Geophysical Research Abstracts
Vol. 15, EGU2013-3770, 2013
EGU General Assembly 2013

Quartz rheology from field observations and numerical modelling

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The mechanical properties of quartz strongly influence the strength of the continental crust and therefore the depth of the brittle-ductile transition and the nucleation depth of major earthquakes. Despite quartz being one of the most abundant minerals constituting the crust, natural examples to constrain quartz rheology are rare. Here, we present a brittle-ductile fault array in the Southern Alps, New Zealand, and use it as a natural laboratory into the rheology of deformed quartz rocks. The faults formed in the hanging wall of the Alpine Fault during the late Cenozoic at $\geq$ 21 km depth. They are near-vertical, systematically and closely spaced, extend laterally and vertically over tens of metres, and strike sub-parallel to the Alpine Fault. They consistently express both dextral and NW-up senses of slip. The faults displace quartzofeldspathic meta-greywacke (Alpine Schist) through predominantly brittle processes. Brittle shearing usually ceases where the faults intersect centimetre-thick quartz veins that are hosted by the Alpine Schist and that are discordant to the dominant schist foliation. In these quartz veins shearing is variably ductile to brittle, with ductile shear strains of up to $\sim$15 over shear zone widths of $\sim$3 cm. We use field-observed geometrical scaling relationships related to the sheared quartz veins, such as ductile shear zone width vs. ductile slip, and interactions between brittle faults and ductilely deforming quartz veins that intersect them to produce a set of viable numerical models reflecting the field observations. Quartz rheology is modelled by linear or power law creep, and the material parameters extracted for the quartz veins, together with viscous and brittle strength ratios between vein quartz and schist. The results indicate that under the prevailing deformation conditions, the dominant deformation mechanism in the quartz veins was dislocation creep, resulting in a non-linear viscous quartz flow behaviour.