Characterization of different Depositional Facies of Rocks from the Kevin Dome for Carbon Sequestration

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Abstract

The Kevin Dome in north-central Montana, USA was selected for CCS demonstration project under the U.S. Department of Energy Big Sky Carbon Sequestration Partnership. Two Wells that were drilled into the middle Duperow formation at this site have been logged and cored. This study discusses characterization of the cores from this well with a special focus on understanding pore and fracture geometry as well as mineralogy. It serves as a prelude for ongoing flow-through experiments testing the response of different depositional facies/geomechanical units to CO₂ injection.

A variety of methods were used to analyze the pore structure (pore size distribution and connectivity) and matrix properties. These include Klinkenberg-corrected gas porosimetry and permeametry, 3-Flex-77K Nitrogen gas adsorption porosimetry, Nuclear Magnetic Resonance (NMR) T2 analysis, X-Ray Micro-Computed Tomography (X-Ray micro-CT), Optical/Confocal Laser Microscopy, Thin section analysis, Back-scattered SEM/EDX, and XRD mineralogy.

XRD mineralogy and EDX elemental composition indicate that the rock facies are mostly composed of dolomite, which may have been formed from secondary mineralization after the initial precipitation of calcite. SEM image analyses reveal the crystals of this mineral and the flow units present. Bulk gas porosity ranged between ~0.6 – 8% and bulk gas permeability ranged between 0.001 – 11 mD. However, the distribution of pore sizes based on NMR T2/T2 measurements and examination of the core and thin sections indicate that multiple flow networks exist in the rock matrix. These include fractures, macropores, and micropores (aperture < 1mm). Preliminary results of N₂-sorption experiments suggest that nano-pores (aperture < 50-100nm) are not important in these rocks. Compared to gas-based measurements, NMR T2 measurement suggests that the void spaces in the matrix are not completely accessible to aqueous fluids under pressure, thus resulting in slightly lower apparent porosity. X-Ray micro-CT and optical/confocal imaging revealed the different flow networks and provide complementary porosity estimates and information on pore connectivity. Our data suggest that fractures and macroporous units were mostly accessed by wetting fluid (water) while non-wetting fluid (gas) gained access to micropores. Thus, the wettability of the injected fluid is crucial in determining the degree of penetration of CO₂ and aqueous fluids into the pore networks. Preliminary observations of flow-through experiments and results of prior work (Vogt et al., 2014) show rapid changes in permeability can occur in carbonate rocks during CO₂ injection. These changes likely result from chemical dissolution of rock matrix by acidified brine that enhance accessibility of the parts of the pore network to highly wetting fluids. These results are crucial for developing a representative large-scale geologic and numerical models for the Duperow formation in the Kevin Dome and similar carbonate CCS reservoirs.