Composition of subduction zone fluids: experiments and eclogites

Jörg Hermann[1]

[1] Institute of Geological Sciences, University of Bern, 3012 BERN, Switzerland.

Subduction zone fluids trigger wet melting in the hot mantle wedge, and thus induce new continental crust formation along subduction zones. The composition of subduction zone fluids can be constrained to a first order by comparing primitive arc lavas with MORB, providing evidence that these fluids are enriched in H_2O, large ion lithophile elements such as Sr and Ba and light rare earth elements. The great majority of these elements are hosted in subducted sediments and altered oceanic crust whereas H_2O mainly derives from subducted ultramafic rocks. Understanding this process thus requires knowledge of the interaction of aqueous fluids derived from metamorphosed ultramafic rocks with high-pressure metasediments and oceanic crust – key investigations of petrologists studying eclogite facies rocks!

Experimental studies have suggested that the "subduction component" might be a slab melt, supercritical fluids, melange diapirs or saline fluids. A recent study has evaluated the Ba-Sr-H_2O systematics of these different scenarios and has suggested that slab melting is the most efficient way to produce the "slab component" (Li *et al.*, 2022). This requires that fluids released from the ultramafic rocks interact with subducted sediments and altered oceanic crust at temperatures > 700°C at sub arc depth. New experimental results on chlorite stability in ultramafic rocks indicate that chlorite dehydration reactions might be of prime importance to deliver H_2O for melting of the slab (Lakey & Hermann, 2022).

Most oceanic eclogite facies rocks are exhumed from fore-arc conditions where the slab and the mantle wedge are decoupled. The heating of the slab leading to chlorite dehydration and slab melting is related to the partial coupling between the down-going slab and the mantle wedge. The eclogite facies ultramafic-mafic rock suites from the Central Alps represent a rare case, where this heating and partial melting is documented. Aqueous fluids released from the breakdown of chlorite in peridotites triggered partial melting in the associated eclogites at conditions of 800 ± 60 °C and 3.0 ± 0.3 GPa. Leucosomes in eclogites consist of quartz, plagioclase and clinozoisite, are rich in SiO_2, Al_2O_3 and CaO and display elevated Pb, U, Th, Sr and LREE similar to the 'subduction component' in arc lavas. Extreme conditions of melting at 950-1000°C are documented in fragments of subducted continental crust such as the diamond-bearing gneisses from the Kokchetav massif. Rare melt inclusions in peak metamorphic garnet show extreme enrichments in LREE and Th, with LREE>LILE, Th>U and H_2O/Ce that are incompatible with the subduction component in arc magmas (Stepanov *et al.*, 2016). The combination of experimental results and detailed investigation of eclogite-facies rocks therefore provides important information on fluid-mediated element recycling in subduction zones and the formation of new continental crust.

Li, H., Hermann, J., Zhang, L., 2022. Melting of subducted slab dictates trace element recycling in global arcs. *Science Advances* 8, eabh2166.

Lakey, S., Hermann, J., 2022. An Experimental Study of Chlorite Stability in Varied Subduction Zone Lithologies with Implications for Fluid Production, Melting and Diapirism in Chlorite-Rich Mélange Rocks. *Journal of Petrology*, in press.

Stepanov, A.S., Hermann, J., Rubatto D., Korsakov A.V., Danyushevsky L.V. (2016). Melting History of an Ultrahigh-pressure Paragneiss Revealed by Multiphase Solid Inclusions in Garnet, Kokchetav Massif, Kazakhstan. *Journal of Petrology*, 57, 1531-1554.