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Syntectonic fluid flow and fluid compartmentalization in a compressive basin: Example of the Jaca basin (Southwest Pyrenees, Spain)

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During compressive events, deformation in sedimentary basins is mainly accommodated by thrust faults emplacement and related fold growth. In such a structure, thrust faults are generally rooted in the basement and may act as conduits or barriers for crustal fluid flow. However, most of recent studies suggest that fluid flow through such discontinuities is not so evident and depends on the structural levels of the thrust inside the fold-and-thrust belt. In order to constrain the paleofluid flow through the Jaca thrust-sheet-top basin (Paleogene southwest-Pyrenean fold-and-thrust belt) we focus our study on different thrust faults located at different structural levels. The microstructures observed in the different studied fault zones are similar and consist of pervasive cleavage, calcite shear and extension veins and late dilatation veins. In order to constrain the nature and the source of fluids involved in fluid-rock interactions in fault zones, a geochemical approach, based on oxygen and carbon stable isotopes and trace elements on calcite, was adopted on the different vein generations and host rocks. The results suggest a high complexity in the paleo-hydrological behaviors of thrust faults evidencing a fluid-flow compartmentalization of the basin. North of the Jaca basin, previous studies in the southern part of the Axial Zones showed the contribution of deep metamorphic water, probably derived from the Paleozoic basement, along along fault zones related the major Gavarnie thrust. Contrarily, in the northern part of the Jaca basin, we evidence the contribution of formation water during the Monte Perdido thrust fault activity. These data suggest a closed hydrological fluid system where distance of fluid flow did not exceeded 70 m. On the other hand, the Jaca and Cotiella thrust faults, both located more to the south in the basin, are characterized by a composite fluid flow system. Indeed, stable isotopes and trace elements compositions of the first generation of calcite veins evidence a relatively closed paleohydrological system, whereas the second calcite vein generation, which is probably associated to the late tectonic activity of the basin, indicates the contribution of both meteoric and marine waters. Based on these results, a schematic fluid-flow model is presented. This model allows to visualize three main fluid flow compartments along a N-S transect.