Poromechanical Response of Coal and Shale Under CO2 Enhanced Recoveries

Author: Hemant Kumar, PhD Student, Energy and Mineral Engineering, Penn State

Research Summary: The evolution of permeability in CO_2-enhanced coalbed methane (ECBM) recovery involves dynamic changes in coal shrinkage/swelling with the change in gas sorption. Injection of CO_2 changes local pore pressures and induces related matrix volume strains, modulated in part by the mechanical boundary conditions. Changes in gas saturation and pressure induce changes in permeability. Permeabilities are also impacted by other important physical phenomena, including moisture contents and the sequence of sweeps by different gases used in ECBM. An experimental suite was developed and carried out to deconvolve the parameters modulating the permeability. A mechanistic model has been developed to explain the evolution of permeability in low rank subbituminous coal. Primarily, effective stress, pore pressure of sorptive gas and moisture content of coal seam modulate the permeability. This model was constrained by the first order observations. Further, this model has been utilized to optimize the CO_2 injection schedule for enhanced recovery of methane. This schedule guarantees that the permeability of the reservoir is always above the initial reservoir permeability during CO_2 enhanced recoveries.

The experimental suite was extended to low density Marcellus shale (low in organic content similar to low rank coals). Interestingly, the permeability evolution in both coal and shale is analogous. However, the magnitude of permeability-influence by various processes is different in both rocks.

Currently, flow instabilities and earlier breakthrough in case of enhanced recoveries are under investigation.