Fault step-over rheology and its effect on earthquake rupture propagation.
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The maximal earthquake magnitude expected to occur along a strike-slip fault system can typically be estimated by the length of fault segments. However, the active trace of such faults is commonly composed of segments separated by step-over zones of various length scale and structural characteristics. The underlying assumption in fault-segmentation based seismic hazard analysis is that one can distinguish between step-overs that would arrest a propagating rupture and those that would not.

Various researchers conducted theoretical studies of the ability of ruptures to jump segment step-overs based on the geometrical properties (segment separation and overlap), structural properties of the fault step-over (whether it is compressional or dilational, and whether it is linked by a dip-slip fault) and considering the effect of pore-fluid pressure changes on rupture propagation through step-overs. Recently, concepts of energy dissipation on and off the fault (i.e. within the step-over zone) were also suggested as additional important factors in rupture propagation across step-overs. However, to date there is no account of the effects that fault zone and step-over zone rheology may have on rupture propagation and arrest. Furthermore, there are no syntheses of the various structure and configuration factors in ruptures propagation into practical criteria of rupture arrest.

The present work uses a 2D finite element method to simulate rupture dynamics along strike-slip fault systems with varying step-over configuration, and a wide range of material properties within the step-over zone. Particularly, we study the effects that damage and porosity may have on rupture propagation by reducing material strength and increasing both on-fault and off-fault dissipation of earthquake energy within the step-over zone.

We find that the presence of damage and porosity in step-over zones significantly reduce the width of step-overs that may be considered as rupture barriers, and therefore greatly increases fault-system stability.

The results are of practical importance to seismic hazard analysis where probable length of rupture and earthquake magnitude are estimated based on mapped active faults. The results portray the importance of assessing the material state and characteristics of fault step-over zones, rather than only the general geometry of the step-over.