Geophysical Research Abstracts, Vol. 8, 07361, 2006
SRef-ID: 1607-7962/gra/EGU06-A-07361

Numerical simulation of crack paths in laboratory compressed Aue granite

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Fracture of rock is a complex process involving different stages from microcrack nucleation, crack coalescence to final macrofailure. The complete solution of a crack growth problem includes determination of the crack path. Laboratory rock testing allows reconstructing the rupture propagation path in rock for a range of different load boundary conditions. We analysed the influence of confining pressure on the rupture path in right cylindrical samples of Aue granite 50 mm in diameter and 100 mm in length. A steel plate acted as stress indenter at the top of the core and resulted in a unidirectional, localised shear fracture. In eight triaxial indenter tests the confining pressure was varied from 0-40 MPa. The crack propagation path was observed post mortem in epoxy-saturated half cores.

To investigate the effect of boundary conditions and material on experimentally observed macroscopic fractures we applied two numerical methods to model the crack paths in 2D. Using a Discrete Element Method (Particle Flow Code), rock fracture was modeled for a material averaging Aue granite properties (Youngs modulus 70 GPa, Poisson ratio 0.19 and peak strength 137 MPa). The model comprised 12,092 particles bonded at their contact points with ultimate strength limits both in normal and shear direction. Bond breakages are used explicitly to represent rock damage. In a second analysis the structure with the same properties was investigated with the Extended Finite Element Method (X-FEM). The mixed mode crack propagation direction was determined by maximizing the energy release rate of the rupture. Both methods (discrete and finite), successfully predict the fracture path at elevated confining pressures, but fail to correctly reproduce the path observed in samples deformed at atmospheric pressure.