Carbon Sequestration Geochemistry: Advances and continuing challenges

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Geologic CO_2 sequestration (GCS) may be critical to reducing carbon emissions to the atmosphere over the next century while maintaining energy supply for a rapidly developing world. But what role does geochemistry play in GCS? Many expect that the trapping of CO_2 in continental and continental margin subsurface rock formations (mainly sandstones) will be done primarily by physical means such as low permeability capping formations (shales).

The geochemical components of GCS can be viewed as falling into three general categories. One involves understanding the nanoscale and molecular origins of properties such as wetting and capillarity. Another concerns fluid-mineral reactions that can result in conversion of CO_2 to solid phases; what are the controls, including at the pore scale, on dissolution rates and secondary mineral nucleation, and can reactive transport simulations accurately predict performance over thousands of years? A third category involves the consequences of damaged structural trapping (seal) formations. For example, if a shale seal is fractured during injection, how will geochemistry affect the transport of CO_2 through fractures and hence the integrity of the seal?

These questions have been the focus of substantial research over the past 10-15 years, much of it supported through the US/DOE Energy Frontier Research Centers (EFRC) program. Recent studies have resulted in new experimental capabilities for studying the relevant processes at *in situ* conditions, new computational approaches, and new insights into the nature of wetting properties, the robustness of capillary trapping, the kinetics of mineral weathering reactions, the possibilities and limitations of mineralizing CO_2 in the subsurface, and the evolution of fractures in shales. The geochemistry of clay-rich caprocks, and the effects of penetration of CO_2 into them, are of continuing interest, as is the behavior of relatively quartz-poor reservoir rocks that have abundant reactive, divalent cation-bearing minerals. Storage in volcanic formations - lava flows, including submarine lavas, as well as volcaniclastic sediments - is receiving increased attention. Volcanic rocks provide options for enhanced mineralization and are important for many regions far from large continental sedimentary basins.