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Opening of the fluid system above basement shear zones during inversion of pre-orogenic sedimentary basins (External Crystalline Massifs, western Alps)

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At mid-crustal levels, rock permeability is believed to be very low except in active fault/shear zones. In sedimentary rocks undergoing tectonic burial during collision shortening, fluid flow is thus considered to be restricted to the rock matrix, until the fluid system locally opens during strain localization in fault/shear zones. This has been especially suggested in the Dauphinois European proximal margin buried below the internal Alpine units.
In this contribution, we present new structural and geochemical data from the External Crystalline Massifs (ECM) of the western Alps, where alpine shortening is accommodated in inverted pre-orogenic basins (inherited from Tethys rifting) by dysharmonic folding in the sedimentary cover above basement shear zones (a few hundred meters wide). Three successive sets of calcite/quartz veins developed in the cover during the entire shortening phase. Oxygen/carbon isotopic data and cathodoluminescence observations suggest that whatever the vein generation, most of the vein material was locally derived from the host-rock by pressure-solution, and could result from small-scale transport via fluids released locally by dehydration metamorphic reactions. Trace element analyses however indicate that a limited amount of basement-derived fluids have flowed in the veins of the sedimentary cover located just above basement shear zones. This supports that (1) the fluid system has locally been opened to basement-derived external fluid since the beginning of shortening of the cover, (2) the opening of the fluid system and the flow of basement-derived fluids predate the propagation of the basement shear zones in the sedimentary cover, and (3) shortening was synchronous in the basement and in the cover. In a second step, such a large-scale fluid flow likely increased drastically when basement shear zones propagated in the cover, as shown by isotopic data in central Alps.
Finally, on the basis of textural equilibrium between quartz and calcite in veins, microthermometry coupled with stable isotopic analysis provides estimates of both fluid temperatures and pressures. The fluid pressure was probably close to lithostatic, thus maintaining fluid overpressures which could, in turn, explain the continuous development of veins at depth during shortening.