MONITORING, VERIFICATION AND ACCOUNTING OF GROUNDWATER SYSTEMS ASSOCIATED WITH STORED CARBON DIOXIDE AT GEOLOGIC SEQUESTRATION SITES

BACKGROUND

Deep geologic sequestration of carbon dioxide (CO_2) that comes from coal-burning power plants and industrial manufacturing processes is being investigated as an effective way to lessen global atmospheric warming. Methods devoted to monitoring, verification and accounting (MVA) activities associated with geologic sequestration are important for helping to protect human health and the environment, preserve sources of drinking water and monitor the integrity of CO_2 storage sites over time. MVA approaches are needed to rapidly identify potential CO_2 and brine leaks that could occur in overlying groundwater of geologic storage sites. The methods deployed for use in the field must be rapid, sensitive and inexpensive for widespread and effective use. A wide range of tools must be available to evaluate the viability of various techniques under changing geologic conditions. In addition, variation of CO_2 concentrations in natural groundwaters must be well understood to quantify potential leaks from geologic sequestration sites.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

PROJECT DESCRIPTION

The National Energy Technology Laboratory (NETL) conducts research on several novel and practical methods for the rapid detection of CO_2 and brine into overlying groundwater at geologic CO_2 storage sites. These currently include the advanced geochemical and isotopic analysis of collected water samples; the direct determination of CO_2 by volumetric expansion and non-dispersive infrared sensors; and the development of emerging in-situ sensing technologies such as novel nanocoatings to enhance fiber optic-based sensors and the rapid detection of ions associated with CO_2-rock interactions using laser-induced breakdown spectroscopy (LIBS). NETL has also developed and deployed various perfluorocarbon tracers (PFT) to aid in tracking CO_2 releases in shallow systems.

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PROJECT GOAL

The primary goal of this project is to develop and test new tools and methods for the rapid detection of potential CO_2 and brine leaks into groundwater systems from CO_2 storage sites.

OBJECTIVES

This project aims to achieve the following objectives:

- Develop a suite of protocols and tools for new types of geochemically based monitoring strategies for groundwater systems
- Develop a statistical understanding of natural groundwater variability in CO_2 storage sites
- Demonstrate the accuracy and robustness of developed tools under field conditions at CO_2 storage system sites or analogous sites that mimic conditions expected in the field

CAPABILITIES

This project will utilize NETL scientists' expertise in aqueous geochemistry, materials science and sensor development, laser technology and field sampling.

BENEFITS

The development of rapid and effective methods to determine potential CO_2/brine leakage from geologic CO_2 sequestration sites will help to ensure the effectiveness of this storage approach and protect the environment. The NETL technologies focus both on rapid screening in water and on more advanced isotopic analyses that allow for understanding of chemical reactions signaling potential leakage sources and pathways.

ACCOMPLISHMENTS

Development of Novel High-Throughput Methods for Metal Isotope Measurements in Brines

The NETL research team has successfully developed high-throughput and novel methods for strontium, lithium, uranium and boron isotope measurement in brine, groundwater and rocks using clean-lab chromatographic separation procedures and NETL's Multi-Collector Inductively Coupled Plasma Mass Spectrometer (MC-ICP-MS).

Figure 1. NETL's MC-ICP-MS housed at the University of Pittsburgh.

These methods are being applied to samples collected at NETL's field monitoring sites throughout the country. Aqueous geochemical signals and natural metal isotopes have been used to characterize brines containing introduced CO_2 and natural groundwaters overlying an enhanced oil recovery (EOR) site. Fundamental controls on water chemistry in this system prior to and following CO_2 injection are being investigated. Preliminary results showed that deep groundwater and brine maintain distinct isotopic signatures that can provide an early indication of potential brine migration.

Figure 2. NETL researchers collecting brine samples at a Texas EOR site.

Direct CO_2 Measurement Tools Applied in the Field

A volumetric expansion method used by the carbonated beverage industry and non-dispersive infrared (NDIR) CO_2 sensors adapted for use in water were tested extensively in NETL laboratories. These methods have been used successfully in the field to detect and directly measure CO_2 concentrations in groundwater pumped to the surface at a storage site in Illinois and at an EOR site in Texas.

Figure 3: Direct analysis of CO_2 using the volumetric expansion method.

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NETL-Developed Sorbent Tubes for Novel PFT for Soil Gas Monitoring

NETL analysis is being conducted to support field CO_2 injection projects. In these studies, various PFTs are added to the CO_2 injection stream at the wellhead.

Concurrently, novel gas-permeable glass tubes filled with Ambersorb© adsorbent are deployed in the soils near the surface and monitored to track if CO_2 leakage has occurred. The tubes are then retrieved for analysis using NETL's thermal desorption with cryogenic focusing gas chromatography/mass spectrometry with chemical ionization and selected ion monitoring. PFTs can be measured down to 200 parts per quadrillion.

Figure 4. Glass tubes filled with Ambersorb® carbonaceous polymer adsorbent (pen for scale).

Emerging In-Situ Sensing Technologies

NETL researchers are working to develop a series of novel in-situ analysis tools for detection of CO_2, pH and bulk water chemistry for future down-hole sensing. These include the development of miniaturized laser-induced breakdown spectroscopy (LIBS) sensing devices that will allow for in-situ real-time analysis of changes in water chemistry, and novel nano-material coatings for fiber optic downhole lines that are engineered to detect CO_2 and/or pH fluctuations at harsh field conditions (elevated temperature and pressure).

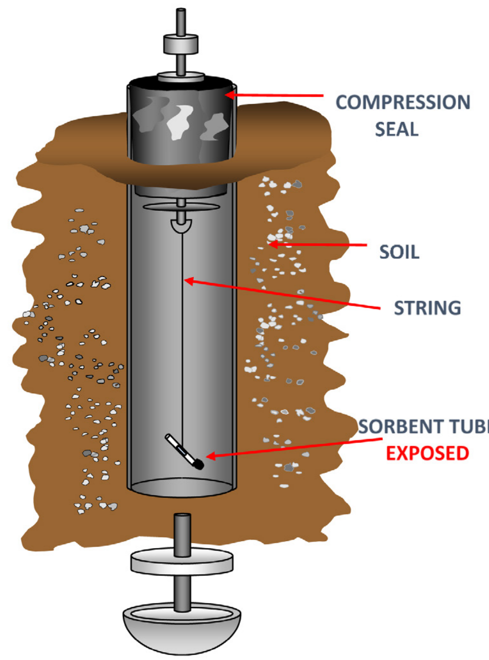

Figure 5. Schematic of the detachable head penetrometer used for deploying sorbent tubes in the field for collecting PFT gas samples.

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