Thermodynamic and trace element modeling to quantify fluid fluxes and fluid-rock interaction in high pressure rocks from the Sesia Zone (Western Alps)

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The amount and composition of fluids percolating through high pressure rocks and the effect of resulting fluid-rock interaction on fluid and wall rock composition has been constrained by thermodynamic and trace element modeling of partially overprinted blueschist-facies rocks from the Sesia Zone (Western Alps). Deformation-induced differences in fluid flux led to a partial preservation of pristine mineral cores in weakly deformed phengite and sodic amphibole grains that were used to quantify Li, B, Sr and Pb distribution during mineral growth, -breakdown and -modification induced by fluid-rock interaction. Our results show that Li and B budgets are strongly fluid-controlled, thus acting as excellent tracers for fluid-rock interaction processes, whereas Sr and Pb budgets in our samples are mainly controlled by the fluid-induced formation of epidote. Our calculations show that fluid-rock interaction caused significant Li and B depletion in the affected rocks due to leaching effects, which in turn leads to an up to five-fold enrichment of these elements in the percolating fluid. Depending on available fluid-mineral trace element distribution coefficients modeled fluid rock ratios necessesary to produce the observed trace element patterns in the affected minerals were up to 1 in weakly deformed samples and at least 1 – 4 in shear zone mylonites. These values can be used to determine time integrated fluid fluxes that were up to 4. 10^2 m^3m^{-2} in the weakly deformed rocks and at least 2 – 8. 10^3 m^3m^{-2} in the mylonites. Combined thermodynamic and trace element models help to quantify metamorphic fluid fluxes and the associated element transfer in complex, reacting rock systems and to better understand commonly observed fluid-induced trace element trends in metamorphic and magmatic rocks and minerals from different geodynamic environments.

Evidence for a Hawaii-Emperor bend in the Rurutu hotspot track

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Hotspots have long been used as an absolute and fixed reference frame for modeling plate motions. However, the paths of hotspot tracks may be complicated by factors related to mantle flow and/or plume motion. The two longest, continuous hotspot tracks recognized on the Pacific Plate, the Hawaiian-Emperor and Louisville chains, exhibit different behavior prior to ~50 Ma, where the Hawaiian-Emperor chain shows a pronounced 'kink', while the Louisville chain is gently curved [1]. Furthermore, the Hawaiian hotspot might have incurred a ~15° southern shift between 80 and 50 Ma, while the Louisville hotspot seems to have behaved more stationary (or moving west to east) over the same time period. The causes of these differences are not well understood, and they have some important ramifications for absolute plate motion models and our understanding of mantle dynamics. Despite suggestions to retire the plume hypothesis, a more conciliary view explains the variety of observations with three different types of hotspots. This would imply the major hotspots may still reflect plate motion with respect to the mantle, although a component of plume motion could also be recorded by the orientation of a volcanic chain.

Recent geochemical evidence and radiometric ages suggest that the Rurutu hotspot is long-lived (100 Ma) [2, 3] and follows a track midway between Hawaii and Louisville. Like Hawaii, the Rurutu hotspot exhibits a sharp bend in the Tuvalu region between Samoa and the Gilberts Ridge, around 35-55 Ma following the latest absolute plate motion models. The hotspot volcanoes are characterized by HIMU-type isotopic compositions [3], distinguishing them from other hotspots such as Samoa [4]. Therefore, the Rurutu hotspot may provide a third, long-lived Pacific hotspot track that can help to deconvolve the effects of plate motion from plume motion in determining the paths of hotspot tracks.

[1] Tarduno *et al*. (2009) *Science* **324**, 50–53. [2] Koppers *et al*. (2007) *Geochem. Geophys. Geosyst.* **8**, 10.1029/2006GC001489. [3] Konter *et al*. (2008) *EPSL* **275**, 285–295. [4] Jackson *et al*. (2011) *Geochem. Geophys. Geosyst.* **11**, 10.1029/2010GC003232.