Tagging Carbon Dioxide to Enable Quantitative Inventories of Geological Carbon Storage

Description

Through its core research and development program administered by the National Energy Technology Laboratory (NETL), the U.S. Department of Energy (DOE) emphasizes monitoring, verification, and accounting (MVA), as well as computer simulation, of possible carbon dioxide (CO_2) leakage at CO_2 sequestration sites, along with risk assessment of those sites. MVA efforts focus on the development and deployment of technologies that can provide an accurate accounting of stored CO_2, with a high level of confidence that the CO_2 will remain permanently sequestered. Effective application of these MVA technologies will ensure the safety of sequestration projects with respect to both human health and the environment, and provide the basis for establishing carbon credit trading markets for sequestered CO_2. Risk assessment research focuses on identifying and quantifying potential risks to humans and the environment associated with CO_2 sequestration, and helping to ensure that these risks remain low.

This three-year project—performed by faculty and researchers from Columbia University—will develop two different injection systems for tagging CO_2 with carbon 14 (^{14}C) at atmospheric level (1 part per trillion) and measuring the radioactivity in collected samples. Such tagging of injected CO_2 will render geophysical methods of CO_2 monitoring quantitative and make it possible to accurately inventory geologically stored carbon. The systems will be tested in the laboratory and at the CarbFix demonstration project in Iceland, where CO_2 is injected into a permeable basalt formation at 600 m depth. Once the technology is proven, adoption of this system will provide a means of verifying the amount of CO_2 stored, thereby increasing confidence in geologic sequestration.

Primary Project Goal

The overall goal of this project is to generate an inventory accounting and verification technology that helps foster public trust in the safety and permanence of CO_2 storage. A direct method of quantitative accounting is to tag the injected high-flow stream of fossil CO_2 with a tracer of ^{14}C at a concentration similar to the natural ^{14}C level in the atmosphere. Because fossil fuels and geologic formations below 800 m in depth contain negligible amounts of ^{14}C, this tracer is an extremely

CONTACTS

Sean Plasynski
Sequestration Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4867
sean.plasynski@netl.doe.gov

Justin C. Glier
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26505-0880
304-285-5255
justin.glier@netl.doe.gov

Klaus S. Lackner
Principal Investigator
Earth and Environmental Engineering
Columbia University
918 SW Mudd, MC 4711
500 West 120th Street
New York, NY 10027-6902
212-854-0304
kslackner@ei.columbia.edu kl2010@columbia.edu

PARTNER

Barnard College

COST

Total Project Value
$2,164,069

DOE/Non-DOE Share
$1,692,269 / $471,801

Table 1: Summary of Major Tasks and Objectives

Tasks	Objectives
Design of the ^{14}C supply units and microcartridge systems for tracer injection	Construct a filling station. Design and fabricate microcartridge systems in two different scales that can hold either dissolved or compressed tracer gas (SF_6 and $^{14}CO_2$). These microcartridges will be designed to inject tracer gases at the 1 part per trillion (ppt) levels.
Laboratory-scale evaluation of injection systems	Design and construct a high-pressure flow system for mixing. At the Lamont-Doherty radioisotope laboratory, test the injection systems, first with SF_6 and later with $^{14}CO_2$, to demonstrate the controlled tracer injection (1 ppt) into water, liquid CO_2, or supercritical CO_2 (flow rate of 1 kg/s).
Development of $^{14}CO_2$ detection system	Develop an improved ^{14}C counting system. Current monitoring equipment for ^{14}C activity is designed for other applications, but can be streamlined and improved for project purposes.
Field tests of developed $^{14}CO_2$ tagging systems	The CarbFix demonstration project in Iceland offers an excellent opportunity to test these devices, with measurements to be verified by conventional ^{14}C detection methods.
Hazard and environmental analyses	Perform a life cycle analysis of the full ^{14}C cycle in the proposed MVA protocol, addressing pertinent hazard and environmental concerns in order to ensure the safety of this MVA method.

sensitive tag for human injected (anthropogenic) carbon. Specific project tasks and objectives toward the overall goal are summarized in Table 1.

Accomplishments

This project was awarded on October 1, 2009, and the following key accomplishments are anticipated:

- The participant will develop two alternative systems to inject 1 ppt of ^{14}C into the flow of CO_2: (1) a microcartridge system for a pure gas tracer and (2) a syringe-based cartridge for the tracer dissolved in a liquid. Collectively, these are referred to as cartridges (see Figures 1 and 2).
- The participant also will design a filling station, located at the manufacturing site, which is capable of supplying ^{14}C and other tracers to the cartridges; and develop an improved tracer detection system. The performance of the tracer injection and detection systems will be validated in both laboratory and field conditions.
- Finally, the participant will perform a hazard and environmental analysis, which will be finalized based on both laboratory and field tests.

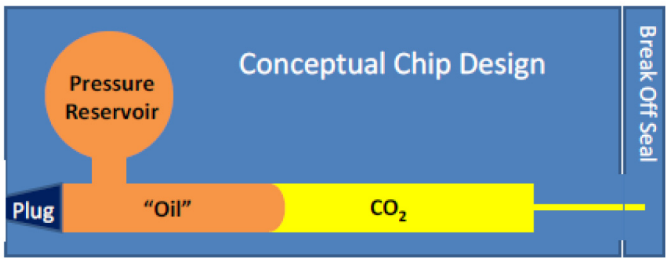

Figure 1. Conceptual design of a microfluidic chip for $^{14}CO_2$ injection.

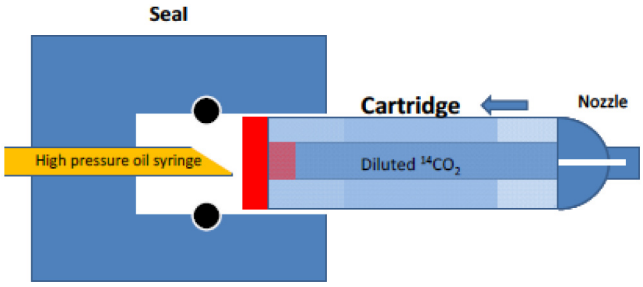

Figure 2. Schematic design of syringe system.

Benefits

The development of a quantitative inventory tool using ^{14}C for geologic storage of CO_2 is expected to result in the first true inventory of stored anthropogenic CO_2 in geologic reservoirs. In combination with conventional geophysical monitoring technologies, it will significantly improve the overall resolution of the monitoring and will contribute to the ground verification of geophysical observations. If successful in proving the CO_2 tagging and injection technology, the work will provide an inventory tool that can definitively establish the amount of carbon stored in geologic formations, thereby helping increase confidence in geologic sequestration.

DE-FE0001535, April 2010