Role of Water in Magma Genesis of a Hybrid Plume with Recycled Eclogite Component

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Introduction: It is believed that magma genesis in mantle plume is largely influenced by recycled oceanic crust component (e.g., Columbia River Basalt; Takahashi et al., 1998; Hawaii, Takahashi & Nakajima., 2002; Sobolev et al., 2007). OIBs derived from mantle plumes are generally higher in H₂O and CO₂ contents than MORB. In order to explore the role of water during magma genesis in a hybrid plume with recycled eclogite component, a series of high-T and high-P experiments were conducted.

Experiments: High-pressure experiments were carried out under a pressure of 2.85GPa with a piston-cylinder, by using spinel lherzolite KLB-1 (Takahashi 1986) and a relatively MgO-rich Columbia River basalt (Takahashi et al. 1998) as layered starting materials (Takahashi & Kushiro 1983). Temperature ranged from 1400 to 1540°C, with water content of 1wt%, 5wt% added in peridotite layer. Wet experiments were carried out with Re-Pt double capsules, while dry experiments with graphite-Pt double capsules.

Results:
1) Anhydrous conditions: 1460°C−1540°C, 3h
   In the case of anhydrous experiments, when peridotite remained subsolidus, molten basalt was separated from peridotite by thin opx band formed by the chemical reaction between Si-rich partial melt of eclogite and olivine in the peridotite matrix, therefore the chemical reaction between basalt and peridotite layer was proceeded only by solid diffusion.
   As peridotite reached its solidus between 1520°C and 1540°C, fully molten basalt melt and melt pockets from peridotite layer linked, judging from sharp changes in MgO and FeO/MgO ratio. Extensive chemical mass transport took place by chemical diffusion and liquid percolation. However, Si-content remained nearly constant even at temperatures above solidus (see Fig.1).

2) Hydrous conditions: 1400°C−1500°C, 3h
   In wet experiments (with 1wt% H₂O in peridotite layer originally), extraction of water took place from peridotite layer into basaltic melt (water was detected by FTIR) giving little influence to the melting process of peridotite.
   On the other hand, in wet experiments (with 5wt% H₂O in peridotite layer), basalt started melting even at 1400°C. At 1480 and 1500°C, melting process in both layers enhanced the chemical exchange of both sides. Fig.2 shows BEI of P900 in which most olivine was converted to opx by chemical reaction with basaltic melt. Thus SiO₂ in basalt decreased while MgO increased sharply (see Fig.2).

To summarize, H₂O promotes melting of only basalt layer under low water concentration, while it enhances melting and chemical interaction between both layers leading to formation of Si-poor and MgO-rich melts in basalt layer by the reaction: oliv + melt = opx + melt

Discussion: In an upwelling mantle plume with recycled oceanic basalt components, water may distribute in peridotite in the deep mantle (i.e., silicate spinel contains up to 3 wt% H₂O). Present experiment implies that extraction of H₂O from peridotite to basalt happens as plume rise, resulting in melting of basalt at lower T and higher P than their anhydrous counterparts. Thus provides a possibility for genesis of silica-poor alkali basalts in most OIB regions.

Fig.1 MgO-SiO₂ of melts in hydrous and anhydrous runs.

Fig.2 BEI of run P900 (1480°C, 3h, 5wt% H₂O)