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Do reactivated faults slip in the direction of resolved shear stress? The effect of shear strength anisotropy induced by linear structures on the fault plane

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Fault surfaces are typically non-planar and display either groove-like relief features parallel to the direction of fault slip or stepped geometries related to the truncated rock layering. This theoretical study examines the mechanical effect of such linear irregularities using Barton's (1973) approach to the derivation of shear strength values for rock discontinuities with asperities.

Under conditions of high effective mean stress, raised normal stresses will lead to a mode of slip in which the pre-existing fault moves by shearing off its linear irregularities. In this mode, slip takes place parallel to the direction of maximum shear stress. An alternative mode of slip involves a dilatational movement as the fault walls ride over the surface asperities. This mode is favoured by low normal stress conditions.

In the second slip mode, the resistance to reactivation varies with direction of slip on the fault plane, i.e. the shear strength of the fault is anisotropic. Minimum shear strength exists in the direction of the preexisting linear structure, and leads to a slip direction that becomes oblique to the direction of maximum resolved shear stress. The importance of this effect depends on the geometry of the grooves; it is significant if the gradient of the sides of grooves is steep.

This effect is not allowed for in standard fault-slip methods which are based on the assumption of isotropy of shear strength (Wallace-Bott hypothesis) and therefore complicates the problem of stress inversion. On the other hand, the new theory suggests that useful information on normal stress magnitudes can be gleaned from observations of surface morphology of reactivated faults.