Fluid processes in subduction zones and global water circulation

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Water within the Earth, including OH and H in minerals, may play an important role in the planetary evolution, yet its distribution and circulation are poorly constrained. Seismic observations, e.g., those based on dense networks over the Japan arcs, suggest deep subduction of water and dehydration of the slab [1 and the refs. therein]. Geochemistry of volcanic rocks is useful for quantifying the amount and composition of slab-derived fluid, and suggests a typical range from 0.1 to 1 wt.% H_2O in the mantle wedge with regional variations according to the tectonic settings [2]. Numerical models provide a consistent view, in which fluid flow with local chemical equilibration explains the above observations [3]. In addition, these models and water solubility to minerals at high pressures [4] imply that a boundary layer with several 1000 ppm H_2O hosted by NAMs subducts to depths greater than 300 km.

The deeply subducted water, especially in the lower mantle, is not well mapped by geophysical means: seismic velocity may be influenced by major element compositions and temperature, while electrical conductivity is sensitive to the amount of water but provides a poor spatial resolution at depths [5]. Geochemistry of oceanic basalts can be used as a probe for the subducted components. Statistical analysis on the mantle isotopic variability suggests that such a component is in fact inherited in the mantle and forms geographical domains, possibly related to the extensive subduction having surrounded the supercontinents in the past, Pangea, Gondwana and Rodinia [6]. Repeated formation-breakup of supercontinents seems to be recorded in the mantle geochemistry, controlling the global material circulation.

[1] Hasegawa *et al*. (2009) *Gondwana Res*. **16**, 370-400. [2] Nakamura *et al*. (2008) *Nature Geosci*. **1**, 380-384. [3] Iwamori (2007) *Chem. Geol*. **239**, 182-198. [4] Bolfan-Casanova (2005) *Mineral. Mag*. **69**, 229–257. [5] Karato (2011) *EPSL* **301**, 413-423. [6] Iwamori *et al*. (2010) *EPSL* **229**, 339-351.

Mantle compositional variability constrained from arc and oceanic basalts

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Mantle compositional variability has been extensively studied using oceanic basalts, including mid-oecan ridge basalts (MORB) and ocean island basalts (OIB), as geochemical 'messages' from the mantle [1]. However, the spatial coverage of ridges and ocean islands is insufficient for resolving even a global distribution of compositional variability (Fig.1). Here we discuss the mantle compositional variability in subduction zones that extend over a long distance comparable to mid-ocean ridges, mostly around the Pacific Ocean (Fig.1). As a result, we are able to map global geochemical domains, when combined with the mantle compositional variability obtained from MORB and OIB.

Arc basalts associated with subduction are the products of interaction between slab-derived materials and mantle wedge beneath the arcs. In order to extract the compositional variability of the mantle, influence of the subducted materials needs to be evaluated. Based on Sr, Nd and Pb isotope ratios mainly from the GEOROC and PetDB databases, and using the multivariate analyses, in particular, Independent Component Analysis, it has been found that depleted portions of the arc basalts well represent the compositions of mantle wedge that has not been fluxed by slab-derived materials. These portions lie on a compositional plane that is well defined by MORB and OIB, and can be decomposed into two independent components. Consequently, geographical domains in terms of 'anciently subducted component' ('IC2' in [2]) have been found and its implications on mantle dynamics are discussed.

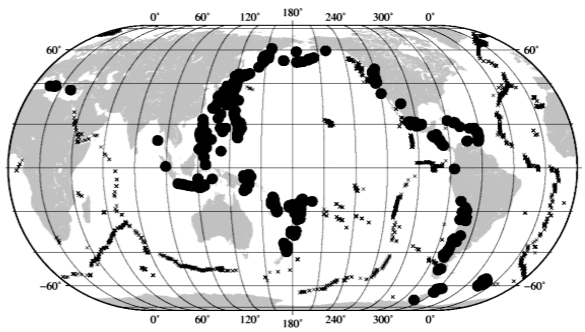

Figure 1: Distribution of oceanic basalts (small crosses) and arc basalts (solid circles) used in this study.

[1] Hofmann (1997) *Nature* **385**, 219-229. [2] Iwamori *et al*. (2010) *EPSL* **229**, 339-351.