In situ study of paleofluid circulation in a syn-rift linkage zone: petro-structural context, mineralogical evolution and fluid compositions associated with Cretaceous Na-metasomatism at the eastern border of the Arize North Pyrenean massif

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Résumé

Understanding how deformation, fluids, and mineral changes interact is central to crustal evolution models. The North Pyrenean Zone, located in the Pyrenean retrowedge, corresponds to an inverted early-Cretaceous rift leading to mantle exhumation. It comprises Mesozoic basins and Variscan basement massifs. Key rifting markers include: (i) thick Albian-Cenomanian detrital sequences, (ii) peridotite bodies reworked into syn-rift sediments, (iii) HT-LP metamorphism of pre-/syn-rift series, and (iv) large-scale metasomatism, evidenced by several talc schists and albitite occurrences. The 3D-4D fluid reservoir model linked to this metasomatism remains poorly constrained.
Our study focuses on the eastern part of the Arize Massif, which exposes a Variscan section from migmatites in the south to low-grade Carboniferous schists in the north. Its northern and eastern borders correspond to a curved fault transitioning from N100∘E-oriented normal fault in the north to N–S-oriented left-lateral fault in the east. This fault separates two structural domains: to the east, the Saint-Barthelemy Massif shows a gently dipping, N100∘E-oriented foliation, while to the west, the eastern Arize shows a N140∘E-oriented left-lateral fault network and a kilometer-scale fold with a steeply-plunging fold axis (304∘/62∘). This fold, affecting the foliation, hosts all metasomatized rocks.

At structurally shallower levels (Carboniferous), the fault network is filled by Fe-mineralization or massive quartz. At deeper levels, pervasive albitization is associated with a three-stages alteration: (i) biotite chloritization and quartz disappearance; (ii) albite replace feldspars; (iii) calcic paragenesis crystallization and neoformed albite. Locally, a late quartz, chlorite ± carbonates assemblage precipitated in the secondary porosity. Initial results show that fluid inclusions trapped in metasomatized apatite and late quartz contain H2O-NaCl-CaCl2 brines (≈ 15% salinity). To further characterize albitization processes, microthermometric, microstructural, geothermometric, and geochronological analyses are ongoing.
These data reveal the functioning of a N140∘E linkage-zone connecting two N100∘E rift segments. High fault connectivity favored deep fluid percolation. We propose seawater-derived fluids interacted with Triassic evaporites before migrating into the basement. Upward flow,

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progressively enriched in Fe through albitization at intermediate levels, controls Fe mineralization higher up. This integrated study highlights the role of linkage-zones in fluid flow in thinned continental crust, with implications for hydrothermal and geothermal systems.

Mots-Clés: Pyrenean rift system, linkage zones, albitization, hydrothermal alteration, structural inheritance