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How Vein Sealing Boosts Fracture Opening

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Veins from from cracks. As such, a stage of brittle failure and fracturing is to be set apart from a stage of opening and sealing. The process of fracture opening requires distortion of the host rocks to create space for the evolving vein. To keep a crack arrested and, at the same time, to widen or stabilize the cavity, the stress intensity factor K_I=(P-S3)(πa) must remain below the fracture toughness K_IC of the host rock, and P-S3 >0 (P and S3 denote pore fluid pressure and absolute minimum principal stress, respectively and 'a' refers to the half-length of the fracture). For purely elastic distortion of the host rocks, maximum aperture W0=K_IC (1-ν2)/(E(π/8)1/2))(2a)1/2 depends on on K_IC, Poisson's ratio ν, and Young's modulus E of the host rocks. Owing to the low values for rock K_IC typically ranging between 0.1 and 1 MPa m1/2, veins formed by purely elastic distortion of the host rocks are restricted to high aspect ratios 2a/W. In metamorphic rocks, veins with low aspect ratios are common; inelastic deformation and viscous creep in the host rocks must have contributed to final vein shapes.
In the present study, I use finite element models to simulate fracture opening and cavity formation supported by viscous creep distributed in the host rock. Simulations are carried out on 2D plate models containing elliptical fractures. The walls of the fractures are coated by thin layers simulating incipient sealing; a residual cavity prevails in the centre of the model veins. Constant displacement is applied to the plate boundaries oriented normal to the cracks. I run a series of models with various viscosity contrasts between the rocks and the sealing. The results of these models indicate the following. (1) Fracture opening is most effective when the viscosity of the sealing ηs exceeds the viscosity of the host rocks ηr (2) The rate of fracture opening increases with increasing values for ηs/ηr . (3) An increase in the thickness of the sealing layer causes an increase in the fracture opening rates. (4) At constant strain rates, the rate of fracture opening increases with increasing strain. These results suggest that vein sealing boosts the rate of fracture opening, and contributes to development of low-aspect ratio veins.