A geometric model for fault zone and fault rock thickness variations

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A weak positive correlation between fault displacement and fault rock thickness over several orders of magnitude has been established from several studies over the past few decades (Robertson 1983, Scholz 1987, Hull, 1988). Here we show that other fault components, such as fault zone thickness (measured as the variably deformed rock volume bounded by kinematically related fault strands) and the fault normal separations for breached and intact relay zones, also show positive correlations with displacement, albeit with progressively lower displacement/thickness (or displacement/separation) ratios. Although the trend defined by fault rock thickness data is generally interpreted as a growth trend, controlled by fault rock rheology (e.g. Hull 1988), recognition of similar correlations for the other fault components suggests an alternative model. In this model a fault initiates as a segmented array of irregular fault surfaces. As displacement increases, relay zones separating the fault segments are breached and fault surface irregularities are sheared off, to form fault zones containing lenses of fault bounded rock. With further displacement, the fault-bounded lenses are progressively comminuted, ultimately being converted to a zone of thickened fault rock. In this model the thickness or width of a fault at a given point is established at relatively low displacements with the strain intensification due to increased displacement resulting in a progressive increase in the proportion of fault rock. The ultimate fault rock thickness is therefore strongly controlled by the fault zone structure inherited from the geometry of the initial fault array and is not simply related to fault rock rheology, i.e. strain weakening or hardening behaviour. The large-scale range on which fault segmentation occurs, together with the irregularity of the fault surfaces that result from segment linkage, provides the basis for application of this model over the entire scale range. This model is consistent with the wide range of fault rock thicknesses measured over relatively short trace lengths of individual faults, together with the large amount of scatter on associated plots, and with the absence of strong correlations between fault rock thickness and lithology. These empirical constraints are also supplemented by the results of newly developed discrete element mechanical models of fault zone evolution, which suggest that fault zone evolution is controlled by the localization and segmentation of faults, a feature which is strongly influenced by the rheology and stacking of the faulted sequence.

References

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