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Strain localization across main continental strike-slip shear zones : a multi-methods approach for the case of the Karakorum shear zone

E. Boutonnet (1), P.H. Leloup (1), A. Rozel (2), N. Arnaud (3), and J.L. Paquette (4)

(1) Lyon 1, France (emmanuelle.boutonnet@ens-lyon.fr), (2) Dipartimento di Scienze Geologiche, Roma 3, Roma, Italy (antoinerozel@gmail.com), (3) Géosciences Montpellier, UMR CNRS 5243, Université de Montpellier 2, France (Nicolas.Arnaud@univ-montp2.fr), (4) Laboratoire Magma et Volcans, UMR CNRS 6524, Université Blaise Pascal, Université de Clermont-Ferrand, France (J.L.paquette@opgc.univ-bpclermont.fr)

Whether deformation within the deep continental crust is fundamentally concentrated in narrow shear zones or distributed in wide zones stays a major controversy of the earth sciences. This is in part because direct measurements of ductile shear or strain rate are difficult, especially when deformation is intense, as it is the case in ductile shear zones.

The Pangong range (India) is an 8km-wide shear zone, corresponding to the exhumed root of the central Karakorum fault zone (KFZ), one of the great continental strike-slip faults of the India-Asia collision zone. Ductile deformation is most intense in the Tangtse and Muglib mylonitic strands, which bracket the shear zone to the SW and NE, respectively. The relationships between dykes emplacement ages (U/Pb dating) and deformation indicate that deformation was not synchronous across the shear zone. Ar/Ar dating document that cooling was diachronic across strike and ductile deformation ($\sim$ 300°C) stopped earlier in the SW than in the NE. Deformation thus appears to have migrated / localized from the whole shear zone to the Muglib strand, the only locus showing evidence for brittle deformation and active faulting.

We compared the strain rates measured at different spatial scales: (1) a global scale investigated by the geological fault rate estimation and (2) a local scale, investigated with the QSR (Quartz strain rate metry) method. The total offset (200-240 km) and the KFZ life span (18 to 25 Ma) yield an average fault rate of 1.1 $\pm$0.2 cm/yr. this corresponds to a global shear rate of 4.4 x10-14 s-1, assuming an homogenous deformation in space and time within a 8 km wide shear zone. Five quartz samples provided deformation temperatures between 348 and 428°C and corresponding paleo-stresses between 24 and 65 MPa. The local strain rates measured within the two mylonitic strands of the fault zone (> 1 x10-13 s-1), are higher than those measured outside of these strands ($\leq$ 1 x10-14 s-1), where deformation is weaker. The strain rate integrated across the shear zone (5.7 x10-14 s-1) is comparable to the one deduced from the geological constraints. We interpret these data as a measurement of the amount of strain localization within the mylonitic strands at $\sim$400°C.

1-D numerical simulations of deformation within the KFZ for a 1.1 cm/yr fault rate, and taking into account the local geometry and rheology of the Tangtse section, yield temperature and strain rates profiles across the shear zone between 20 and 9 Ma. Two main parameters susceptible to explain the strain localization were investigated: (1) local heat flow variations resulting from granites emplacement and shear heating, and (2) rheological contrasts between the various lithologies. The simulations show localization of the deformation in the two mylonitic strands starting at $\sim$17 Ma. This strain localization appears to result more from the rheological contrasts, with the granite being soft levels with respect to the surrounding rocks, than from the temperature anomalies that vanish few Ma after granite emplacement.