Geophysical Research Abstracts
Vol. 16, EGU2014-14668, 2014
EGU General Assembly 2014

Measuring Stress-dependent Fluid Flow Behavior in Fractured Porous Media

Da Huo and Sally Benson
Stanford University, United States (dhuo@stanford.edu)

Maintaining long-term storage of CO_2 is one of the most important factors for selecting the site for a geological CO_2 storage project. Nevertheless, it is important to be prepared for possible leakage due to leaking wells or leakage pathways through the seal of a storage reservoir. This research project is motivated by the need to understand unexpected CO_2 leakage. The goal of this research is to investigate stress-dependent fracture permeability and relative permeability of CO_2/brine systems. Laboratory measurements of fracture permeability and fracture apertures have been made as a function of effective stress. The phenomenon that permeability decreases with effective pressure increase is observed. Due to deformation of the fracture surface during periods with high effective stress, hysteretic behavior of fractured rock permeability is also observed in core flood experiments. A series of experiments are conducted to investigate permeability hysteresis. A single saw-cut fracture is created in the rock sample to simplify the problem and to focus on the fracture itself. Permeability is measured using a high pressure core flood apparatus with X-Ray CT scanning to measure the fracture aperture distributions.

Two permeability data sets, including a high permeability fractured Berea Sandstone and a low permeability fractured Israeli Zenifim Formation sandstone, show clear hysteretic behavior in both permeability and fracture aperture in repeated cycles of compression and decompression. Due to closure of the fracture aperture, when a fractured rock is compressed axially, the permeability has an exponential decline with effective pressure, as expected from stress-dependent permeability theory. When the fractured rock is decompressed afterwards, permeability increases, but not along the compression pathway and never returns to the original value. Depending on the nature of the fracture and host rock, permeability can decrease from a factor of 2 to 40. After one or more compression cycles, the effective stress needs to drop by more than 75% to cause a significant increase in permeability.

Stress-dependent relative permeability is also likely to be stress dependent, but is very difficult to measure. Pyrak-Nolte (1990) pointed out that non-wetting phase tends to have a more significant deduction compared with wetting phase if the fracture aperture is closing. Our experiment also observes that large apertures will close first. Due to the fact that non-wetting phase tends to stay in large apertures and wetting phase tends to stay in small apertures, we also get the same phenomenon that the fracture closure/opening will mainly affect the non-wetting phase channels in fractures.