTER: Engage with the goals of the SubTER crosscut to develop capabilities and methods to monitor subsurface permeability and reactive fluid flow dynamics with sufficient spatiotemporal resolution to facilitate adaptive operations in relation to subsurface energy systems. NETL is currently leading a Big Data Project and collaborating on two Cement Projects, a Borehole Stress Project, and a Bayesloc Project.
- Monitoring Team / Migration of CO_2/Brine Plumes and Groundwater Impacts: Evaluate by forward models low-cost, next generation, routine surveillance methods to detect lateral and vertical migration of CO_2/brine plumes for: 1) locating the CO_2/brine interface in storage formations, and 2) surveilling drinking water aquifers to detect possible CO_2/brine incursions. Develop and demonstrate a suite of protocols and tools for geochemically-based monitoring strategies for groundwater systems. Characterize statistically the natural groundwater variability in CO_2 storage systems.

- Field Activities: Expand field testing through collaboration with regional partnerships and other field demonstration projects to validate tools and techniques developed for tracking the CO_2/brine interface and monitoring groundwater of geochemical relevance as they relates to geologic carbon sequestration. Continue to provide analytical support for the SW Partnership Farnsworth Field project to detect perfluorocarbons (PFC) tracers co-injected with the CO_2 and other potential projects requesting support.

- Catalytic Conversion of CO_2 to Industrial Chemicals and Evaluation of CO_2 Use and Re-Use Strategies: Explore and develop research on new catalyst technologies for converting CO_2 into a feedstock for chemicals that can be sold to offset capture costs, reduce demand for petrochemical-based feedstocks, promote green products, and develop new markets and job opportunities while leveraging and complementing Program funded external research. Provide a basis and verification of how new materials translate to technology by undergoing "Cost and Performance Metrics Used to Assess Carbon Utilization and Storage Technologies" provided by the Office of Program Planning and Analysis.

ORD Objectives and Expected Benefits Under Core R&D

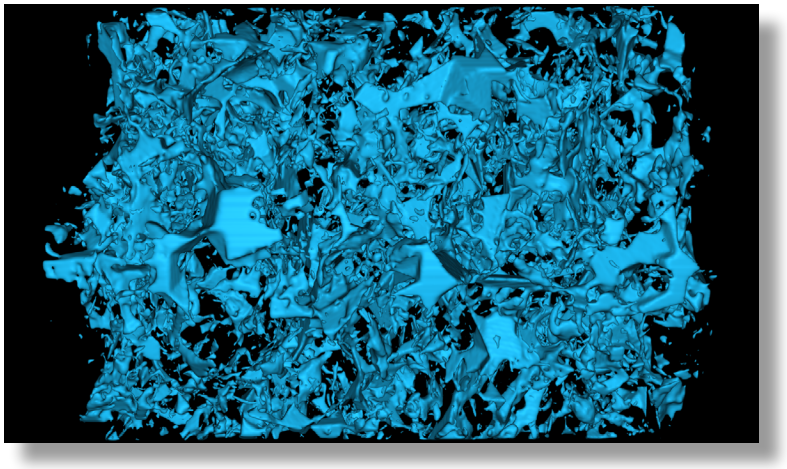
Research being conducted by ORD will enable the development of technologies that will significantly improve the safety and permanence of geologic CO_2 storage.

Objectives include:

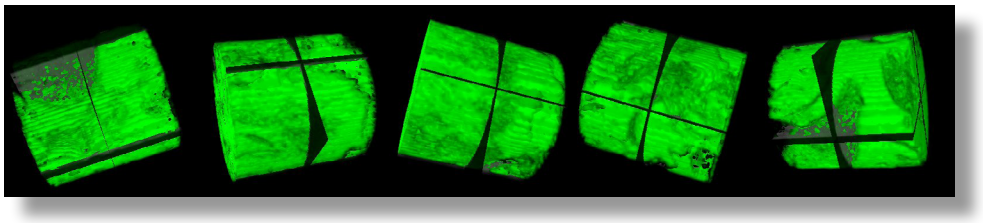
- Geologic Storage Technologies, Simulation, and Risk Assessment: Geologic Storage research will refine methods for capacity estimation, geospatial data management, and determine geochemical and geomechanical impacts on capacity, injectivity, wellbore security, and storage permanence.

- Monitoring, Verification, Accounting, (MVA) and Assessment: MVA technologies and techniques will be developed to track CO_2, brine, and pressure plume migration in the deep subsurface, into groundwater aquifers and to the atmosphere.

- Carbon Use and Reuse: CO_2 Utilization will focus on developing technology to convert CO_2 into industrial chemicals.



X-ray CT image of Mt. Simon pore space.



3D Computed Tomography (CT) rendering of CO_2 (green) displacement through a heterogeneous reservoir rock.

Expected benefits include:

- Geologic Storage Technologies and Simulation and Risk Assessment:

Outcomes: (1) improved techniques for characterizing reservoirs (including shales) and seals with respect to reservoir performance; (2) improved models for injection into fractured media, including associated storage and natural gas production; (3) public database of key reservoir properties in the presence of CO_2; (4) defendable DOE prospective CO_2 resource methods for onshore and offshore reservoirs; (5) data mining techniques to understand induced seismicity; (6) national geospatial platform that supports research and assessments and that facilitates preservation and transfer of data; (7) provide guidance on wellbore security in offshore storage environments; and (8) support the crossfunctional SubTER technical team.

Impacts: Improve the science base needed to lower uncertainties in quantitative prediction of long-term containment of CO_2.

- Monitoring, Verification, Accounting (MVA), and Assessment:

Outcomes: (1) MVA tools and protocols to track CO_2, brine, and pressure plume migration in the deep subsurface, into groundwater aquifers, and to the atmosphere, including statistical database for natural groundwater system; and (2) support the department's crossfunctional SubTER technical team.

Impacts: Compliance with the Environmental Protection Agency (EPA) goal of zero impact to groundwater systems and verifying the storage goal of 99% permanence.

- Carbon Use and Reuse:

Outcomes: Effective conversion of CO_2 into valuable chemicals.

Impacts: Technologies that offset capture costs, reduce demand for petrochemical-based feedstocks, promote green products, and develop new markets and job opportunities.