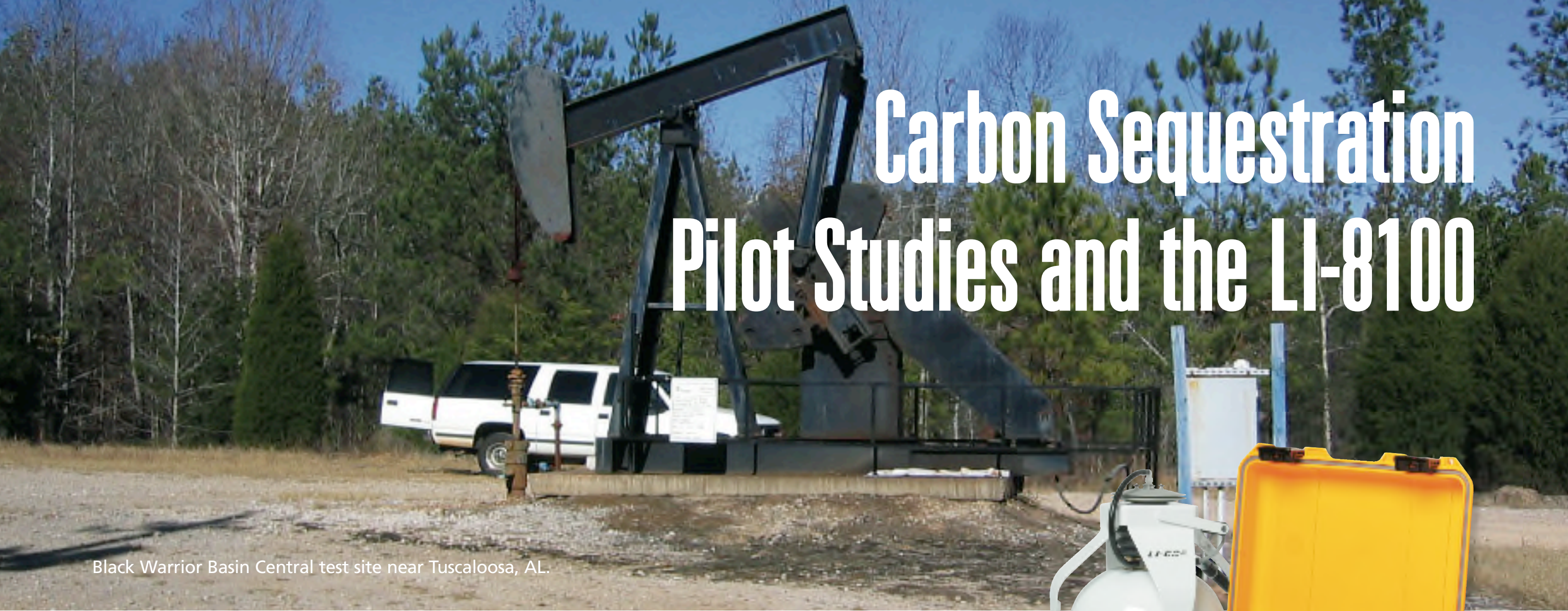
Carbon Sequestration Pilot Studies and the LI-8100



Black Warrior Basin Central test site near Tuscaloosa, AL.

It is rare that a day goes by when we're not presented with more concerns of the effects on global climate change due to increased greenhouse gas emissions. While experts may not always agree on the solution, most agree that technology-based solutions should be evaluated and ready should they need to be implemented. One technology, of a diverse portfolio of options, is Carbon Capture and Storage (CCS), also known as carbon sequestration. Most efforts involving CCS focus on the capture of CO_2 from large-scale stationary sources with storage in deep geologic formations (i.e., depleted oil and gas fields, saline formations, and unmineable coal seams), or terrestrial sequestration (i.e., trees, soil, etc.).

Adam Dayan, a graduate student at the University of Alabama, performs surface CO_2 monitoring with the LI-8100 and 8100-103 at the Black Warrior Basin test site.

LI-COR LI-8100 Soil CO_2 Flux Analyzer with 20 cm Chamber

A number of U.S. and international collaborations are currently underway with the goal of providing safe, cost-effective methods for capturing and storing greenhouse gas emissions. One of these collaborations is the Southeast Regional Carbon Sequestration Partnership (SECARB), which encompasses eleven states in the southeastern United States. Funded primarily by the U.S. Department of Energy (DOE) with cost-sharing from select industry partners, SECARB currently has a number of active field tests, including: 1) two coal seam projects, one of which is in the Black Warrior Basin Central near Tuscaloosa, Alabama, designed to test the economic feasibility of CO_2-enhanced gas recovery (EGR) and geologic sequestration, and 2) a deep saline formation study near the Victor J. Daniel, Jr. power plant, a coal-fired plant near Escatawpa, Mississippi, where geologic storage will be evaluated.

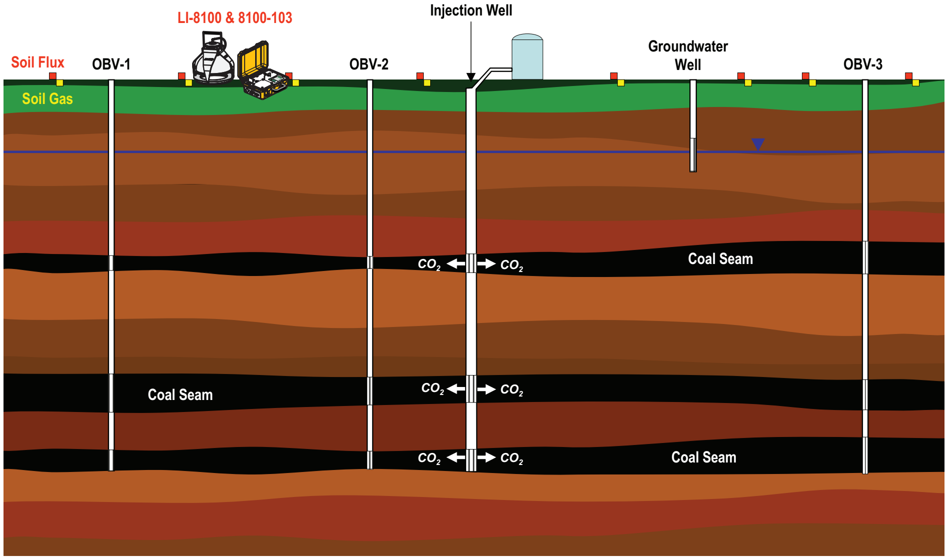


Illustration of Black Warrior Basin test site. Observation wells are spaced approximately 150 ft. apart. Surface monitoring for CO_2 seepage is performed with the LI-8100; subsurface CO_2 monitoring and groundwater testing is also conducted.

As a vital part of the SECARB initiative, a prominent southeastern electricity provider, Southern Company (Atlanta, GA) is participating in these field tests that will monitor for long-term storage permanence and environmental safety, using both surface and subsurface detection methods.

Phase I of the test project (2003-2005) consisted of characterizing the geologic formations as to their potential as sources/sinks for CO_2. Phase 2, which is currently ongoing, consists of the characterization and validation of a selected geologic formation and demonstration of sequestration through small-scale CO_2 injections that will take place in early 2008; surface monitoring will continue for several years following CO_2 injection. In Phase 3, the upcoming deployment phase, large scale injections will take place to verify technical, regulatory, and economic feasibility of carbon sequestration with the continued evaluation of monitoring protocols.

For surface CO_2 monitoring, Richard Esposito of Southern Company along with other SECARB team members selected the LI-COR LI-8100 Automated Soil CO_2 Flux System and 8100-103 Soil Chamber to perform baseline monitoring before CO_2 injection, to establish natural rates of CO_2 flux at the test sites. After Phase 2 injection, monitoring will continue for approximately two years. Currently, Esposito and colleagues are using the LI-8100 and the 8100-103 20 cm Survey Chamber to take weekly soil CO_2 flux readings over a roughly 5 square acre area in the Black Warrior Basin, as well as at Mississippi Power Company's Victor J. Daniel, Jr. power plant. LI-COR Scientists traveled to Alabama and Mississippi to visit with SECARB team members to demonstrate the use of the LI-8100 system at both sites. After using the LI-8100 for several months, SECARB team members have been pleased with the performance, according to Esposito.

"No reason to change a good thing".

– Richard Esposito

Black Warrior Basin

The coal seam formation lies about 1200 ft. below ground surface, and contains coal bed methane (CBM). Methane production has tapered off, and in some areas future plans call for production to eventually cease unless some type of enhanced recovery is not implemented. The injected CO_2 will be evaluated from the perspective of both enhanced CBM recovery and carbon sequestration. Since coal seams are generally thin (< 2m) and shallow, in geologic terms (< 1000m), surface monitoring of the seepage of CO_2 through soils to the atmosphere is very important. The Black Warrior Basin is estimated by Jack Pashin at the Geologic Survey of Alabama to have a potential storage capacity of 342 million tons of CO_2 in coal seams alone. Coal seams are potentially a very safe candidate for the geological sequestration of CO_2.

Victor J. Daniel, Jr. Power Plant

This pilot test is designed to evaluate a large, deep saline formation for CO_2 sequestration. The target reservoir is the massive sand unit of the Lower Tuscaloosa Formation. This brine formation lies nearly two miles below the surface and is overlain by several regional low-permeable cap rocks As with the Black Warrior Basin site, Esposito and his colleagues plan to collect baseline soil flux data before injection takes place and to monitor for several years after injection.

The LI-8100

The LI-8100 System provides the capability to perform rapid survey type CO_2 flux measurements with either a 10 cm (8100-102) or 20 cm (8100-103) soil chamber, as well as long-term unattended measurements with either of two long-term chambers. In addition, the LI-8150 Multiplexer connects easily to the LI-8100 to provide for connection of up to 16 long-term chambers, giving wide spatial and temporal sampling coverage. A trace gas sampling kit is also available (p/n 8100-664) that allows air samples to be collected from the same air stream used to measure soil CO_2 flux in the LI-8100's soil chamber; the concentration of the gas species for those collected air samples can then be analyzed in the laboratory with gas chromatography or mass spectroscopy methods. If you would like to learn more about how the LI-8100 can help in your research, call one of our Application Scientists at LI-COR, or visit www.licor.com/8100.

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www.southernco.com

www.doe.gov

www.netl.doe.gov/technologies/carbon_seq/partnerships/partnerships.html

www.secarbon.org

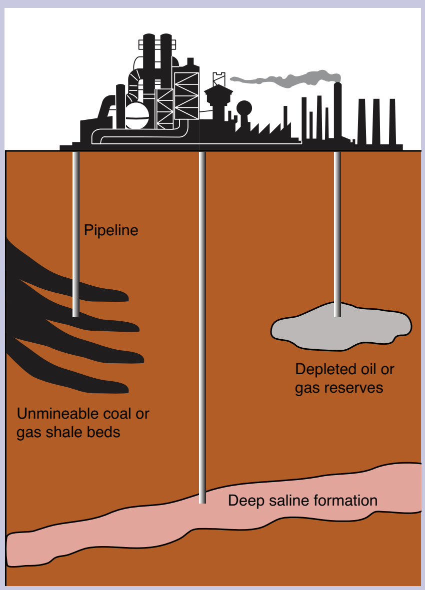
portal.gsa.state.al.us/CO2/SECARB2/secarb2.htm

How Carbon Sequestration Works

Depleted oil and gas fields are proven CO_2 traps; in addition, their geology and reservoir characterization is generally well known. Oil fields offer the opportunity for enhanced oil recovery (EOR) which helps off-set the costs of sequestration operations.

Deep saline formations contain pore spaces filled with salt water and can possess very large capacity for CO_2 storage due to high porosity and permeability. Saline formations are also often overlain by impermeable cap rocks that can make them very safe storage sites.

Unmineable coal seams are well assessed and have a large capacity for CO_2 storage; they are sometimes thin and shallow, however, which makes monitoring important for the protection of potable ground-water supplies and surface ecosystems very important.



As CO_2 is pumped into the ground, it is trapped in the pore spaces between the rocks. Depending on the characteristics of the rocks and fluids, CO_2 can be trapped in any of four ways:

1) Structural & stratigraphic trapping – CO_2 is initially more buoyant than water, and rises to the top of the rock formation where it is trapped by an impermeable seal or cap-rock such as shale or anhydrite.

2) Residual trapping – CO_2 becomes trapped as an immobile phase within the dead-end pore spaces of the rocks, much like a sponge.

3) Solution trapping – CO_2 dissolves into formation fluids such as into brines, where it becomes heavier than the water without CO_2, and thus sinks to the bottom of the formation.

4) Mineralization – CO_2 reacts with naturally occurring divalent cations to become part of the solid mineral matrix and forms stable carbonate minerals.

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