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Linking deformation structures and low-temperature metamorphic recrystallization: chlorite-illite equilibria in the Nevado-Filabrides complex (Betic Cordillera, Spain)

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Ductile deformation is partly accommodated by mineral recrystallization. Mineral growth is controlled by both thermodynamics and reaction kinetics, where fluid availability and deformation also play a key role, in particular at temperatures below about 400°C. In these temperature conditions, phyllosilicates are ubiquitous and reactive, and often replace the peak metamorphic minerals along the retrograde path. Phyllosilicate assemblages are thus of potential to estimate the pressure-temperature conditions of deformation and provide information on the dynamics of shear zone development.

This study focuses on a cross-section in the Nevado-Filabrides complex (Betic cordillera, Spain), which was exhumed along a ductile detachment. We present four outcrops located at different distances from the detachment, for which both the deformation structure densification with detachment proximity and the metamorphic P-T conditions have already been well constrained. The studied unit contains abundant chlorite and illite, often observed seemingly at textural equilibrium.

In order to highlight the link between phyllosilicate crystallization and deformation, electron microprobe chemical maps were performed on deformation microstructures (schistosity, shear bands, pressure shadows) where chlorite and illite are present. Using a multi-equilibrium approach with a thermodynamic model for clay minerals, we estimated P-T conditions of crystallization for the successive chlorite-white mica and chlorite-illite assemblages. Obtained P-T paths span the range 250°C - 550°C. These results are in good agreement with calculated pseudo-sections but are inconsistent with parts of the previously published retrograde paths, whose low-pressure high-temperature results are likely offset.

Interestingly, chlorite and illite seemingly at textural equilibrium were very rarely computed as such. This might be explained by 1) inadequacy of the thermodynamic models at the latest conditions of re-equilibration, 2) small scale inter-stratification of clay minerals making electron microprobe measurements inaccurate, 3) preferential re-equilibration of one phase. Therefore in this case, the link between deformation microstructures and mineral recristallization cannot be identified a priori. However, detailed analysis of the variations of composition of the chlorite-illite parageneses gives information on their structural position into the deformation microstructures, which in turn gives insights into the chronology and progressive development of shear bands, pressure shadows and C/S structures.