Fluid circulations associated with the necking of the crust: the example of the Mont-Blanc detachment fault

Nicolas Dall'asta1, Guilhem Hoareau1, Gianreto Manatschal2, and Charlotte Ribes3

1Université de Pau et des Pays de l’Adour, E2S UPPA, CNRS, LFCR-France
2Université de Strasbourg, CNRS, ITES UMR 7063, Strasbourg F-67084, France
3TOTAL SA - Centre Scientifique et Technique Jean Féger (CSTJF) – TOTAL – France

The external crystalline massifs of the Alps, which include the Mont-Blanc massif, are found in between the external and internal parts of the orogen. The external parts correspond to the proximal domain of the Alpine Tethys (Helvetic domain), whereas the internal part corresponds to the former distal domain of the margin (Penninic domain). Therefore, the Mont-Blanc massif is a key place for understanding the proximal-distal transition during Jurassic rifting of the Alpine Tethys.

Despite numerous seismic observations at modern passive margins, the tectono-sedimentary and fluid evolution recorded in these domains called necking zone remain poorly understood. Many questions remain concerning the thermal evolution, the origin and composition of the fluids, their link to large-scale hydrothermal systems, and the impact of element transfer on the diagenesis of syn-rift sediments.

Here we focus on the Col du Bonhomme (southern Mont-Blanc massif near Bourg St-Maurice, France), where late Triassic / early Jurassic to late Jurassic sediments preserve pre-Alpine contacts between the sediment and the basement. The syn-rift sedimentary tract is composed of Sinemurian to Pliensbachian sandstones called “Grès Singuliers”, lying unconformably above the pre-rift and over an exhumed fault plane corresponding to the top basement.

Characterization of the faults and overlying sediments requires a multi-scale and multi-disciplinary approach combining field observation, petrography, sedimentology, structural geology, and geochemistry. The protolith of the fault rocks is a Variscan migmatitic gneiss. The damaged zone consists of cataclasites and the core zone is made of black gouge. The gouge is overlaid conformably by Liassic sandstones that contain reworked clasts of cataclasite. The observations that the top basement fault is cut by a Pliensbachian high-angle normal fault and Triassic clasts occur in the gouge enables to date this fault as Early Jurassic.

At the micro scale, the basement shows hydration leading to chloritization of biotite and sericitisation of feldspaths (orthoclase and plagioclase). A strong hydration-assisted deformation
with increase of deformation toward the fault core leads to the formation of cataclasites. They are composed of quartz, sericite with small remnants of orthoclase, chlorites with secondary pyrites and rutiles. The fault core is a black gouge with grain size comminution and mineral neoformation.

Evidence for fluid flow is observed in the fault leading to the hydrothermal alteration of the basement (sericitisation of feldspah and corrosion of quartz) and the formation of syn-gouge quartz and quartz-adularia veins in the black gouge (datation using the Rb-Sr an adularia and U-Pb on calcite method is in progress).

Based on our observations we interpret the fault observed at Col du Bonhomme as a Jurassic exhumation fault associated with the necking of the European crust during Jurassic rifting. This preliminary work shows that the fault acted as an important pathway for crustal fluids with important transfer of silica and at least K, Fe and Ti. The Col du Bonhomme area gives an opportunity to study fluid circulation and basement alteration along a rift-related detachment fault in the necking domain and therefore to understand fluid-mediated element mobility during rifting.

**Keywords**: Detachment fault, Mont-Blanc massif, Fluid circulation, Alpine Tethys, Necking zone