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Experimental granite stimulation through reactive fluid flow for Enhanced Geothermal Systems (EGS)

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Reactive transport is crucial in many geological and geo-engineered fluid-solid processes such as natural rock alteration, hydrothermal ore deposit formation, CO_2 sequestration, and energy recovery from Enhanced Geothermal Systems (EGS). In EGS, chemical stimulation through reactive fluid flow, results in dynamic changes of the mineral composition and petrophysical properties. Porosity generation and maintenance of permeability are essential for EGS, as they enable efficient fluid flow and consequently heat transport. However, the parameters governing the efficiency of chemical stimulation of low-permeable rocks are incompletely understood and experimental studies are scarce.

To simulate reactive transport processes in low-permeable crystalline reservoirs and to investigate petrophysical property changes, we conducted hydrothermal batch and flow-through experiments on the laboratory-scale, stimulating granite with modified regular mud acid (RMA) under geothermal reservoir conditions.

We characterized and quantified chemical, mineralogical, and microstructural changes of granite exposed to reactive fluid by integrating X-ray powder diffraction (XRD), scanning electron microscopy (SEM), electron probe micro analyses (EPMA), Raman spectrometry, optical profilometry, and X-ray micro-computed tomography (µCT; enabled through the EXCITE network at the Centre for X-ray Tomography, Ghent University). This analytical approach allowed us to delineate fluid pathways and to identify the locations of secondary phase formation and reaction-induced porosity, thus offering insight into the reaction process and its dependence on the experimental parameters.

Our observations indicate that the experiments effectively stimulate granite and significantly increase interconnected porosity, driven by formation of dense secondary phases that are only partly replacing the original mineral assemblage. Depending on the fluid composition, secondary phases coat the initial phases or partly fill the newly-generated pore space. As a consequence of the porosity increase, permeability also rises markedly, reflecting the enhanced connectivity of the evolving pore network.

These key findings underscore the potential of chemical stimulation to induce petrophysical property changes (porosity and permeability) that are beneficial for the exploitation of crystalline geothermal reservoirs.