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Geothermal Technologies Program

Stress- and Chemistry-mediated Permeability Enhancement/Degradation in Stimulated Critically-stressed Fractures

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1. PROJECT SUMMARY

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Objectives: This proposal will investigate the interactions between stress and chemistry that have been shown to exert a controlling influence on the magnitude and the longevity of permeability-enhancement induced on hydraulically and chemically stimulated fractures. Hydraulic and chemical stimulation of critically stressed fractures are essential mechanisms to develop the plumbing of EGS reservoirs. However, anticipated magnitudes of permeability enhancement, and how the initial enhancement will either grow or degrade with fluid and thermal production remains poorly understood. Importantly, current observations offer conflicting views of whether permeability of stimulated fractures will grow under net dissolution, as the mechanical and chemical agents that develop fracture porosity outpace those that destroy porosity, or conversely degrade. A consistent view of the thermal, hydraulic, mechanical and chemical processes that influence permeability-enhancement is sought.

Approach: Given the paucity of data supporting our understanding of the hydraulic and chemical stimulation of critically stressed fractures, we propose to conduct unusually well-constrained tests on natural fractures at cycled *in situ* effective stresses (0-20 MPa) and temperatures (50˚C-300˚C). Two complementary experimental approaches are proposed. The first involves flow-through tests on hydrostatically compressed fractures with continuous monitoring of permeability, mineral mass effluent, and periodic imaging by X-ray CT – these will evaluate the relative roles of closure stress and mineral dissolution and precipitation in mediating permeability changes. The second will involve flow-through tests on fractures subject to both normal and shear stresses, constrained within a double direct shear device, similarly monitored for mass and mineral fluxes, to examine the competition between effects that enhance fracture porosity (*viz.* dilation, free-face etching), and effects that destroy it (*viz.* mineral mobilization by pressure solution, mineral precipitation, and the formation of gouge).

The full suite of observations from these complementary tests will be used to develop and refine mechanistic models for permeability enhancement in natural fractures. Controlled variables will include temperature, normal and shear stresses, flow rates, and the composition of injected fluids. Observed test outputs will be the composition and rates of remobilized and effluent mineral fluxes, effluent aqueous chemistry, and imaged and sectioned maps of in-fracture porosity. Circulation fluids will include condensate, brines, and chelating agents initially screened (EDTA, HEDTA), and yet to be identified, in a parallel effort by EGI (Peter Rose, personal communication). Process-based models will be developed to quantify the interaction of thermal, hydraulic, mechanical and chemical processes that control the development and longevity of permeability enhancement in EGS reservoirs, including the development of coupled reactive (chemistry)-stress-flow-transport models. Peter Rose of the Energy and Geoscience Institute of the University of Utah will collaborate on experimental design.