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Synkinematic phyllosilicates in a thrust fault zone : good proxy for PT conditions, deformation mechanism and mass transfers (example of the Monte perdido Thrust in southern Pyrenees)

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Thrust fault zones in foreland basins are often characterized by highly foliated shear bands generally enriched in phyllosilicates which can play a major role on the mechanical behaviour of the fault. These textural modifications, as well as the chemical modifications in the core zone of the fault, depend on the mechanisms of deformation and fluid-sediment interactions. In this context, investigations of synkinematic clay minerals allow determining the origin of the fluid from which they precipitated, the PT conditions as well as the mechanisms of deformation.
Our study is focused on clay mineral assemblages (illite and chlorite) in two thrust faults located in the Monte Perdido massif (southern Pyrenees): (i) the major Torla fault (kilometric offset)that affects Upper Cretaceous –Paleocene platform carbonates and lower Eocene marls and turbidites and (ii) a detachment fault which affects the lower Eocene Millaris marls. The core zone of these two faults consists of an interval of intensely foliated clays-bearing rocks bounded by major shear surfaces. The deformed sediment is markedly darker than the protolith. Calcite-quartz shear veins along the shear planes are abundant. Bulk chemical analyses and Rietveld refinement of the bulk rock XRD from the highly deformed sediments and hanging wall and footwall protoliths has allowed a quantification of the mineral proportions and mass balance calculation. Mineralogical variations between the protolith and fault zone samples have been estimated by the Gresens calculation (Gresens, 1967). According to this calculation, the highly deformed sediments registered volume reduction of up to 50% but without important chemical variations except calcium and LOI loss. However, SEM and TEM investigations of the deformed sediments show that chlorite precipitated coevally to the shear displacement and small crystals (<2 μm) of authigenic illite underline the cleavage. The newly formed chlorite is a Fe-rich chlorite (Si2.86Al1.14O10(Al1.67Fe2.31Mg1.71)6(OH)8). Temperatures of chlorite formation calculated by thermodynamic models range from 210°C to 265°C. Taking into account thermometric data from fluid inclusions in calcite and quartz veins, we established that the formation of the synkinematic chlorite occurred under about 6.5km burial. These data suggest that calcite and quartz pressure solution was not the only mechanism of deformation but that thrust fault activity induced mineralogical reactions implying partial dissolution and recrystallisation of phyllosilicates in the presence of fluid in a relatively closed system.