EGU Galileo Conference
GC4-Subduction-36, 2018
Exploring new frontiers in fluids processes in subduction zones

Material Transport in Subduction Zones: Not all Flow is Fluids (invited)

Horst Marschall (1,2)
(1) Goethe Universität Frankfurt, Institut für Geowissenschaften, Frankfurt am Main, Germany (marschall@em.uni-frankfurt.de), (2) Dep. Geology & Geophysics, WHOI, Woods Hole, MA 02543, USA

Magmas produced along convergent plate margins show geochemical evidence for the contribution to their source of components derived from the subducting slab. The magma source lies in the wedge-shaped region of the mantle between the down-going and the overriding plates. Much discussion has focussed on the mode of transport of the slab-derived components from various sources within the subducting slab to the magma-source region in the mantle wedge. Hydrous fluids and silicate melts have classically been favoured as the major vehicles of long-distance material transport in this context. However, more recently models that include mixing at the slab-mantle interface followed by solid-state diapirism have been developed [1].

Metamorphic dehydration of slab-materials is the process by which the hydrated oceanic crust (including sediments and serpentinites) is transformed into relatively dry high-pressure rocks. This releases hydrous fluids (or silicate melts) that carry solutes from their original sources within the slab to the slab-mantle interface [2]. Detailed field studies in terrains with exhumed high-pressure rocks have produced evidence for transport of fluids along short-lived channels that act as transport pathways over distances beyond the scale of the outcrop and possibly across the entire thickness of the subducted crust [3]. However, fieldwork has also revealed evidence for intense mechanical mixing at the slab-mantle interface between solid crustal components of the slab and the overlying ultramafic mantle [1, 4]. Advective and diffusive metasomatism controls the chemical and mineralogical alteration of this mélange material. Any buoyant fluids that are produced in the slab have to migrate into this dynamic reaction zone from where they can either progress into the overlying mantle or be guided upwards parallel to the slab-mantle interface toward the trench.

Fluids therefore play a key role in the formation of the mélange zone at the slab-mantle interface and in its enrichment in fluid-mobile elements. However, it is not clear what their role is in connecting the mélange zones (or the slab itself) to the source region of arc magmas. Proponents of long-distance fluid-transport envisage the formation of arc magmas by melting of the mantle wedge that is metasomatized by slab-derived fluids and/or melts. However, a recent geochemical meta-data study including all available data for volcanic rocks from eight global oceanic arcs demonstrated that any such model is incompatible with the observed geochemical data [5].

In contrast, the mélange-diapir model is in agreement with the observed geochemical compositions in all investigated arcs [5]. Diapiric up-rise of buoyant mélange material into the hot corner of the mantle wedge has been identified in analogue and high-resolution numerical experiments and provides a mechanism to transport the characteristic slab signature from the slab-mantle interface into the source region of arc magmas. Long-distance material transport from the slab surface to the arc-magma source region, thus, likely operates in the form of solid diapirs, not hydrous fluids or melts.

[1] Marschall, Schumacher (2012) Nat.Geosci.; [2] Zack, John (2007) Chem.Geol.; [3] John et al. (2012) Nat.Geosci.; [4] Bebout, Barton (2002) Chem.Geol.; [5] Nielsen, Marschall (2017) ScienceAdv.