Geophysical Research Abstracts
Vol. 15, EGU2013-346, 2013
EGU General Assembly 2013

Strain localisation and thermal evolution of a thick ultramylonitic shear zone

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Ultramylonites are the ultimate product of mylonitisation in ductile shear zones where strain causes almost complete recrystallisation of the rock. They are the weakest rock in a shear zone and accommodate high amounts of strain, usually in a relatively narrow band. However, ultramylonitic shear zones hundreds of metres thick are occasionally reported in the literature, indicating inefficient localisation processes. This work describes the >3.5 km thick El Pichao shear zone of the Sierra de Quilmes, a metamorphic complex of the 470 Ma Famatinian orogeny in the Sierras Pampeanas of Argentina. The core to the El Pichao shear zone is a one kilometre thick band of continuous ultramylonite. Although rare, other shear zones of comparable thickness are reported in the literature and are often related to major orogenic fronts. The width of shear zones is determined by plate velocity and rock strength, with greater widths at high velocities and low rock strength. Shear zones widen when the degree of strain localisation decreases. This can be caused by hardening of the shear zone, weakening of the host rock, or an increase in temperature which decreases the yield stress of the rock. There are several mechanisms that can lead to each outcome but these are difficult to determine in studies of shear zones.

El Pichao shear zone overprints granulite facies migmatites in the hanging wall, granites in the ultramylonitic shear zone core, and amphibolite facies Grt-schists in the footwall. Field relationships and mineralogy suggest that the migmatitic hanging wall was at higher temperatures during shearing than the ultramylonitic granitic core. Theoretically this makes the migmatites easier to deform than the granite. Additionally, the migmatite is very heterogenous with a mica-rich mesosome and syn-kinematic Qtz-Kfs rich leucosomes making it the ideal site for strain localisation and partitioning between strong and weak phases. Despite this, ultramylonite is localised to the granitic core and is rarely developed in the migmatites, indicating that the granite must have been the weakest lithology during shearing. This suggests a complex thermal evolution beginning with shearing in the hanging wall causing thrusting, cooling, and crystallisation of the migmatite, followed by a later period of shearing which thrust the migmatite on top of the schist footwall causing ultramylonitisation of the granite. This study investigates this theory using detailed microstructural and quantitative textural studies including the CPO of the major minerals. This is paired with thermodynamic modelling of the P/T-conditions during shearing in the different lithologies and with estimates of strain and displacement in the shear zone. This combination allows unique insight into the effect of temperature gradient and lithology on microstructure development during shearing and assists in our understanding of thick ultramylonitic shear zones.