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A Perspective on Assessment for Geological Carbon Sequestration in a Saline Reservoir: Where Does this Process Find Itself Today?

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The assessment of reservoir suitability for geological carbon sequestration derives numerous elements and processes from conventional oil and gas production experience, yet the differences are substantial enough to require many unique components to such an assessment. Ultimately, the process of supercritical carbon dioxide (CO_2) injection is simply the reverse of fluid production. However, for those who have worked with hydrocarbon production, the geological components of a sequestration project are complicated by an unfamiliar and evolving regulatory framework, an injectant with unique characteristics, lack of clear economic incentives compared to development of a market commodity, the critical need for public outreach, and a target reservoir for which key data may be lacking. The effort to develop a sequestration site is further complicated by the need to deliver millions of metric tonnes of CO_2 annually to a well field by a pipeline which itself requires assessment and development of a right- of-way. None of these concerns are insurmountable, but the level of interdisciplinary teamwork necessary certainly approaches that of a complicated state-of-the-art offshore hydrocarbon development.

The urgency do develop geological carbon sequestration has substantially increased in 2009 as the political willingness to address climate change through restrictions on emissions has advanced. In the U.S., the Department of Energy's Regional Carbon Sequestration Partnership (RCSP) program, while in place since 2003, has suddenly become a much higher profile source of actual field test expertise. There are answers which we wish we had today that are now only beginning to emerge as the RSCP develops deployment tests at the million-tonne scale. The questions remain numerous.

While permitting a CO_2 Enhanced Oil Recovery (EOR) project is straightforward in states where Class II Underground Injection Control (UIC) wells exist, regulatory unfamiliarity with CO_2 injected into a saline reservoir requires extensive dialogue and willingness of the applicant to work closely with regulators who normally permit waste disposal wells as Class I, consider experimental wells as Class V, and will soon permit CO_2 injection wells as Class VI. The form of CO_2 as a supercritical fluid may be unfamiliar to regulators and to utilities and biofuel producers, among the major stationary sources. Injecting a buoyant fluid, and also one that dissolves in brine to lower pH and increase corrosion potential, presents considerations that operators must address, regulators must become familiar with, and the general public must understand as not presenting insurmountable risk.

The economic incentive to develop geological sequestration and address the interaction between injected CO_2 and the reservoir framework will increase under a carbon tax or a cap-and-trade system. A tonne of CO_2 emissions avoided can only be validated with respect to a robust reservoir and seal framework that retains the CO_2 with an exceedingly small leakage rate. Further, that leakage rate and trajectory must be such that damage and resultant liability are avoided, an outcome that could negate the value of a sequestration project and foster abandonment of the technology due to negative regulatory and public perception. Public perception and acceptance is so essential to the success of geological sequestration that rather than a public outreach program being an afterthought, it must be a forethought such that it is developed concurrently with subsurface characterization studies.

Saline reservoir sequestration targets may or may not be the same geological formation that produces hydrocarbons within a basin or region. If below common drilling depths, knowledge of key reservoir properties (thickness, porosity, permeability, areal extent of favorable reservoir facies, etc.) will be sparse. The same would likely be true for the primary reservoir seal. Geophysical data acquisition may have been optimized for shallower hydrocarbon targets such that structural complexities are less well known at depth. Experience in U.S. mature oil reservoirs, especially the addition of proved reserves through reserve growth by infill drilling and the recognition of unswept reservoir volumes during EOR development, all but assures that CO_2 plumes will be subject to the same reservoir heterogeneities. Simple plume geometries are subject to revision continually as geologists, geophysicists, reservoir engineers, petrophysicists and specialists in reservoir- and basin-scale modeling acquire more data as sequestration projects develop. What is new to such teams is that it is not only a reservoir-trap system that must be dealt with but an entire stratigraphic column that is at issue because of plume buoyancy. Fresh water resources, ecosystems, and human life and property must be protected and effective containment must be demonstrated by monitoring. The “stratigraphic column” of concern therefore now extends from the below the reservoir (source of deep-seated faults which may or may not be transmissive) through potable groundwater and the soil zone to the atmosphere above the site (escaped CO_2 may not disperse under certain conditions).

The seven regional partnerships under DOE and similar projects in Europe, Australia, and elsewhere have made significant progress in addressing the issues and constraints defined herein. In the U.S., RCSP project staff have contributed to numerous regulatory forums and efforts to develop sequestration guidelines and regulatory frameworks, such as the work of the World Resources Institute, the Interstate Oil and Gas Compact Commission, and the U.S. Environmental Protection Agency’s effort to develop Class VI injection rules. The number of forums and conferences on sequestration around the world has mushroomed in the last 18 months. Yet, for all the dialogue, it seems that we still have a considerable distance to go. We must take the best practices manuals, the guidelines documents, the hands-on experience gained and apply that understanding to ever more projects and do so quite rapidly to have the impact that the climate scientists suggest is needed by 2030 or 2050. It will be interesting to look back 10 to 15 years from now and see if we have met our objectives for excellent geoscience, concurrent protection of surface and subsurface resources, management of large and diverse data sets, effective public outreach, and secure carbon sequestration in saline reservoirs *at the required scale*.