

The microvein dilemma

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Repeated fracturing and sealing of a rock can in general follow two possible mechanisms: The crack-jump mechanism and the crack-seal mechanism.

The crack-seal mechanism is active if the veins are more compliant than the host rock. The vein is readily reactivated and grows in aperture and length with each iteration of fracturing and sealing.

The crack jump-mechanism on the other hand acts when the veins are strong and do not re-fracture easily. Rather than reactivating preexisting veins, new fractures form in the host rock producing closely spaced bundles of micro veins.

Identification of the prevalent mechanism allows to quickly determine whether the host rock or the veins are the weakest component of a system.

Another possibility to assess the relative strength of veins and host rock are by the intersection topology of veins at low angles: If the strength of vein and host rock are similar then the younger vein will crosscut the older vein, forming an X junction. If the vein is however much weaker or stronger compared to the host rock younger vein get deflected by the older veins, forming an Y junction.

Investigating vein systems from the Oman Mountains we made several observations that are not in agreement with this simple distinction:

Most veins show microstructural evidence for multiple opening events and it can be assumed that each macroscopic vein results from repeated reactivation of an initial micro vein by the crack-seal mechanism. However at the same time parallel micro veins exist with a low spacing, which is an indicator that the crack-jump mechanism prevails and micro veins are in general stronger than the host rock.

Late fractures and vein sets are often found to preferentially reactivate micro veins although the same micro veins are part of a closely spaced parallel set which is indicative for the crack-jump mechanism and thus stronger veins. At the same time micro veins of the same set intersect each other by crosscutting, even when the angle between the micro veins is low. This behavior suggests that the vein does not influence the fracture propagation of the younger vein, which means at such low intersection angles that the strength of vein and host rock must be very similar.

This contrasting behaviour can be observed in one single outcrop and for veins belonging to the same set. We present and discuss several mechanisms that are able to resolve this dilemma. Possible resolutions are (1) intrinsic and random strength variation (2) complex temporal evolution of the strength heterogeneity (3) a different growth mechanism of micro veins and crack-seal veins, e.g. subcritical vs. critical fracture growth.