GEOMICROBIOLOGY RESEARCH

INTRODUCTION

NETL continues our ongoing research in geomicrobiology to characterize microbial communities and relevant microbial processes in environments related to energy production.

Microbial processes affect oil and gas reservoir properties such as porosity, permeability, pH, and interstitial fluid chemistry. Characterization of dominant microbial communities and respective microbial processes will help researchers optimize oil and gas production, carbon storage, and waste management. Microbial processes also offer a likely option for alternative energy or enhanced energy recovery with less waste and reduced environmental impacts.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

COMPETENCY

Researchers rely on metagenomics—the study of genetic material obtained from environmental samples—to further understand how geomicrobiology impacts energy environments. However, critical metagenomic characterization of various environments related to energy production are not yet available. To determine the role microbiology will play in advancing energy technology, relevant samples must first undergo thorough microbial characterization.

Access to environmental samples related to energy production such as oil and gas fields, carbon storage reservoirs, fluid impoundments, and coalbed reservoirs is key to successful metagenomic analysis. Traditionally, these types of samples have been difficult to obtain. However, because NETL is the only U.S. DOE national laboratory devoted to fossil energy research, it has forged connections within the energy industry that can facilitate acquisition of relevant samples.

NETL key capabilities also ensure success in the characterization of microbial communities and their biological processes. These capabilities include:

- Anaerobic reactors and high-pressure, high-temperature reactor vessels to simulate subsurface conditions.
- Capabilities to cultivate microbial communities in strict anaerobic environments.
- 16S rRNA gene sequencing methods to investigate abundant microorganisms of various energy environments.
- Next generation sequencing capabilities to determine the functional potential of microbial communities in energy environments.
- Quantitative polymerase chain reaction (qPCR) to evaluate approximate microbial population in energy environments.
- Fluid Chemistry Laboratory and Material Characterization Laboratory to measure inorganic and organic constituents in formation fluids and solids.
- Bioinformatic capabilities that allow processing and detailed analysis of sequencing data.

RESEARCH PROJECTS

NETL has amassed a wealth of knowledge and operates with unique expertise in various energy processes and geomicrobiology. By combining and refining these tools, the Laboratory can fill knowledge gaps in the complex biogeochemical systems common in environments related to energy production. A better understanding of geomicrobiology will facilitate new technologies in a variety of energy fields. Ongoing research includes characterizing the microbial community in environments, such as:

- Future carbon storage reservoirs and CO_2 leakage analogues.
- Produced water and impoundment fluids in unconventional resource environments.
- Future microbially enhanced coalbed methane environments.
- Biocide-amended produced waters.
- Coal and gas reservoirs affected by acid mine drainage.

Research Partners

Leidos Research Support Team (LRST) | Carnegie Mellon University | Oak Ridge Institute for Science and Education (ORISE) | University of Pittsburgh | West Virginia University

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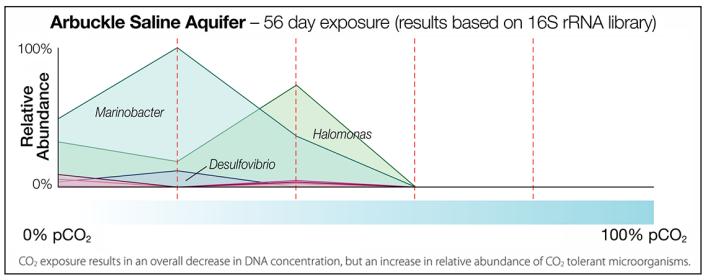
ACCOMPLISHMENTS

NETL is leveraging connections within the energy industry with its competency in metagenomics and geochemistry to create an unparalleled biogeochemical characterization of energy environments. The following represent recent accomplishments:

- 16S gene clone libraries and quantitative PCR were used to analyze the CO_2-driven microbial change in a carbon storage reservoir, an enhanced oil reservoir, and a CO_2 leakage scenario. Results suggest that CO_2-driven pH reduction causes a decrease in diversity.
- 16S high-throughput sequencing on samples from over 100 unconventional gas production wells demonstrated a microbial community dominated by selected microorganisms. Preliminary results suggest that biocide amendments impact the microbial community.
- Metagenomes from various subsurface energy environments have been evaluated for key carbon degradation pathways, carbon fixation pathways, and nutrient cycling pathways.
- Draft genomes with over 99 percent completion have been reconstructed from deep subsurface energy environments. These draft genomes allow a detailed look at key metabolic pathways of abundant subsurface microorganisms.
- Pan-genomic and pan-metagenomic analysis demonstrate core functional pathways and unique functional pathways amongst various energy environments. Results suggest functional similarity amongst communities within the same basin/reservoir compared to geographically separated systems with analogous conditions.

Geomicrobiology research at NETL is ongoing. The Laboratory anticipates further evolution of the characterization of microbial communities and biological processes, resulting in more effective oil and gas production, safer storage of CO_2, and more efficient management of waste.

This ultimately helps ensure the energy security of our nation for future generations



CO_2 exposure results in an overall decrease in DNA concentration, but an increase in relative abundance of CO_2 tolerant microorganisms.