METHANE HYDRATE
ONSITE RESEARCH FACILITIES

The pressure core cutting chamber, which is one component of the pressure core characterization and X-ray visualization tool (PCXT) being developed at NETL. This specialized cutter is designed to cut core samples while maintaining in-situ pressure conditions up to 4,500 psi.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

BACKGROUND

Methane hydrate represents a potentially vast natural gas resource for the U.S. and the world. Once thought to be rare in nature, we now know that methane hydrate deposits occur in great abundance in association with arctic permafrost and in sedimentary deposits found along continental shelves. Recent scientific research suggests that the gas hydrate abundance contains more organic carbon than all the world's coal, oil, and gas combined. One objective of the National Energy Technology Laboratory (NETL) is to develop the knowledge base and facilities to support the safe development of gas hydrate resources.

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INTRODUCTION

NETL's Methane Hydrate research team is working to build and maintain a world-class methane hydrate research laboratory. NETL's onsite facilities are designed to accommodate bench-scale experimental work on gas hydrate specimens collected with specialized pressure coring equipment and maintained at in situ subsurface pressures. Facilities under development include: (1) a multi-property characterization chamber (MPCC) and mini-MPCC for real-time sample observation with a micro- computed tomography (CT) scanner and (2) a multi-component pressure core characterization and X-ray tool (PCXT).

PROJECT GOAL

The goal of the Methane Hydrate project is to develop onsite research facilities that can be used for state-of-the-art laboratory testing on natural hydrate-bearing sediment samples preserved under elevated pressures and low temperatures. This goal is well aligned with the NETL objective to obtain high-quality experimental data on hydrate-bearing sediments that will help guide models and methods to accurately predict changes in the subsurface (permeability, strength) during gas production scenarios..

PROJECT OBJECTIVES

Project objectives include the following: (1) develop the MPCC and mini-MPCC for real-time sample observation with a micro-CT scanner; (2) development of a multicomponent PCXT; and (3) laboratory experimentation on natural hydrate bearing pressurized samples

PROJECT DESCRIPTION

This project is aimed at developing a suite of laboratory tools for experimental work on methane hydrate-bearing samples collected in the field and preserved under in-situ pressures. These tools include the MPCC, mini-MPCC, and PCXT. Together, these tools allow for core-scale and pore-scale analysis of geophysical, geomechanical, and hydrological properties of natural hydrate specimens, in pressurized chambers designed to maintain in-situ sample conditions.

NETL CAPABILITIES

MULTI-PROPERTY CHARACTERIZATION CHAMBER (MPCC) & MINI-MPCC

The MPCC is a core-scale analysis chamber used for testing and imaging of hydrate-bearing sediments. It is designed to perform geophysical, mechanical, and hydrological measurements on standard, 2.5-inch diameter core samples. The MPCC apparatus at NETL is capable of measuring sample permeability, saturation, acoustic velocities, and mechanical properties, including material strength, strain, and stiffness. NETL is also developing a mini-MPCC for pore-scale testing of hydrate-bearing sediments on a much finer scale. This instrument is designed for testing 0.25-inch diameter core specimens.

The MPCC and mini-MPCC are mounted on carts and can be moved to one of NETL's CT scanners for real-time imaging during experimental steps. The MPCC is designed to be compatible with NETL's industrial and medical CT scanners, which are capable of image resolution down to 30 µm. The mini-MPCC (Figure 1), compatible with NETL's µ-CT scanner, is capable of scanning and imaging processes occurring at the pore scale (image resolution ~1 µm).

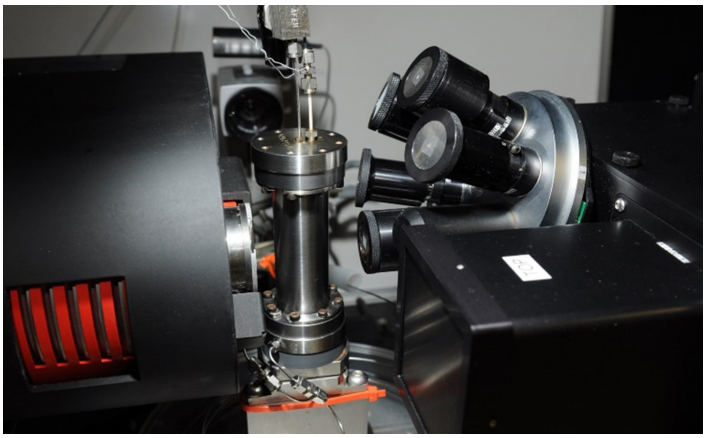

Figure 1: mini-MPCC mounted in the µ-CT scanner (yellow arrow)

PRESSURE CORE CHARACTERIZATION AND X-RAY TOOL

The PCXT is an advanced laboratory apparatus designed to retrieve, transfer, cut, sub-core, and characterize natural samples of hydrate-bearing sediments at PT conditions. Operation of the PCXT occurs in a temperature controlled cold room and using high-precision pumps to maintain pressure in the assembled unit. It is designed to be operated at NETL, using natural core delivered from sampling sites in pressurized transport chambers. The PCXT can also be deployed to the field for onsite testing of hydrate-bearing specimens during active drilling and coring activities.

Key components of the PCXT include a core manipulator (for temporary storage of core extracted from a transport chamber), core cutter (a chamber in which core specimens can be cut without losing pressure), sub-coring device (for cutting smaller core specimens from larger core samples), and multi-property testing chamber. The testing chamber is equipped to measure seismic wave velocity, geomechanical properties, and multi-directional permeability of hydrate-bearing samples. The PCXT also includes a CT-scanning chamber for high-resolution imaging of hydrate-bearing samples.

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JOINT ACOUSTIC VELOCITY MEASUREMENTS & μ-CT IMAGING

Combining high resolution μ-CT imaging with acoustic velocity measurements enables us to visually identify changes within the rock or pore space and tie those changes to the observed variations in acoustic velocities. This information can then be used to enhance and improve our models to better predict changes in the field. These combined measurements will expand our understanding of how the sediment behaves during methane production from hydrates. Utilization of this tool set is not just limited to hydrate research but can be applied to a variety of other research areas where core or pore space changes are of interest (etc. CO_2, H_2).

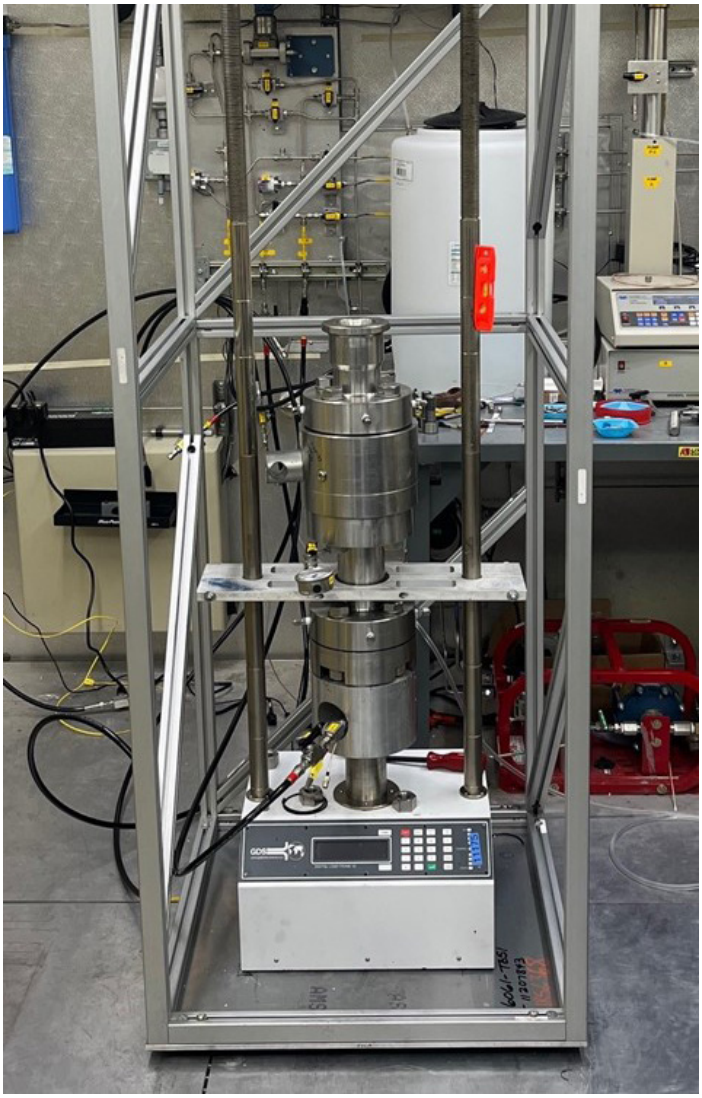

Figure 2: The effective stress chamber (ESC) is a critical component of the pressure characterization and X-ray tool. This chamber is used to measure acoustic, mechanical, and hydraulic properties of pressure core specimens while maintaining in-situ pressure and temperature conditions.

PROJECT BENEFITS

Research facilities developed by the NETL Methane Hydrate research team are designed to support experimental work that will lead to a better understanding of methane hydrate properties and pore-scale behavior. In addition, these facilities will help establish NETL as a world class laboratory for fundamental research on methane hydrate samples. The ability to conduct research at in situ pressure and temperature conditions is critical and will ultimately lead to more realistic scenarios for producing gas from hydrates, as well as better strategies for minimizing environmental impacts of naturally occurring hydrates.

ACCOMPLISHMENTS/SUCCESSES

The NETL Methane Hydrate research team completed the design and fabrication of the PCXT apparatus, including the core manipulator, core cutter, sub coring device, and multi-property testing chamber. Additionally, the design and functional shakedown for gas-fluid relative permeability test setup utilizing MPCC was completed. Current work includes analysis of recovered hydrate-bearing sediment from the Alaska North Slope and the Gulf of Mexico.

As a steward of our nation's natural resources, NETL is searching for new ways to improve materials and processes to mitigate the environmental impact of fossil fuel extraction as we work toward the further development of renewable energy resources.

NETL is a U.S. Department of Energy national laboratory that drives innovation and delivers technological solutions for an environmentally sustainable and prosperous energy future. By leveraging its world-class talent and research facilities, NETL is ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while developing technologies to manage carbon across the full life cycle, enabling environmental sustainability for all Americans.

Research Partners

U.S. Geological Survey | Georgia Institute of Technology | University of Pittsburgh | Rensselaer Polytechnic Institute | West Virginia University

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