the ENERGY lab

R & D FACTS

Geological & Environmental Systems

NETL-ORD Geoimaging Characterization
NETL's Computed Tomography (CT) Scanners

Background

Traditional petrographic and core-evaluation techniques evaluate the properties of core samples to determine how they contribute to the fluid flow characteristics and structural integrity of the rock. Often this type of evaluation includes sectioning of the core in a destructive fashion and capturing the details of the internal structure of the rock samples. NETL has three Computed Tomography (CT) scanners and a mobile core logging unit that work together to provide characteristic geologic and geophysical information at different scales non-destructively: the core logger measures field properties, the medical CT scanner can discern bulk density variations, the industrial CT scanner can identify pore networks, and the micro CT scanner analyzes pore surfaces. The internal structure of rock cores can be non-destructively characterized to obtain porosity, fracture apertures, subsequent permeability, overall structure and material makeup, yielding both field relevant parameters and micropore statistics.

Description

NETL's **mobile core logging unit** measures the physical properties of geologic materials that are comparable to field observations. The NETL logger is able to rapidly obtain high-resolution data including p-wave velocity, gamma-density, natural gamma, resistivity, magnetic susceptibility, and X-ray fluorescence from whole-round and split core samples. These measurements assist in understanding characteristics of rocks and sediment that are meaningful for geologic, fluid flow, and physical analysis purposes. For example the core logging unit can help determine the chemical makeup as well as the structural competency of a core sample to help determine the suitability of a formation for hydrocarbon extraction and/or CO_2 injection.

Mobile Core Logging Unit

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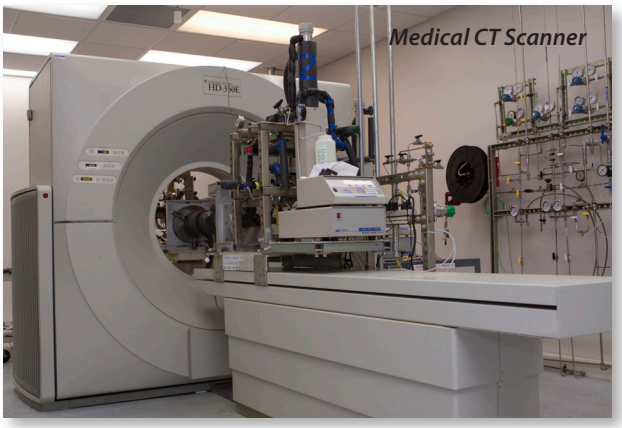
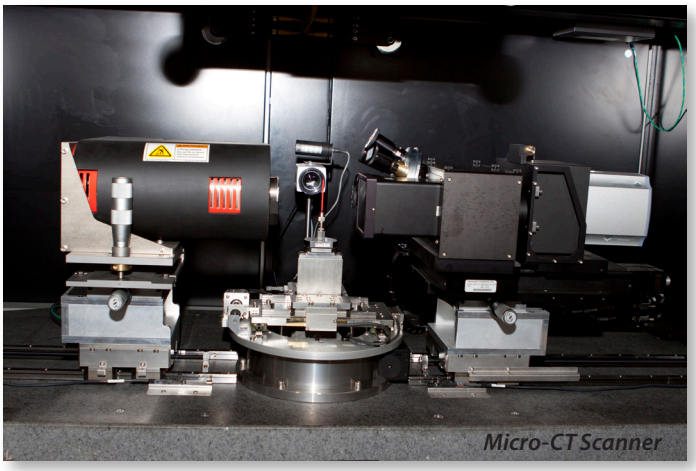
The **medical CT scanner** is being used for fluid flooding evaluations and observations of sub-core bulk properties. This machine has the lowest resolution of the three scanners, limited to 250 micron X 250 microns X 1000 microns. However, the speed and throughput allows for larger core samples to be non-destructively scanned in a relatively short period of time. This scanner is also outfitted with Hassler-style core holders and a flow apparatus that allows for in-situ pressures and temperatures to be applied to the samples for flow and saturation experiments during scanning. When compared to the other CT scanners the medical unit is able to provide full core scans within a few seconds whereas the same operation may take hours or days to provide higher resolution scans. This allows for researchers to quickly visualize and analyze both physical and chemical changes in the core sample, when collecting effluent.


Medical CT Scanner

The **industrial CT scanner** provides a balance between the micro-CT and the medical CT scanners. It offers pore scale resolution for smaller samples, but can also observe in-situ pressure controls and flow ability of large or irregularly shaped samples. This facility provides insight into various rock properties with scan resolutions greater than 20 microns. The industrial scanner can provide nondestructive reconstructions with or without a pressurized and temperature controlled core holder. When utilizing the core holder units, CT scans can be taken of the samples at reservoir conditions before, during, and after flooding and flow experiments to quantify physical and chemical changes, when collecting effluent.


Industrial CT Scanner

The **micro-CT scanner** operates at the highest resolution and captures high-contrast images within samples ranging from the size of a grain of sand up to 50 mm. This type of analysis provides resolution at the single micron scale and has been primarily used to provide detailed porosity, structural, and mineralogic compositional data on small cores and core cuttings of sandstone, limestone, volcanic rock, shale, coal, and cement. This unit is intended to take very small samples from a geologic sample and provide very high resolution data of the geometry and structure with the trade-off multiday scans.


Micro-CT Scanner

Goal and Objectives:

The core logging unit and CT scanners test results are used to identify key characteristics of rock formations. These systems have broadened observation capabilities over a range of scales. More specifically, these devices may be used to:

- Characterize a wide range of formations and compare/ contrast the relevant flow properties within geologic samples.
- Obtain data that will assist in computer simulation efforts such as, simulation of CO_2 sequestration in brine-saturated sandstone formations.
- Examine the fundamental physics of how fluid flow in porous geologic media occurs.
- Use the data to assist computer simulations of CO_2 injection and the development of coal-swelling models for realistic evaluation of technical and economic feasibility of CO_2 sequestration in coal seams.
- Open the CT scanners' and core logging unit's capabilities to many types of research applications.
- Expose students and the research community to the technologies' potentials. and near-surface monitoring technologies through verify storage permanence and track plume movement.

Capabilities

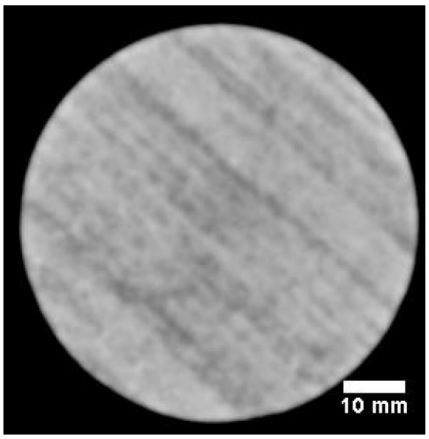
The addition of these technologies has allowed NETL's Morgantown, WV, and Pittsburgh, PA, laboratories access to more comprehensive evaluations of cores and extensive characterization of a variety of geomaterials, including sandstones, limestones, carbonates, coals, and gas shales. These capabilities also permit complex processes, such as oil recovery and CO_2 storage, to be examined in actual core samples at in-situ conditions. This allows for researchers to study in detail the changes within a geologic sample and/or a fluid that can occur during complex operations. This information can lead to better techniques to improve the efficiencies of these processes in the future.

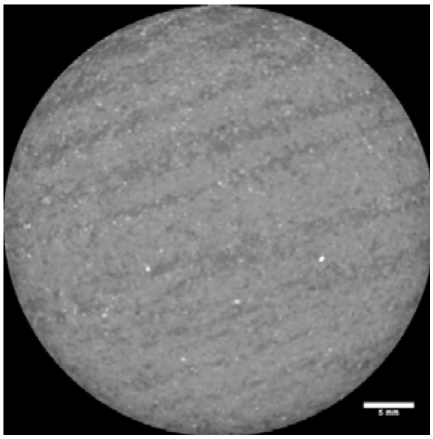
Benefits:

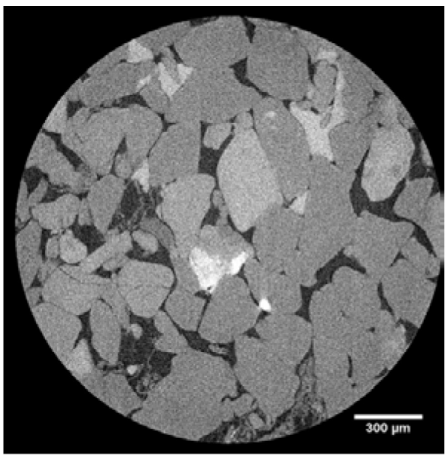
Researchers can evaluate reservoir cores at in-situ confining pressures while simultaneously observing changes in pore fluids, bulk material densities, and the structure of the rock matrix. This information is essential to realistic numeric simulations, economic evaluations, and field character-ization efforts. By having more detailed information available for numerical simulations, economic evaluations, and characterization the overall outcomes of these endeavours will be more accurate and precise and provide a greater deal of certainty for policy makers.

NETL is able to identify parameters associated with relevant properties of storage formations such as those identified in the 2010 Carbon Sequestration Atlas. Estimating the storage potential within porous and permeable lithologic units required to store CO_2 will be useful in controlling greenhouse gases.

Carbon sequestration, enhanced oil recovery, geothermal energy extraction, shale gas development, and other real world field developments are just a few of the processes that can benefit from core evaluations. Capabilities can also be applied to a variety of research areas looking to analyze characterization, hydrate formation, and fluid progression on a micro-scale.







Dry sample scans of a sandstone core provided by the medical, industrial, and micro-CT scanners.

Accomplishments:

Successes include evaluating coal interactions with CO_2 at varying pressures; observing viscous fingering in high-permeability strata as well as core anomalies that can be discerned in-situ while testing is progressing; obtaining real-time images of CO_2 injection in a sandstone core initially saturated with brine; and observing the dissolution of fractured surfaces due to interaction with CO_2 saturated brine.

NETL works with regional partners to characterize regional pilot plans and sequestration activities. The research results from these partnerships have the potential to limit dependence on foreign oil, extend the domestic oil supply, reduce oil costs, and further research on carbon sequestration and enhanced oil recovery techniques. These capabilities have generated research that stretches outside of the United States with carbon storage projects in Brazil and China.

For more information about evaluating geologic materials at NETL, please see our NETL-ORD Geomaterials Research Facilities fact sheet.