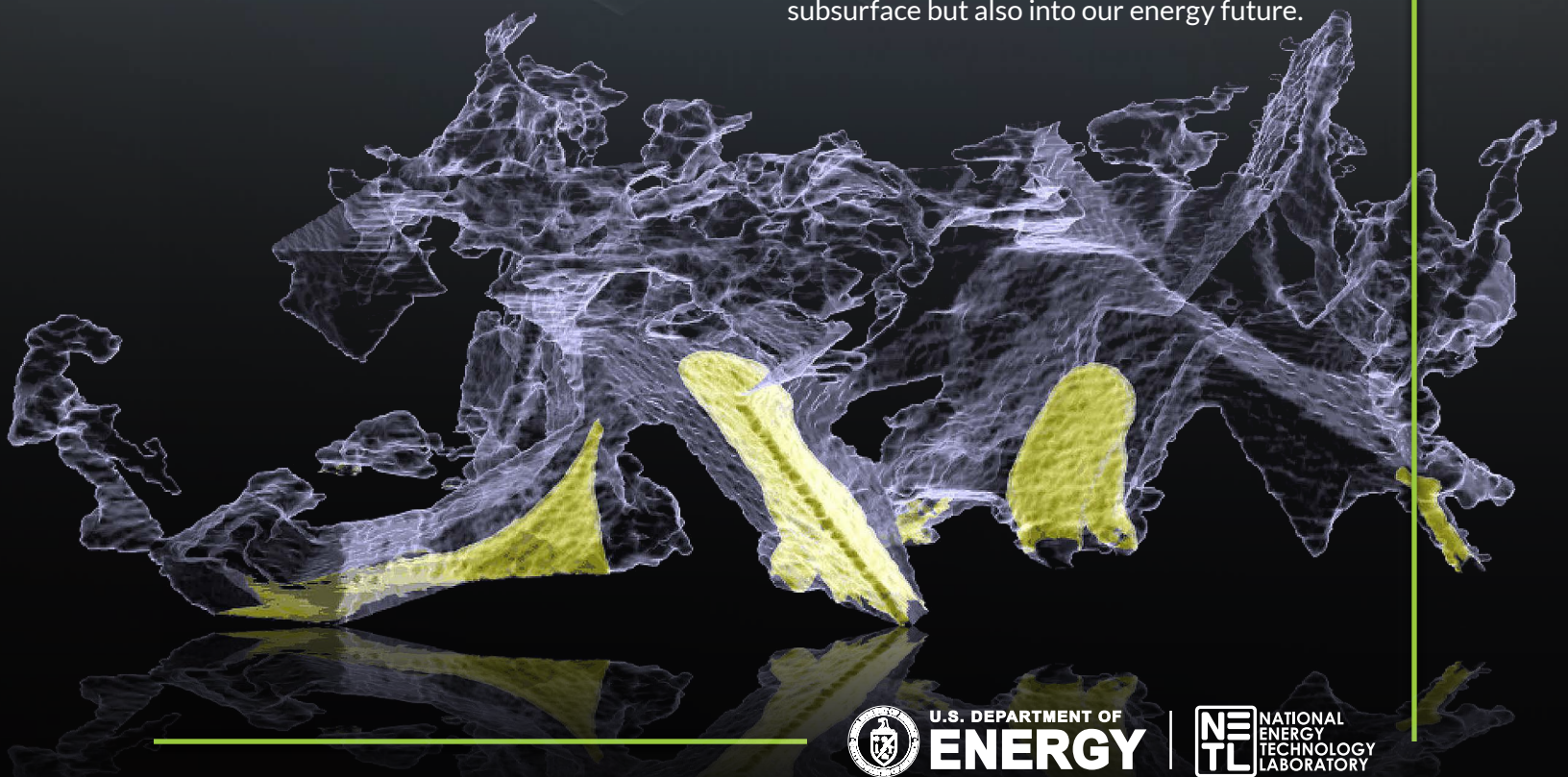
GEOLOGICAL & ENVIRONMENTAL SYSTEMS

Sustainable Production and Utilization of Domestic Energy Resources

The path to our energy security may take us underground—from rocky reservoirs where CO_2 can be stored, to new subterranean storehouses of fossil fuels that we are only now learning to access. At NETL's Center for Geological and Environmental Systems, researchers explore ways to use the Earth's subsurface to our advantage and in a way that is environmentally sustainable.

The insight NETL researchers provide contributes to improved methods for drilling offshore oil wells, locating a site for a hydraulic-fracturing well, and determining how much CO_2 can be injected into a storage site. Their work also optimizes how air, land, and water are monitored at drilling sites. With the laboratory equipment and computational models housed at NETL's facilities, researchers can peer not only into the subsurface but also into our energy future.



U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

GEOLOGICAL & ENVIRONMENTAL SYSTEMS

1

METHANE HYDRATE RESEARCH FACILITY

METHANE HYDRATE FOR STORING & TRANSPORTING METHANE GAS

Methane hydrate—molecules of natural gas trapped in an ice-like cage of water molecules—represents a potentially vast naturally-occurring methane resource for both the U.S. and the world. NETL's Methane Hydrate Laboratory has developed unique capabilities to synthesize and study hydrate cores in the laboratory, as well as obtain and study gas hydrate-bearing sediment core samples retrieved from naturally-occurring methane hydrate cores. NETL's pressure core analysis and X-ray computerized tomography visualization system (PAXS) is a unique toolset that allows NETL to obtain, transport, manipulate, and characterize hydrate-bearing core samples in situ, without disruption to desired temperature and pressure conditions while visualizing the pore space of sediments. The research goal is to understand the hydrate behavior under natural and gas production conditions, while modeling and predicting the reservoir responses resulting from gas production, as well as the impacts of natural disturbances on gas production potential and the environment.

2

GAIA COMPUTATIONAL FACILITIES

DATA SCIENCE FOR SUSTAINABLE ENGINEERED-GEOSYSTEMS RESEARCH

NETL scientists use the Geoscience Analysis, Interpretation, and Assessment (GAIA) Computational Facilities for collaborative research. The GAIA facilities allow geological and environmental sciences researchers to draw on common tools, data, and software in a coordinated environment that offers a shared resource for conducting computer-based analytical work. The labs share software and video connectivity for real-time collaboration and research. With the GAIA facility capabilities, researchers can visualize, interpret, analyze, and model geospatial data sets from the lab or the real world. The research conducted here helps ensure the safe and reliable use of our natural resources, development of new energy resources, and responsible stewardship of the environment. As an aid, NETL scientists also have access to JOULE - a supercomputer with a 5.63 PFLOP processing speed that ranks in the top 25 fastest supercomputers in the U.S.

3

SUBSURFACE PHENOMENA & PROCESSES LAB

CO_2 STORAGE STABILITY, SEAL INTEGRITY & DRILLING FLUID PERFORMANCE

In this lab, NETL researchers study subsurface geologic systems that are good candidates for CO_2 storage. The lab's facilities can simulate the conditions found 10,000 feet underground, which helps scientists understand how geologic formations will perform as long-term carbon storage sites. The lab is equipped with autoclaves that allow researchers to perform experiments under high temperatures and pressures. These autoclaves shed light on the reactivity of solutions, geochemistry of shale gas environments, response of microbes exposed to CO_2, and other topics. The laboratory also includes several flow-through systems that can simulate CO_2-enhanced oil recovery, CO_2-water-rock interaction of core samples under CO_2 storage conditions, and the interaction between drilling fluids and the borehole wall.

4

BIOGEOCHEMISTRY & WATER LAB

SUSTAINABLE SHALE GAS DEVELOPMENT

The treatment and disposal (or reuse) of produced water is an important aspect of hydraulically fractured shale reservoirs. Solid wastes, such as drill cuttings and water treatment residues, need to be disposed of appropriately to avoid environmental issues. Well integrity issues (e.g. from interactions between abandoned mine water and wellbore cement or inadequate construction of new wells) can lead to leakage pathways in the casing-cement-rock system that may impact groundwater chemistry. NETL is performing laboratory experiments to evaluate the potential for contaminant release from solid wastes under different environmental scenarios, the effects of subsurface conditions on wellbore integrity, and the evolution of groundwater chemistry during oil and gas development. NETL is also developing rapid sample processing and analytical chemistry tools for natural geochemical tracers that can be used to identify the sources of fluids and gases in complex geologic systems undergoing energy development. The suite of analytical tools available includes standard water chemistry analysis (such as inductively coupled plasma optical emission mass spectrometry and ion chromatography), multicollector-inductively coupled plasma mass spectrometry for metal isotope analysis, and voltammetry-based techniques for detecting redox-active species.

5

GEOLOGICAL SCIENCES LAB

GEOMATERIAL CHARACTERIZATION

Traditional petrographic and core evaluation techniques typically aim to determine the mineral makeup and internal structure of rock cores to analyze properties influencing fluid flow. Often this type of evaluation is destructive—physically sectioning the core to view internal composition details. The Center for Advanced Imaging and Characterization provides an alternative to these traditional methods. The lab hosts three computerized tomography (CT) X-ray scanners—with imaging capabilities from millimeters to microns—that enable characterization of the internal structure of rock cores. Supporting flow-through instrumentation enables direct measurement of fluid/rock interactions at representative subsurface pressures and temperatures within the CT scanners. These technologies work in tandem to provide characteristic geologic and geophysical information of real materials at real conditions.

6

AIR MONITORING FACILITY

OIL & GAS IMPACTS ON AIR QUALITY

NETL scientists are working to improve their understanding of oil and gas development on air quality. Their goal is to keep the environment protected while ensuring an adequate domestic supply of natural resources. NETL researchers use their mobile air monitoring laboratory to measure air concentrations of pollutants emitted from oil and gas production activities. The data is used in atmospheric chemistry and transport models to understand local and regional air quality impacts. Airborne geophysical surveys are used to locate unregistered oil and gas wells that may be unplugged. Emissions from these unplugged wells may pose a threat to nearby communities.

AIRBORNE SURVEYS

Similarly, airborne geophysical surveys are helpful to quickly and accurately map metallic infrastructure associated with oil and gas production. In some cases, this infrastructure can provide pathways for hydrocarbons to infiltrate into underground drinking water aquifers as well as into the air.

SEISMIC MONITORING

Passive seismic monitoring performed during oil and gas well stimulation is used to determine the extent of fracture growth and to study the potential link between hydraulic fracturing and seismicity.

7

SUBSURFACE EXPERIMENTAL LAB

STUDYING WELLBORE INTEGRITY AND ENHANCING THE SUCCESS OF CARBON STORAGE TECHNOLOGIES

Using pressure vessels that simulate the conditions found deep underground, this lab provides researchers a way to evaluate how subsurface formations will perform as carbon storage sites. Studies in this laboratory focus on the impact of multiphase flow, chemical precipitation and dissolution, along with geomechanical stress on flow properties. The equipment in this lab makes it possible to accurately characterize geologic formations and predict how CO_2 will behave after underground injection. This knowledge helps scientists determine the rate at which CO_2 can be injected into a formation, how much the formation can hold, how long it can remain contained, an ultimately lower the uncertainty in long term containment of CO_2.

To improve safety and reduce risks of wellbore integrity, NETL research has been at the forefront of assessing the quality and reliability of the cement related to offshore drilling, shale gas production, and carbon storage. A thorough scientific understanding of wellbore materials is needed to ensure safe construction and maintenance of all oil and gas wells. In this lab, wellbore cement research is conducted to determine its behavior under relevant downhole conditions. This includes simulating frequent stress loading and unloading as well as characterizing cement/fluid/rock/gas interactions under a wide range of subsurface conditions. This research is important to determine the chemical, mineral, microstructural, and mechanical changes within the reservoir, wellbore cement, and casing to evaluate long-term wellbore integrity and risk assessment. Specific examples of NETL wellbore research projects conducted in this laboratory include NETL's foamed cement project, which evaluates cements used in the offshore wells drilled in the Gulf of Mexico, and an investigation of how abandoned mine water reacts with wellbore cement in shale gas wells that are drilled through abandoned flooded mines. Research performed in this lab is also leading to industry standard calculations of cement characteristics and properties.

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- Gas Hydrate Synthesis Lab – *Morgantown*
- Subsurface Phenomena & Processes Lab – *Albany*
- Center for Advanced Imaging & Characterization – *Morgantown*
- GAIA Computational Facilities – *Albany*
- Biogeochemistry & Water Lab – *Pittsburgh*
- Oil & Gas Field Monitoring Facilities – *Pittsburgh*
- Subsurface Experimental Lab – *Pittsburgh*

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Program staff are also located in Houston, TX and Anchorage, AK

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