SIT03-06 Room:106 Time:May 25 15:30-15:45

Experimental Study on the Hawaiian Plume with Recycled Eclogite: Part-1: Constraints on potential temperature

TAKAHASHI, Eiichi[1*] ; GAO, Shan[1]

[1]Magma Factory, Earth and Planetary Sciences, Tokyo Institute of Technology

Potential mantle temperatures (PMT) of plumes are thought to be significantly higher than shallow asthenosphere (200~300C). Excess PMT of the plume is very important in calculating the plume flux among the heat budget of the Earth dynamics (e.g., Sleep, 1990). In order to produce large amount of tholeiite magma in the shield building stage at the base of old Pacific plate, potential temperature of the Hawaiian plume is considered to be at least 300C higher than asthenosphere judging from the peridotite dry solidus at 3 GPa, base of the oceanic plate (e.g., Watson & McKenzie, 1991).

If large amount of recycled eclogite component is involved in the genesis of LIP magmas (e.g., Hawaii hot spot: Hauri, 1996; Takahashi & Nakajima, 2002, Sobolev et al., 2007, Columbia River flood basalt: Takahashi et al., 1998), PMT of the plumes which have been estimated based on peridotite dry solidus alone should be largely in error. For example, Takahashi et al.(1998) concluded that temperature of the initial emplacement stage of the Yellowstone plume may be only 100C higher than normal asthenosphere, based on melting study of the Columbia River basalts. In order to evaluate the role of recycled eclogite in magma genesis of Hawaiian plume, we carried out hig-P and high-T melting experiments. Chemistry of the recycled eclogite will be discussed in Part 2.

High-pressure melting experiments were carried out under dry and hydrous conditions with layered eclogite/peridotite starting materials. Spinel lherzolite KLB-1 (Takahashi 1986) was employed as peridotite component in this study. Two basalt components were tested as recycled crust component: 1) Columbia River basalt (CRB72-180, Takahashi et al., 1998) which is relatively enriched in K, Ti and LREE (K2O?1wt%, TiO2=3.15wt%), N-type MORB (NAM-7, Yasuda et al., 1994) (for REE patterns, see Fig.1 of Gao et al. this conference, Part 2 of this work). The 2.85GPa experiments (corresponding to about 80km depth which is the top most horizon of the Hawaiian plume head) were carried out with Boyd-England type piston-cylinder apparatus at (1460~1540C for dry experiments; 1400~1500C for hydrous experiments), The 5GPa experiments (corresponding to about 150km depth on the plume axis) were conducted by Kawai-type multi-anvil apparatus (1550~1650C for dry experiments; 1350~1550C for hydrous experiments).

Melts formed by reactive melting of dry eclogite and peridotite changes dramatically in the temperature range across the solidus of peridotite KLB-1 from basalt (below dry solidus) to picrite (20-40C above dry solidus). Basaltic melts are not saturated with olivine both at 2.85 and 5 GPa and therefore they are separated by peridotite matrix by Opx film. Chemical reaction between the basalt melt and the peridotite matrix proceeds only slowly by solid-diffusion across the Opx film. In hydrous experiments, solidus of peridotite decreases significantly and therefore the reaction between hydrous melt and the partially molten peridotite matrix proceeds at temperatures below peridotite dry solidus.

Based on present experiments, we propose that potential temperature of the Hawaii plume may be only 100-150C above that of normal asthenosphere. Tholeiite magma in the shield building stage may be formed slightly under hydrous condition near the dry solid of peridotite (1450-1500C at about 3 GPa). Chemical distinction between Hawaiian shields (e.g., Mauna Loa and Kilauea) might correspond with difference in mixing ratio or degree of the chemical reaction between the recycled eclogite blocks and the ambient peridotite.

Potential mantle temperature in other mantle plume (OIB, flood basalt, etc) will be discussed in the light of present experiments. Our model predicts lower plume temperatures than most previous estimates. Plume flux may be related to the amount of entrained eclogite than potential temperature.

Keywords: Hawaiian plume, recycled eclogite, magma genesis, potential temperature