Thermo-mechanical behavior of a granodiorite from the Liquine fractured geothermal system (39 degrees S) in the Southern Volcanic Zone of the Andes

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Abstract

Fractures and faults in granitic rocks play an important role in geothermal systems because they permit the circulation of hot fluids. However, the thermo-hydro-mechanical behavior of granitic rocks has predominantly been studied at temperatures exceeding 300 degrees C but many geothermal systems experience temperatures much lower than this. The aim of this study was to evaluate how the depth, temperature, and amount and rate of mechanical loading associated conditions, that are realistic in low temperature geothermal system, influence the physical properties of geothermal reservoir hosting rock. We carried out both room temperature and low temperature thermo-mechanical tests on a granodiorite sample from the Liquine area, Chile, and performed post-experimental X-ray microtomography analysis to numerically estimate the permeability of the generated fractures. The results showed that both rock strength and rock stiffness decreased with increments of temperature treatment related to the development of thermal crack damage at temperatures > 150 degrees C and through the development of sub-critical cracking at constant temperatures between 50-75 degrees C. Slowest deformed samples also exhibited lower strengths, attributed to the development of sub-critical cracking. The cyclic triaxial loading test indicated that significant mechanical fracture damage was only initiated above 80% of the peak stress regardless of the number of repeated loading cycles at lower stresses. Low-temperature treatment appears to be a conditioning factor, but not the dominant factor in controlling the physical properties of reservoir hosting rocks. Our findings indicate that thermal crack damage is likely important for developing microfracture related permeability at depths between around 2-6 km where the temperature is sufficiently high to induce thermal cracking. At shallower depths, such was previously estimated the reservoir of Liquine, thermal crack damage is only generated adjacent to fractures that remain open and circulate the hot fluids but sub-critical cracking over time reduces the strength of rocks in lower temperature regimes. These processes combined to produce a geothermal reservoir in Liquine which likely first required the presence of a highly fractured fault zone.

Palabras clave

Palabras clave de autor: Crystalline rock; Thermo-mechanical properties; Hydro-mechanical properties; Fractured geothermal system; Andean Southern Volcanic Zone

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