Materials Characterization Work

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Primary CNF Tools Used: Scanning electron microscope, laser-scanning confocal microscope

Abstract:

Spallation induced by rapid hydrothermal heating was investigated as a possible method of drilling rock.

Summary of Research:

In this study, an electrically-heated hydrothermal jet was impinged on the surface of cylindrical Barre Granite samples (basement rock) contained in an autoclave reactor to induce localized thermal stress. Comminution of the rock surfaces was achieved at supercritical water conditions, temperatures from 535-580°C and pressures of 22.5-27 MPa. These conditions simulate those encountered in drilling deep, water-filled wells at depths greater than about 2300m. Preferential removal of quartz grains from the rock matrix was observed.

The experimental results of the comminution tests were quantified by examining the sample's top surface prior to the spallation experiments with the scanning electron microscope (SEM), determining the crystal/mineral composition to a resolution of ~ 10 μm. After spallation they were examined with a laser-scanning confocal microscope (LSCM), which acted as a profilometer measuring the amount of mineral removed (see Fig. 1).

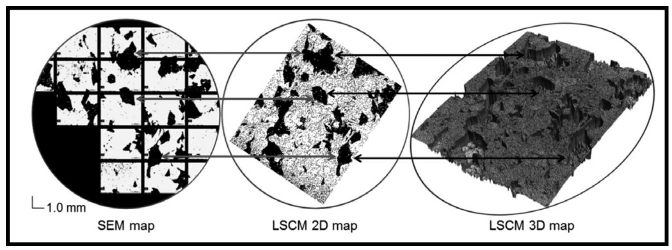

Figure 1: Left to right, the SEM scan of the silicon element (Si) on the unspalled rock sample's top surface identifying the silica rich quartz zones to a resolution of ~ 10 µm, compared against the LSCM 2D scan of the same sample's post-comminution test surface. The color-corrected 'black' quartz crystals in the SEM image and the 'black' subducted areas in the 2D LSCM comminuted image correspond to each other and the 3D colored LSCM map. Observation indicates that quartz crystals are preferentially removed.

The comminution tests consistently resulted in heterogeneous removal of surface material. Comparing the diminished areas to the SEM mineral map it was determined that exposing Barre Granite to a supercritical water jet preferentially removes quartz crystals, see Figure 1. Additionally, the boundaries of the subducted quartz grains are very distinct which further strengthens an argument for preferential removal of silica; however, no rock spalls were recovered from these experiments.

These experimental results were published at the 43rd Stanford Geothermal Conference.