Geophysical Research Abstracts
Vol. 12, EGU2010-6836, 2010
EGU General Assembly 2010

Episodic Seismicity from Near Surface to Base of the Crust

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Episodic brittle-ductile interactions reflect a complex interplay of micromechanical hardening and softening that typical involves some type of fluid pressure transition in combination with introduction of new material that acts as the switch from coseismic to interseismic response. Three crustal levels reflecting distinct temperature-pressure conditions are used to demonstrate the independence of this cyclic behaviour on depth, though it is best prescribed by certain combinations of crustal parameters and host lithologies. The situations examined comprise: (1) upper crustal faulting of limestone/shale units 3-5 km depth; (2) mid-crustal faulting developed at 520°C and 20km depth; and (3) brittle shear and cataclasis in mafic granulites deforming at 750-800°C and 30km. Each regime exhibits variations in fluid pressure represented, respectively, by carbonate saturated water, shear-induced melt (pseudotachylyte) and anatectic melts and/or pseudotachylyte. In terms of the rock record, evidence of seismic events are embedded as the new or reconstituted material introduced to the deforming host as a consequence of brittle deformation; for example, calcite veins and pseudotachylyte. This new material acts as an important sink for strain energy whereby brittle responses are suppressed until such time as a new critical state is reached. In turn, the strain rate softening abetted by the new material provides a ductile overprint of their own syn-fracture origin. A common microstructural aspect of the otherwise distinct materials is the intense development of glide-mediated deformation, as opposed to creep, in the latter stages of a ductile (interseismic) period. This raises the issues of whether all seismic events are nucleated as classic pressure-dependent brittle failure, or if plastic instabilities can initiate the same macroscopic response.