Geophysical Research Abstracts, Vol. 8, 05656, 2006
SRef-ID: 1607-7962/gra/EGU06-A-05656

Migration of fault activity in extensional settings: observations and causal mechanisms

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Deformation of the continental crust often initiates with distributed strain accumulation, characterised by structural complexity, and evolves through time towards strongly localised deformation on a relatively small number of discrete fault zones. A key question is what controls the transition from one regime to the other within a rheologically layered lithosphere and how rapidly does the transition occur? Observations of the evolution of extensional fault systems over a range of spatial and temporal scales enable us to understand in more detail the underlying controls on the localisation process by preserving information about strain rate variations over a range of timescales. This information may be derived from the accumulation of datable stratigraphic horizons within fault-controlled depocentres, or from the preservation of geomorphic features of known age, and integrated with present-day geodetically-determined strain rates and knowledge of fault activity from historical seismicity. A widely observed characteristic of extensional settings is that strain localisation manifests itself in the near-surface by a systematic migration of fault activity through time. Faults that were active initially become inactive, while other faults in the same extensional province record an increase in slip rate as they accommodate a greater proportion of the total strain. In this presentation we review the field evidence for this phenomenon and demonstrate how these observations may be used to infer the underlying controlling mechanism(s). We consider a model in which strain localisation depends on the coupling between strain (and/or strain-rate) softening along brittle faults in the near surface, and temperature-dependent viscous deformation at greater depth. We suggest that the rate of change of fault activity is the key observable that may allow us to

constrain the relative importance of these two deformation mechanisms in controlling lithospheric-scale strain localisation.