Environmental Impacts of CO2 Sequestration in Sedimentary Basins

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Carbon dioxide capture and sequestration (CCS) in deep geological formations has emerged as an important pathway for reducing greenhouse emissions. Sedimentary basins in general and deep saline aquifers in particular are being investigated as possible long-term repositories for large volumes of anthropogenic CO2. We are participating in several of the approximately 25 field demonstration projects in the USA that are being conducted to investigate the storage of CO2 in various rock formations using different injection strategies, monitoring methods, hazards assessment protocols and mitigation strategies. In addition to identifying adequate storage capacity in proximity to major CO2 sources, key questions remaining include the extent of CO2 leakage related to the storage injectivity and integrity. Numerous uncertainties and scientific gaps still exist in quantifying CO2-brine-mineral interactions at reservoir conditions, because supercritical CO2 is buoyant, displaces huge volumes of formation water and becomes reactive to minerals, and well cements and pipes when dissolved in the formation water. Detailed chemical and isotopic analyses of water, associated gases, and added tracers obtained from Frio I and II field tests, near Houston, Texas, proved powerful tools in: 1) tracking the successful injection and flow of CO2 in the reservoir sandstone; 2) showing that injected CO2 was not detected in shallow groundwater; 3) detecting that some CO2 leaked into the overlying B-sand that is separated from C by 15 m of shale and siltstone; 4) showing mobilization of metals (Fe, Mn, Pb, etc) and toxic organic compounds (e.g. BTEX) following CO2 injection; 5) showing major changes in chemical and isotopic compositions of formation water, including a dramatic drop in calculated brine pH, from 6.3 to 3.0. Geochemical modeling, chemical data and Fe isotopes indicate rapid dissolution of minerals, especially calcite and Fe-oxyhydroxides, and suggest that release of some of the Fe and other metals may have been caused by corrosion of well pipe. Significant isotopic and chemical changes, including mobilization of metals and BTEX, were also observed in shallow groundwater following CO2 injection at the ZERT site, Bozeman, Montana. Geochemical techniques, which have sensitive chemical and isotopic tracers for tracking water-CO2-sediment interactions, are recommended for CO2 injection sites to monitor injection performance, and for early detection of any leakage.