

Tracing meteoric fluids in fault and detachment systems

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Meteoric fluids play a central role in understanding the mechanics and deformation processes of fault and shear zones in the continental crust. At the same time the hydrogen (and to some degree oxygen) isotopic compositions of meteoric fluids reflect changes in the continental hydrological cycle such as orographic rainout, atmospheric circulation or continental (paleo-)climate. Tracing the isotopic composition of such meteoric fluids through time is therefore an important tool in understanding the interactions of Earth surface and geodynamic processes. Once combined with adequate geochronological techniques stable isotope geochemistry of fault and shear zone-related mineral proxies thus allows us to investigate the role of fluids within various compartments of continental (and in some cases oceanic) crust.

Here we present select examples of hydrogen isotope geochemistry from syntectonic hydrous minerals in fault and shear zone environments that collectively document that meteoric fluids can be traced to significant depths during deformation. In particular we highlight how combined geochronological and isotope geochemical data can track changes in fluid composition through time either as a result of changing meteoric water compositions or due to changes in fault and shear zone permeability.

Understanding the role of fluid interactions within actively deforming crust is a key element in assessing natural hazards and hence a question of large societal relevance. We advocate that the study of such active deformation zones –past and present– will require a concerted effort from various disciplines including careful characterization of the timing and conditions of deformation events through time.