Coupling of Geochemical and Geomechanical Processes in the Manipulation of Fracture Systems in Subsurface Formations Used for Carbon Sequestration

Award Number: FWP-100249

Project Summary:

Project work included the study of two shales with varying mineral compositions, clay-rich Marcellus and carbonate-rich Green River, with and without exposure to laser light. Microscale X-ray computed tomography (micro-CT) and scanning electron microscopy were used to help measure changes in the porosity and mineralogy of the sample. These data provided valuable information to understand the effect of the laser drilling process on the microstructure and mineralogy of the rock. The porosity of the samples was investigated with the micro-CT reconstructions after laser treatment. Using the segmentation approach developed for this project work, the porosity was measured as a function of distance from the exposed surface. This provided key information on how the laser light and heat affected the porosity of the sample and whether or not it had sealing capabilities.

Prime Performer:
SLAC National Accelerator Laboratory

Principal Investigator:
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Project Duration:
03/01/2016 – 02/28/2017

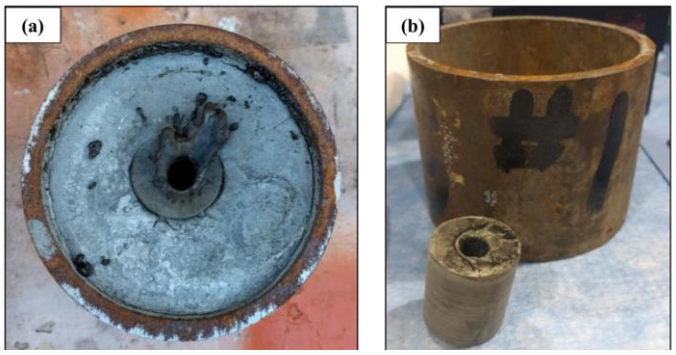
Performer Location:
Menlo Park, California

Program:
Carbon Transport & Storage

Project Outcomes:

Several key findings resulted from the project work. Based on the analyzed volumes and the porosity measurements as a function of depth from the exposed surface, there appear to be very different behaviors in the two shales investigated. Considering only porosity measurements, the Green River shale has a significantly larger altered zone than the Marcellus. Measuring the distance between the exposed surface and 10% porosity in both samples yields roughly 650 μm in Marcellus and 1800 μm in Green River. This sizeable difference is also apparent when visually inspecting the reconstructed slices. Although this affected region may vary in size and appearance, the presence of many voids or bubbles along the surface is common in both shales.

Figure 1: (a) The laser treated shale core is seen in the concrete and pipe. (b) Once the core is removed, a small section can be isolated for imaging in the micro-CT.



Additionally, with the use of laser drilling applications, several different laser parameters would be optimized to determine specific machine settings for each shale formation type specific to the drilling site. The excessive heating and evidence of gaseous bubbling and porosity changes as shown for the Green River shale could indicate that a lower laser power might have produced different results.

This work provided an initial assessment of the impact of laser drilling on two representative shale samples, and for the first time, examined with 3D X-ray imaging the fine structural details of the resulting porosity changes. Using the micro-CT reconstructions, the porosity has been measured and can be used as a quantitative indicator for how the rock has been modified. Further investigation and additional comprehensive studies are recommended to fully understand how this altered region affects the permeability.