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Plans to Address Knowledge and Data Gaps Identified During Development of the U.S. Geological Survey CO_2 Storage Resource Assessment Methodology

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The U.S. Geological Survey recently developed a methodology to assess the technically available CO_2 storage resource of geologic strata (http://pubs.usgs.gov/of/2009/1035/). One of the goals of that study was to identify knowledge gaps that need to be addressed to refine the methodology. Major knowledge gaps include understanding what controls the rate at which CO_2 can be injected into geologic strata ("injectivity") both initially and through the life of an injection project, the continuity of the physical properties of both storage formations and their respective seal formations, the volume of pore space that will be occupied by free-phase CO_2, how geologic formations will respond to the pressure increases associated with the injection of CO_2, and a methodology to aggregate the formation-level storage volumes to a basin-level and eventually a national-level storage estimate. Several of these, and other, knowledge gaps will be filled by research associated with large-scale CO_2 injection pilot-projects; in the interim, the USGS is in the initial stages of laboratory and data-mining efforts to address these issues.

In order to understand injectivity, and the effects of storage strata compartmentalization, available data on injectivity reported for hazardous waste injection wells and productivity reported for oil and gas wells will be analyzed. Furthermore, microscopic observation of CO_2 movement through water-wet synthetic porous media (bead packs, micromodels) at pressures and temperatures representative of subsurface conditions will be conducted to understand issues related to injectivity, compartmentalization, and storage efficiency. This work will allow direct observation, albeit on a very small scale, of buoyancy versus capillary forces, and their effect on the distribution of CO_2 within porous media. Buoyancy forces act together with the pressure gradients during injection to distribute CO_2 within the storage formation; however, capillary forces can hinder the buoyancy of CO_2, trapping discrete, isolated CO_2 blebs surrounded by water within pore spaces. Direct observation of the distribution of free phase CO_2 and water within the synthetic porous media will allow us to refine conceptual models of CO_2 accumulation within geologic formations.

The USGS research on seal formations will address two aspects of seal property characterization. This work will attempt to identify what components of methods that have been used extensively in hydrocarbon exploration and development are relevant for CO_2 storage. The initial step will be to examine the state of our current knowledge of the depositional environments of seal formations (initially mudrocks) to understand the potential impact of the primary depositional features of mudrocks on seal properties and the spatial variability of the properties critical for CO_2 storage. Better understanding of the basic depositional properties of these rocks on local and regional-scales will allow for the creation of geologic models to predict the spatial variability of the seal properties relevant to CO_2 storage across a basin. The second step will be to investigate the geophysical characterization of seals, relevant to CO_2 storage, by using wellbore logging techniques to identify the properties that may be most useful for predicting seal integrity on a basin-wide basis. In particular, both the utility of previously recorded logs (historic data), as well as the potential of any novel logging tools or techniques, to provide detailed characterizations of regional seal properties, and their relation to CO_2 storage, will be evaluated.

In addition to knowledge gaps, there are some significant data gaps that will need to be addressed. To fully understand the potential impact of formation water displacement by CO_2 injection and storage, baseline information on formation water chemistry and salinity is needed. Although data from the petroleum industry are available in the USGS produced-waters database, the data are limited in quality, scope, geographical extent, and are not current. An inventory of ground-water-quality data from 3,000 to 13,000 ft deep across the United States needs to be performed to identify available water analyses and, more importantly, to identify gaps in measurements of components that may affect ground water quality and the near-surface environment. This formation water database would also allow for the exclusion of some strata from the assessment, as the USGS methodology sets a minimum salinity limit of 10,000 mg/L for assessments. Geologic strata with formation waters less than this salinity will not be assessed by the USGS at this time.

This proposed research is a starting point for refining the USGS CO_2 storage resource assessment methodology. However, there are still significant data and knowledge gaps that will need to be addressed in the future as CO_2 storage projects come on-line. The assessment methodology should be improved by the filling of these gaps; however, the process is iterative as knowledge gaps will likely be revealed through this research and future assessment work.