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Weakening processes in thrust faults: example of the Monte Perdido thrust fault (South Pyrenean orogenic prism, Spain).

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In thrust and fault-belts, the development of low angle thrust faults composes a real mechanical paradox. Although fluid pressure is an important parameter controlling fault reactivation, the presence of fluid could be responsible for fluid-rock interaction and trigger the apparition of weaker hydrous minerals.

In this study, we aim to decipher the mechanical processes accompanying the shear surfaces reactivation in thrust faults. The current investigations focus on the Monte Perdido thrust fault (south Pyrenean orogenic prism). The fault zone consists of an interval of intensely deformed clays-bearing rocks bounded by major shear surfaces. Structural analysis in the fault zone evidence the presence of shear-surfaces veins developed at a low angle with principal stress. Petrographic, SEM and TEM observations coupled to geochemical and thermometric analysis in the fault zone highlighted two principal stages of deformation:

The first stage corresponds to the development of calcite shear veins by the reactivation of ancient weakness structures. Stable isotope analysis on calcite cement from shear veins and their host sediments revealed that fault involved in a closed hydrological system facilitating an increase of fluid pressure. The spatial relationships existing between shear veins and cleavage seams attest that pressure solution is the major deformation process. Applying the 2D reactivation model (Sibson, 1985) we determined that shear reactivation was possible under suprahydrostatic fluid pressure ($P_f > \sigma_3$).

The second stage corresponds to shear reactivation involving clay minerals. Detrital chlorite and illite were affected by dissolution recrystallization processes. Chlorite precipitated along shear surface whereas illite recrystallized along cleavage surfaces perpendicular to σ_1.

These contrasted results allow to propose a model of fault reactivation. The incremental reactivation of the previous shear surfaces was facilitated by a suprahydrostatic fluid pressure. Furthermore, some evidences of hydrostatic fluid pressure during calcite cement precipitation support that incremental shear surface reactivation follows a fluid pressure cycle. Pressure solution processes triggered a calcite departure from host sediments to veins increasing the relative clay minerals content. As a result, the host rock frictional coefficient decreased from 0,65 to 0,25.

Consequently, during the last stage of deformation, shear surfaces could be reactivate without a high fluid pressure contribution. The presence of high illite and chlorite content in host sediment and along shear surfaces acted as a fault weakening, facilitating stable creeping deformation.