Geophysical and Mineralogical Controls on the Rheology of Fracture Slip and Seal Breaching

Award Number: DE-FE0023354

Project Summary:

This project examined geophysical and mineralogical controls of caprocks on fault slip, permeability evolution, and the potential for seal breaching. In particular, the objective of this project was to determine the dynamic response of faults to shear reactivation, their post slip and inter-seismic healing, their response to chemically reactive alteration, and then upscaling via digital rock physics models. The project performed testing on rock samples to study faulting and fracturing and used the data to develop models that describe caprock response to stress as well as provide a caprock screening tool.

Prime Performer:
Pennsylvania State University

Principal Investigator:
Dr. Derek Elsworth

Project Duration:
10/1/2014 – 9/30/2018

Performer Location:
University Park, Pennsylvania

Program:
Carbon Storage

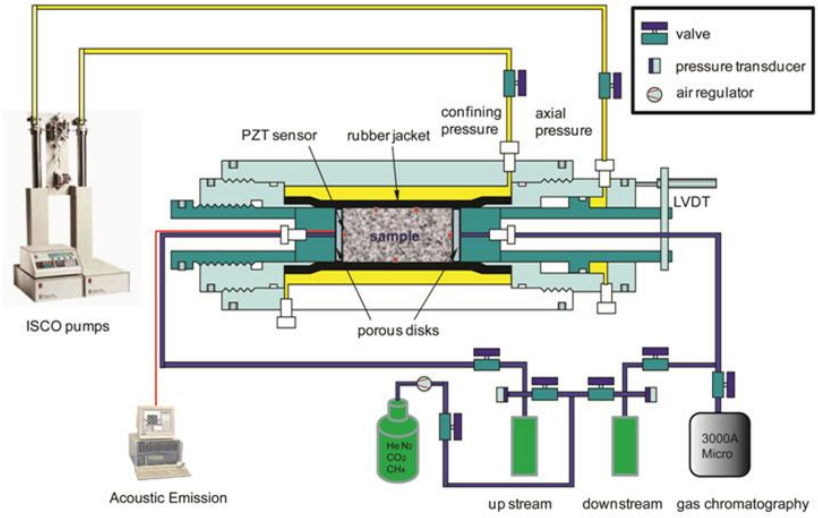

Figure 1: Experimental setup used to study the fault rheology and fluid transport in rock samples. The sample is placed within a pressure vessel to study its behavior under pressure that mimic real-world conditions.

Project Outcomes:

This project carried out laboratory testing and modeling to study the relationship between the frictional properties of faults/fractures and changes in permeability resulting from slip. Direct-shearing laboratory experiments were performed on rock samples to measure the frictional strength and stability (i.e., aseismic or seismic slip), while also measuring permeability changes. Process-based models, including distinct element models (DEM), were applied to simulate the observed friction-stability-permeability responses. Experimental and analytical results showed that observed friction-stability-permeability relationships may be explained via an integration of three interconnected physical mechanisms: (1) different mineral composition of fractures has a distinct effect on frictional strength and frictional stability; (2) competition between wear products and fracture dilation depends on material strength and brittleness; and (3) swelling of clay-rich asperities and clay-rich wear products directly seals the fracture aperture, therefore reducing the permeability.

Presentations, Papers, and Publications

Final Report: Automated High Power Permanent Borehole Seismic Source Systems for Long-Term Monitoring of Subsurface CO_2 Containment and Storage (March 2019) – James Kengo Andersen