Geophysical Research Abstracts
Vol. 18, EGU2016-18065, 2016
EGU General Assembly 2016

Fractured-rock permeability-versus-stress relationships from in situ experiments

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The purpose of this presentation is (1) to review field data on stress-induced permeability changes in fractured rock, (2) to describe back-analysis of fractured rock stress-versus-permeability relationships through model calibration against such field data, and (3) to discuss observations of chemically mediated fracture surface compaction and its effect on fractured rock permeability. Reviewed field data on stress-induced permeability changes, some of which are used for model calibration, includes in situ block experiments, borehole injection experiments, observations of depth dependent permeability, studies of excavation-induced changes in permeability around tunnels, and permeability changes associated with a large-scale rock mass heating experiment. It is suggested that model calibration of stress-versus-permeability relationships against field experiments involving simultaneously elevated stress and temperature may be strongly affected by additional temperature dependent fracture closure and fracture surface interlocking. This is a phenomenon that has been observed both in the lab and the field and has been described as thermal over-closure related to better fit of opposing fracture surfaces at high temperatures. The same phenomenon has also been described as chemically mediated fracture closure related to pressure solution of fracture surface asperities. The back-calculated stress-versus-permeability relationship may implicitly account for such effects, but the relative contribution of purely mechanical versus chemically mediated mechanical changes is difficult to isolate.