Element mobility in low-grade shear zones and strain accommodation: insights from geochemistry and microstructures of granitoids of central Pyrenees (Axial zone)

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Shear zones developed in greenschist-facies conditions are often considered as open geochemical systems and preferential pathways for fluid percolation that favours the syn-kinematic growth of weak phases (i.e. phyllosilicates) and strain localisation. However, differences in the geochemical behaviour of low-grade shear zones are observed, with potential implications on strain accommodation from sample to an outcrop scale. In the Axial zone of the Pyrenees, the Bielsa and Maladeta granitoids are altered and deformed in greenschist-facies conditions at 250-350°C (chlorite thermometry). While shear zones of Bielsa are spaced of ~100-200 m and organised in an anastomosed net, in Maladeta they are spaced of ~ 1.5 km, leaving large parts of the granite undeformed. At microscopic scale, quartz shows little recrystallisation by bulging in Bielsa mylonites and intra-grain misorientation of parent quartz grains up to 40°. In Maladeta mylonites, pervasive recrystallisation of quartz by subgrain rotation is instead observed. New grains have no internal misorientation and relicts of parent quartz grains exhibit subgrains of a similar size of recrystallised grains. Pervasive alteration is observed in Bielsa granitoid, with more than ~50 % volume of mylonites made of interconnected white mica grains, while in Maladeta the magmatic mineral assemblage is largely preserved and white mica form less than 30 % volume of high strain samples. Major, minor and trace element geochemistry across Bielsa shear zones show systematic loss up to 50% of Na and K and variations in Ca due to feldspar breakdown and Ca-bearing fluid circulation, pointing to an open system behaviour relative to these elements during deformation. In contrast, across Maladeta shear zone, no systematic element loss or gain is observed, but only lateral element migration suggesting a "closer" system behaviour during shearing. The similarity of temperature ranges estimated for deformation and of the overall strain intensity in high strain samples of both massifs show that quartz recrystallisation mechanisms are not primarily controlled by temperature differences but they likely depend on the ratios between weak (phyllosilicates) and strong mineral phases (feldspar, quartz). Pervasive fluid percolation promotes abundant white mica growth around quartz grains in Bielsa, preventing quartz recrystallisation and favouring strain distribution in micas at an outcrop scale. Localised fluid percolation in Maladeta prevents pervasive white mica growth and preserves frequent quartz-quartz grain boundaries, thus favouring quartz recrystallisation and extreme strain localisation at an outcrop scale. Since white mica growth is closely related to fluid percolation and alteration, in the case of Bielsa and Maladeta granitoids, different "openness" of the low-grade shear zones appear to control the microstructures at the sample scale up to an outcrop scale.

Keywords: Greenschist-facies shear zone –Mass transfer – Quartz deformation- Axial zone

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