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Thermicity and fluid flow related to the evolution of the South Pyrenean Foreland Basin (SPFB)

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The East-West trending South Pyrenean Foreland Basin (SPFB), formed during the upper Cretaceous and the early Miocene due to the collision between Iberian and European plates, is filled by marine to continental deposits affected by a set of successive southvergent thrusts. In the western part of the SPFB (Jaca basin, Spain), from the North to the South the basin is subdivided into four parts: the internal Sierras, the turbiditic basin, the molassic basin and the external Sierras.

In order to better constrain the fluid flow dynamic and the thermal regime of the basin during its tectonic evolution, we propose to estimate the temperatures and the O and C isotopic signatures of fluids, as well as the maximum temperatures recorded by pre- to syn-tectonic sediments of the Jaca basin.

The C and O isotopic composition has been measured on ∼100 veins and host sediment samples. The peak temperatures have also been estimated on 80 bulk rocks and calcite/quartz veins using a combination of several techniques, including Raman Spectroscopy of Carbonaceous Material, vitrinite reflectance, fluid inclusion microthermometry and mass-47 clumped isotopes.

We show that in most tectonic fractures, primary fluid inclusions are characterized by moderate salinities (∼2.5 wt%) compatible with connate or evolved meteoric waters, with increasing meteoric signature in the south of the basin. As suggested by temperature determinations and stable isotopes, involved fluids were generally in thermal and isotopic equilibrium with the host sediments, suggesting a low fluid-rock ratio (i.e. no significant fluid flow). These results support previous speculations of moderate fluid-flow through thrust faults and the hydrological compartmentalization of the Jaca basin during deformation (Lacroix et al., 2014).

In addition we demonstrate that measured peak temperatures rapidly decrease southward, from ∼240°C±30°C in Cretaceous to Eocene sediments located in the North of the basin close to the axial zone, to 60°C±30°C in the external Sierras. A temperature up to 240°C in the lower turbiditic basin cannot be explained satisfactorily from balanced cross sections and standard geothermal gradient in a foreland basin (∼15°C/km). In addition, local positive thermal anomalies are reported close to the thrust faults (Torla to the east, Sigües to the west).

We envisage several hypothesis to explain 1) the high burial temperature recorded in turbidites, and 2) the local thermal anomalies. Those include the remanence of the mid-Cretaceous high heat flow identified in the northern part of the orogenic prism, circulation of hot fluids, tectonic load or the effect of deformation.