the ENERGY lab

PROJECT FACTS

Carbon Sequestration

New Approach for Long Term Monitoring of Potential CO_2 Leaks from Geologic Sequestration

Background

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) is helping to develop technologies to capture, separate, and store carbon dioxide (CO_2) in order to reduce green-house gas (GHG) emissions without adversely influencing energy use or hindering economic growth. The capture of CO_2 from large point sources and subsequent injection into deep geologic formations for permanent storage, otherwise known as carbon capture and sequestration (CCS), is one option that is receiving considerable attention. Geologic sequestration involves storing CO_2 in deep underground geologic formations in such a way that CO_2 will remain permanently stored. Without CCS technologies, the CO_2 would contribute to global climate change.

All CCS projects must incorporate extensive monitoring, verification, and accounting (MVA) plans in order to ensure safety and viability of long-term CO_2 storage. MVA research is focused on developing techniques to provide an accurate account that the stored CO_2 will remain safely and permanently stored in suitable geologic formations. Furthermore, assuring human health and safety and preventing potential damage to the host ecosystem will be essential in obtaining permits for geologic sequestration projects.

Brookhaven National Laboratory (BNL), a multi-program lab operated by Brookhaven Science Associates for the DOE, has developed a unique instrument for non-destructive, *in situ*, quantitative soil analysis for carbon and other elements. The instrument is based on gamma-ray spectroscopy which is induced by fast neutrons undergoing inelastic neutron scattering (INS) and thermal neutron capture (TNC) with soil elements. The INS technique significantly improves, quantifies, and expedites the determination of the efficacy of different land-management methodologies for ensuring carbon sequestration and assuring soil quality. Its high sensitivity can detect changes in soil carbon induced by stressed vegetation impacted by the slow carbon-dioxide seepage from geological storage. It offers a non-invasive method for continuous monitoring of the soil carbon and other elements in situ over both specific plots and large areas. This new approach can be used to detect slow CO_2 leaks if they should occur and evaluate small changes in the below-ground CO_2 by using very sensitive monitoring devices.

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PROJECT DURATION

Start Date
10/01/2007

End Date
09/30/2010

COST

Total Project Value
$1,005,000

DOE/Non-DOE Share
$1,005,000 / $0

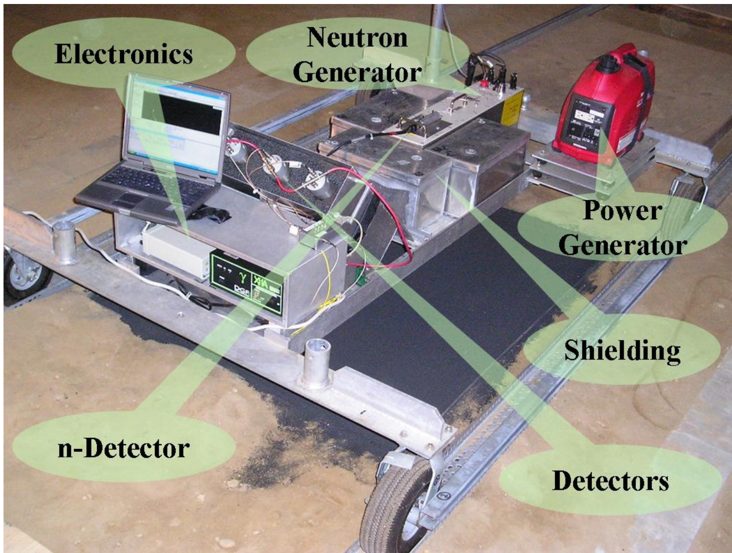

Figure 1. Mobile INS system

These devices offer a unique non-destructive method of measuring CO_2 leaks (should they occur) that is efficient, inexpensive, and covers large volumes of space in a shorter period of time which results in less impact to surface vegetation. In addition, this technology using an INS system offers new capabilities for detecting CO_2 leaks from geological formations both above and below ground, and may overcome many obstacles posed by the broadly accepted standard chemical methods for soil analysis by dry combustion, and commonly used technique.

Project Description

BNL is investigating the viability of an integrated approach for non-destructively monitoring the potential impact of long-term low-level CO_2 seepage from underground storage formations. Exploration of this ground monitoring technique will provide the commercial industry with enhanced development and use of deep-ground sensors for validating carbon-sequestration and deploying it to additional geologic sequestration sites in coordination with NETL.

Under this project, BNL has improved upon the alpha prototype system that has been constructed and tested in static and dynamic scanning conditions in numerous field studies. The team is preparing to test and deploy the beta prototype which has significant improvements, such as replacing the sum amplifier with independent data acquisition for each detector, and redesigning and implementing a noiseless power generator. The alpha prototype INS system was demonstrated in numerous static and scanning studies in fields ranging from those with low bulk density, pure organic soils, to ones with a high bulk density of overburden in abandoned mine lands. In addition, the system's capabilities were verified in forest ecosystems and at the Zero Emission Research and Technology Center

Figure 2. INS system ready for field deployment

(ZERT), the ZERT facility can simulate carbon-dioxide seepage from deep geological formations. Basic measurements at the ZERT facility support the 2008 observations in soil carbon suppression due to belowground CO_2 injection. This data is currently being reviewed. This new initiative will implement INS over the long term to effectively monitor near-surface carbon buildup resulting from the seepage of CO_2 sequestered in geological formations. This second generation of INS allows for an enhanced level of carbon detection in soil from the current detection limit of 0.5 percent to 0.01 percent.

Subsurface geologic and terrestrial storage of carbon dioxide emissions are viable techniques to lower greenhouse gas (GHG) emissions and to address climate change. During a four-year period, BNL will monitor non-destructively the impact of chronic low-level CO_2 seepage from underground storage formations on the soil and vegetation. By combining above- and below-ground observations with changes in biological processes, scientists will be able to detect and monitor the low- level seepage.

Project Goals

The main purpose of this project is to demonstrate the capability of a new instrument to detect in a non-destructive manner, near-surface belowground carbon, and to apply its use for monitoring geological sequestration and mine-land restoration. Three key project goals are to (1) design and construct a novel system for soil analysis with unique capabilities surpassing those currently available; (2) perform system validation in various soil types where the soil's carbon content was well characterized; And, (3) demonstrate the system's viability for monitoring carbon-dioxide seepage from below ground reservoirs.

The project's focus is to demonstrate the viability of an integrated approach for non-destructively monitoring the impact of long-term low-level CO_2 seepage from underground storage formations on the soil and vegetation. This approach will enhance techniques for monitoring geological sequestration and mine land restoration for carbon credit trading.

Objectives

The short-term objectives of this project include:

- In-air experiments to determine silicone gamma ray cascade factor that overlap with carbon photopeak.
- Finalize quantitative analysis of gamma ray spectra.
- Integrate, test, deploy and characterize the INS beta prototype.
- Integrate the INS system with the planned experiments at the Zero Emissions Research and Technology (ZERT) facility at Montana State University.
- Perform soil carbon determination experiments on Mammoth Mountain, where natural CO_2 leakage has occurred.
- Perform Monte Carlo simulations on moisture, soil bulk density, and soil carbon profile on carbon signal yield and system calibration. Simulate soil porosity and gausses phase affect on carbon signal.
- Establish INS baselines at two mine reclamation areas (Ohio and Pennsylvania) with two different remediation protocols.

Figure 3. INS system deployed in a wheat field in Montana

The long-term objectives include:

- Completion of INS system characterization and deployment at two additional geologic sequestration sites in coordination with NETL staff. (For example Frio Brine Pilot site)
- Implementation of the INS system in a systematic soil carbon monitoring at CO_2 injection facilities.
- To identify the mechanism of soil carbon changes under high and low soil atmosphere CO_2 concentrations.
- Follow-up monitoring of mine land reclamation.
- Calibration of the image pixels from aerial spectral scans with INS scans.
- Validation of the project hypothesis, i.e., how long term, low rate CO_2 seepage from geological formations affects surface biota.

Accomplishments

- An INS system for non-destructive, in-field soil carbon analysis, in both static and scanning modes was constructed and tested. The results constituted the proof-of-principle, and demonstrated the feasibility of using the system as intended.
- BNL researchers partnered with scientists from the Agricultural Research Service (ARS) of the U.S. Department of Agriculture in NC, AL, SC, and OK, and with scientists from several Universities in PA, OH, and MT in conducting measurements of soil carbon using the INS system and cross correlating the findings with concomitant soil analysis by the standard method. The results showed very good agreement between these two methods.

Benefits

The anticipated benefit of such a system is the ability to monitor critical MVA issues associated with CCS projects. Researching and perfecting a cost effective and reliable monitoring technique is an important part of making geologic sequestration a safe, effective and acceptable method for greenhouse gas control. On-going monitoring is required as part of the process for underground injection and will be used for tracking the location of injected carbon dioxide, ensuring that injections are not leaking, and for verification of the quantity of carbon dioxide that has been injected underground is not adversely impacting the environment. The primary benefit of this project is to offer a solution for the long term monitoring of carbon changes in the near surface resulting from CO_2 seepage from geological formations and its potential effect on vegetation and subsurface carbon over large areas. Project accomplishments can be applied to other regions and applicable industries if it is perfected.

DOE's Carbon Sequestration Program is working to develop technologies to promote the cleaner use of fossil fuels and for capturing and permanently storing CO_2, a greenhouse gas that can contribute to global climate change. This new adaptation of the INS system will enhance long-term monitoring of CO_2 at geologic sequestration sites by improving the ability to detect the unlikely occurrence of a CO_2 leak.