CO_2 Sequestration in Saline Formations—the Frio Brine Pilot Project

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The Frio Brine Pilot Project, funded by the U.S. Department of Energy (DOE), was designed to demonstrate early success injecting CO_2 in a high-permeability, high-volume sandstone representative of a broad area that is an ultimate target for large-volume sequestration. A national review of prospective sites for storage of CO_2 in brine-bearing formations had earlier identified the U.S. Gulf Coast as an ideal area because of large thicknesses of highly porous and permeable sandstones, inter-layered with and overlain by shale seals. The area is also desirable because of the concentration of CO_2 sources, such as power plants, refineries, and chemical plants.

The Frio Pilot site is in the heart of this favorable fairway and was chosen because of the willingness of the surface and subsurface owners to host the project and because some of the existing infrastructure could be used for experiments. In effect, the project was an experiment funded by DOE, operated and hosted by the Bureau of Economic Geology (BEG), and open to multiple scientific organizations, which ran a variety of monitoring experiments before, during, and after the injection.

About 1,600 metric tons of CO_2 was introduced into the well-characterized Frio Sandstone at a depth of 1,500 m. There was one subsurface monitoring point—a well located 30 m away from the injector and structurally updip. Breakthrough of CO_2 from the injector to the monitoring well occurred after 51 hours of injection. From the monitoring well, small-volume samples were extracted using an ingenious “U” tube system developed at Lawrence Berkeley National Lab. Other monitoring efforts included downhole temperature and pressure gauges, downhole electric logging, azimuthal vertical seismic profiling (VSP), crosswell seismic, surface-based electromagnetic surveying, tracer surveys, and pressure response to injection pulsing. Results of each of these experiments have been reported by the research partners and can be accessed via the project Website: http://www.gulfcoastcarbon.org

Results of the monitoring projects have been used to validate conceptual and numerical models for evolution of the CO_2 plume as it formed and migrated updip. These models were developed by Christine Doughty at LBNL. Comparing these models with information on plume size, shape, and saturation from monitoring experiments suggests that residual CO_2 saturations are approximately 20%.

The Gulf Coast Carbon Center (GCCC), led by BEG, is actively planning for a regional sequestration industry. The Frio Pilot demonstrated the potential for large-volume storage in saline, brine-bearing formations. Regional and local geology is well understood, and “stacked sinks” of EOR targets and large-volume saline formations make this one of the premier areas in the world for CO_2 storage. The U.S. Gulf Coast accounts for some 16% of national stationary CO_2 emissions (~1 GT/year), creating a notable source/sink combination. GCCC is pursuing a vision whereby the first phase of sequestration occurs as commercial EOR projects. In this phase, much of the necessary infrastructure could be developed. Later, much higher volume storage is envisioned in saline formations (~222 GT CO_2 capacity, assuming the use of only 1% of available pore

volume from 4,000 to 12,000 ft), supplemented by smaller volumes (~0.7 GT CO_2 capacity) of postproduction storage in abandoned oil fields.