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Different microstructures in low grade shear zone formed at comparable temperatures: effect of pre and syn-kinematic fluid-rock interactions

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Different microstructures and quartz recrystallization mechanisms can be observed in shear zones of granites that formed in similar greenschist-facies conditions. It is generally assumed that temperature plays a major role on quartz rheology and recrystallization. However, at low-grade conditions, fluid percolation also controls strain accommodation, by favouring the growth of weak phases as phyllosilicates. The relative importance of temperature over fluid-induced softening reactions on microstructures remains however poorly constrained mainly because comparative studies among low-grade shear zones are lacking.

The present work focusses on two granitic massifs of the central Pyrenees deformed at greenschist-facies conditions but showing different structural styles. While in Bielsa granitoid, shear zones are spaced of ~ 100-200 m, in Maladeta strain is localised in shear zones spaced of ~ 1.5 km. The Bielsa granitoid, is pervasively altered at late-Variscan time, as suggested by petrography and trace elements variations uncorrelated to strain gradients, and then at Alpine time. Alpine mylonites are made of white mica at ~ 50 % vol. Quartz poorly recrystallizes by bulging. Geochemical whole-rock analyses show systematic variations of alkali, fluid and volume with increasing strain. These results point to a pervasive fluid-rock interaction before and during deformation in Bielsa. In contrast, in high strain rocks of Maladeta, the magmatic mineral assemblage is largely preserved. Quartz pervasively recrystallizes by sub-grain rotation and white mica is less abundant (20% vol). Consistently, geochemical whole-rock analyses show no or little major element transfer across Maladeta shear zone at constant volume. This point to a lower pre and syn-kinematic fluid-rock interaction in Maladeta than in Bielsa. Thermometry on metamorphic chlorite show similar temperature ranges for deformation in the two massifs (280-350°C).

Variations of pre-kinematic hydrothermal alteration therefore strongly affect quartz recrystallisation mechanisms and microstructures, by controlling the abundance of weak phases as white mica. This process is observed despite very similar temperature ranges. Such variations may also explain the difference of structural style in the two massifs (distributed vs localised deformation) up to an outcrop scale.