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BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

DRINKING **WATER** RESEARCH PROGRAM

UNDERSTANDING GEOCHEMICAL IMPACTS OF CARBON DIOXIDE LEAKAGE FROM CARBON CAPTURE AND SEQUESTRATION

Issue:

Carbon capture and sequestration (CCS) in the earth's subsurface can potentially offset global CO_2 emissions derived from the combustion of fossil fuels. Research and development of CCS technology encompasses a wide range of issues to investigate collection of CO_2 from emission streams, transport of CO_2, injection into deep geological environments, and tracking the long-term fate of CO_2 in the subsurface.

Even with the large physical separation between storage reservoirs and surficial environments, there remains concern that CO_2 stored in reservoirs may eventually leak back to the surface through abandoned wells or along geological features such as faults. Leakage would reduce the effectiveness of CCS, possibly lead to human health and ecological impacts at the ground surface, and possibly harmfully impact water quality of near-surface aquifers used for drinking water.

Scientific Objective:

The U.S. Environmental Protection Agency's (EPA) Water Research Program in the Office of Research and Development is conducting research to better understand the geochemical consequences of CO_2 leakage into ground water. The research is part of the program's effort at protecting the quality and sustainability of water resources.

Leakage of CO_2 into ground water could result in decreased pH, increased mineral dissolution, and possible release of metal and metalloid contaminants. On the other hand, increases in CO_2 concentrations could also result in increased attenuation of certain metals and act to retard contaminant migration. Geochemical causes of contaminant mobilization are expected to result from a combination of low pH dissolution of mineral hosts, enhanced solubility due to metal-carbonate complexation, and/or desorption of metals from mineral surfaces. Attenuation processes involve sequestration via carbonate mineral precipitation and sorption, particularly of anionic contaminants at the mineral-water interface.

Research is focused in three topical areas:

- **Geochemical Modeling** Research is conducted to advance the application of geochemical modeling that can be used as a predictive tool for evaluating risks to water quality. Developing modeling procedures will help to identify contaminants that

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pose the greatest risk and indicate the need for more detailed chemical analyses.

- **Experimental Verification** Experimental studies will make use of high-pressure/high-temperature reactors for examining element partitioning between aquifer solids and water over a range of CO_2 partial pressures. This type of experimental system is well suited for studying the kinetics of mineral-water reactions as well as testing predictions from geochemical models.
- **Natural Analogs** Projects evaluate instances where natural processes have generated high CO_2 levels in ground water and interpret geochemical observations from these unique natural analogs.

The National Risk Management Research Laboratory (NRMRL) has a long history of conducting research on metal speciation, transport and fate, and contaminant remediation in ground-water systems. One aspect of this research examines the assimilative capacity of natural environments to attenuate inorganics and hydrocarbons (U.S EPA, 2007a, 2007b). Research conducted to better understand impacts stemming from CO_2 leakage builds upon previous efforts in the area of contaminant behavior in ground-water systems and takes advantage of in-house expertise and infrastructure in contaminant hydrogeology.

Application and Impact:

Assessing the risk of carbon dioxide leaking out of storage units and the consequences thereof is one of the most important and demanding tasks for assuring that geologic storage projects are safe and effective (Benson, 2005; Wilson et al., 2007).

The outcomes of this research, conducted through the Drinking Water Research program, will be implemented in an adaptive approach for developing regulations for CCS that allows EPA to establish regulations to protect underground supplies of drinking water (USDWs), and enable changes to regulations over time as information from demonstration projects and other studies becomes available.

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