

## Effects of fault-controlled CO<sub>2</sub> alteration on mineralogical and geomechanical properties of reservoir and seal rocks, Crystal Geyser, Green River, Utah

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The coupled chemical and mechanical response of reservoir and seal units undergoing CO<sub>2</sub> injection is critical for accurately modeling reservoir behavior in response to the introduction of CO<sub>2</sub>. Carbon sequestration, a climate change mitigation strategy, requires extensive risk assessment which relies heavily on numerical models of subsurface reservoirs. These models utilized for risk assessment are fundamentally limited by the quality and validity of their input parameters. Existing models generally lack constraints on the effects of diagenesis, failing to account for the coupled geochemical or geomechanical processes that affect reservoir and seal unit properties during and after CO<sub>2</sub> injection. For example, carbonate dissolution or precipitation after injection of CO<sub>2</sub> into subsurface brines may significantly alter the geomechanical properties of reservoir and seal units, specifically leading to solution-enhancement or self-sealing of fractures. Acidified brines could potentially erode and breach sealing units. In addition, subcritical fracture growth enhanced by the presence of CO<sub>2</sub> could ultimately compromise the integrity of sealing units under otherwise stable stress states, or enhance permeability and porosity of the reservoir itself. Such unknown responses to the introduction of CO<sub>2</sub> can be addressed by laboratory observations and measurements where existing data is lacking. However, these laboratory experiments are fundamentally limited in scale and scope, both spatially and temporally, so the study of natural analogs like Crystal Geyser, Utah is critical to fill in gaps, verify extrapolations, and guide experimental CO<sub>2</sub> sequestration research. Crystal Geyser, in particular, can help address and answer questions up to the reservoir scale and from engineering (10<sup>1</sup>-10<sup>3</sup> yrs) to geologic time scales (> 10<sup>4</sup> yrs). The Little Grand Wash and Salt Wash fault systems near Green River, Utah, host many fossil and active CO<sub>2</sub> seeps, including Crystal Geyser, and has been cited as a faulted anticline CO<sub>2</sub> reservoir analog. The site has been extensively studied for sequestration and reservoir applications, but less attention has been paid to the diagenetic and geomechanical aspects of the fault zone. XRD analysis of reservoir and sealing rocks collected along transects across the Little Grand Wash Fault reveal mineralogical trends in the Summerville Fm in the footwall (a siltstone seal unit) with calcite and smectite increasing toward to the fault, whereas illite decreases. In the Mancos Shale, found in the hanging wall, calcite abundance peaks 10 to 30 m away from the fault. These trends are likely the result of CO<sub>2</sub>-related diagenesis, and similar trends are also observed in sandstone units at the site. Fracture mechanics testing of unaltered and CO<sub>2</sub>-altered sandstone and siltstone samples shows that CO<sub>2</sub>-related diagenesis, which is indicated by bleaching of the Entrada Fm, has decreased the fracture toughness by 40%. The subcritical crack index is similarly affected by alteration. These compositional and mechanical changes are expected to affect the extent, geometry, and flow properties of fracture networks in CO<sub>2</sub>-rich environments, and thus may significantly affect reservoir and seal performance in CO<sub>2</sub> reservoirs.

**Keywords:** CO<sub>2</sub>, sequestration, fault, fracture