Coupled Geochemical-Mechanical Evolution during Injection of CO_2-charged Brine into Sandstones

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Fluid-rock interactions play an important role in science and engineering processes such as chemical stimulation of enhanced geothermal systems and carbon capture, utilization, and storage. Often, these interactions involve geochemical reactions such as mineral dissolution/precipitation, and mechanical responses such as rock matrix deformations. The feedbacks between these interactions might result in changes of hydraulic properties such as permeability and porosity, and mechanical properties such as Biot coefficient. However, laboratory observations on these changes due to coupled geochemical-mechanical interactions are still sparse.

In this study, reactive flow-through experiments were performed on sandstone samples from deep geothermal sites in Lithuania in an effort to enhance reservoir productivity. To examine the geochemical reaction effects on rock mechanical and hydraulic properties, three consecutive steps have been implemented during the experiments: (1) pre-acid stimulation, (2) acid stimulation, and (3) post-acid stimulation. At Step (1), a series of experiments at reservoir conditions has been performed to investigate the effects of effective stress, confining pressure, and pore pressure on the bulk permeability of this sandstone sample. At Step (2), a 3-week reactive flow-through experiment at reservoir conditions (with pore pressure of 100 bar, confining pressure of 200 bar and temperature of 40 °C) has been performed right after the Step (1), using acid (CO_2-enriched brine) injection, to examine the effects of geochemical reactions on its bulk permeability. At Step (3), similar to Step (1), a series of experiments at reservoir conditions has been performed to investigate the effects of effective stress, confining pressure, and pore pressure on the bulk permeability after acid stimulation. In addition, fluid samples were collected during the experiment in Step (2) and analyzed using ICP-OES to infer mineral reactions. Our experimental observations should certainly contribute to the interpretations on coupled geochemical-mechanical evolutions during processes such as chemical stimulation of enhanced geothermal systems and carbon capture, utilization, and storage.