Fault Interaction and the Growth of Faults on Earthquake and Geological Timescales

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Fault interactions are an essential feature of the vast majority of fault systems, whether they are characterised by soft-linkage or hard linkage (Walsh & Watterson 1991). Fault interactions in soft-linked fault systems are reflected in the ductile deformations that accommodate displacement transfer (e.g. relay ramps in normal fault systems), whilst interactions in hard-linked fault systems arise from physical linkage of faults and the related coupling of their growth. Whether a fault system is hard-linked or soft-linked, fault interaction reflects the strain concentrations and shadows arising from short-term stress-dependent behaviour of faults. In this talk, using fault growth constraints from both ancient and active rifts, we show that this short-term behaviour is responsible for the emergence of interdependent displacement histories in which each fault is an essential element of a system which displays a remarkable degree of kinematic coherence. As a consequence, on spatial scales greater than an individual fault and on temporal scales greater than several earthquake cycles, the behaviour of individual faults can be relatively predictable and all of the faults within a system combine to provide a system that is geometrically relatively simple and coherent.

Fault interaction therefore produces similarities and profound differences in the patterns of displacement accumulation on individual faults over earthquake (e.g. tens of thousands of years) and geological (e.g. millions of years) timescales. For each timescale longer faults, which accommodate larger sized earthquakes, generally accumulate greater displacement and have higher displacement rates than shorter faults. On geological timescales this hierarchy of fault size is typically maintained throughout deformation and ultimately results in displacements accruing at near-constant rates (Nicol et al. 1997). Long-term stability of fault behaviour contrasts markedly with the highly variable displacement rates and earthquake clustering often observed for faults on earthquake timescales. These complex patterns of paleoearthquake recurrence are thought to be due stress transfer between faults during rupture and to reflect fault interaction. Therefore, although fault interaction and related stress-dependent behaviour provides a means of reconciling the variability of fault growth rates over earthquake timescales, it also gives rise to the stability of growth rates over geological timescales. A key to improving our understanding of fault growth is identifying the temporal and spatial length scales over which faults interact.

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