Characterization of meteoric water infiltration in Variscan shear zones

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Crustal-scale shear zones are sites of significant fluid circulation. The Armorican Massif (AM) and the French Massif Central (FMC) are part of the internal zones of the Variscan Belt, where leucogranites were emplaced within ductile shear zones during the Late Carboniferous. Combining structural, microstructural, hydrogen (δD) and oxygen (δ18O) isotope and geochronology of syntectonic granite, we determined the mechanisms of fluid flow and fluid-rock interaction in these fossil hydrothermal systems.

The δD values of muscovite (δDMs) allowed us to determine the source of fluids that infiltrated different types of shear zones in the AM. Combined with temperatures of hydrogen isotope exchange deduced from quartz microstructures, EBSD and Ti-in-Ms thermometry, we calculated the δD values of water (δDwater) present during high-temperature deformation. A 41‰ difference in δDwater values from deep to shallow crustal levels reveals a mixing relationship between D-enriched metamorphic/magmatic fluids (δDwater ~ -33‰) and that of meteoric fluids with δDwater values as low as -74‰. This is further supported by fluid inclusions in quartz grains that contain very low salinity water (0 to 7 wt% eq. NaCl) and which have intermediate δD and δ18O values.

In the FMC, syntectonic leucogranites from the Millevaches massif yield δDMs values as low as -116‰ that indicate an incontestable signature of meteoric fluids. The penetration of meteoric fluids occurred between ~320 and 300 Ma (40Ar/39Ar and U/Th-Pb) through brittle fractures in the upper crust while the emplacement of high-grade metamorphic rocks sustained fluid convection at depth.