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Experimental Study on the Hawaiian Plume with Recycled Eclogite: Part 2, Constraints on Chemistry of Recycled Component

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Introduction: It is believed that recycled oceanic crust is involved in the magma genesis of the Hawaiian mantle plume (e.g., Hauri et al., 1996; Takahashi & Nakajima., 2002; Sobolev et al., 2007). Takahashi & Nakajima (2002) proposed that magma produced near the axis of the plume head may be mixtures of two types of melts 1) basaltic andesite melt formed by melting of eclogite and 2) picritic melts formed by the reactive melting of eclogite and peridotite. However, geochemical feature of recycled oceanic crust component is still under disputed. A sequence of high-T high-P experiments were conducted to figure out constrains of such recycled component. Experimental details are shown in Part 1 of this presentation.

Phase and major elements features:
1) Anhydrous conditions: (CRB: 1460˜1540C, 3h for 2.85GPa; N-MORB or CRB: 1550˜1650C for 5GPa):
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 layers proceeded only by solid diffusion. As peridotite reached its solidus between 1520C˜1540C, 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.
2) Hydrous conditions: 1400C˜1500C, 2.85GPa 3h
In wet experiments (with 1wt% H_2O in peridotite layer originally), extraction of water took place from peridotite layer into basaltic melt (water was detected by FT-IR), giving little influence to the melting process of peridotite. On the other hand, in wet experiments (with 5wt% H_2O in peridotite layer), basalt started melting even at 1400?C. At 1480C and 1500C, melting process of both layers enhanced the chemical exchange of both sides. H_2O 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 melts in basalt.
In the case 5GPa, 1wt% H_2O, coexisted hydrous vapor and hydrous silicate melt generated under temperature 1350˜1450C (about 200C below peridotite dry solidus). Ti, K, P are enriched in the hydrous vapor.
REE features.

Rare earth element patterns: Columbia River basalt is enriched in LREE than N-MORB, run products of this study turned out to have a similar pattern (Fig.1, normalized patttern by CI chondrite)) with their starting material (basalt). Since REE elements prefer to stay in the melt, increasing degree of partial melting will lower the whole REE elements abundance in the melt. REE abundance of lava from Kilauea and Mauna Loa is also plotted in this diagram, showing sharp decline of HREE components in these shield stage lava. Garnet (the key component of eclogite) is the only known mineral that prefers heavy REE. Although garnet together with Cpx are the residual phase at 2.85 and 5 GPa experiments, REE patterns of Kilauea and Mauna Loa are far more depleted in HREE than melts produced by our experiments. .

Discussion: In an upwelling mantle plume with recycled oceanic basalt components, both tholeiitic magma and alkali component could be obtained from hybrid melting of basalt and peridotite. H_2O promotes the melting process and generate more mafic melts. Very depleted HEE pattern of Hawaiian tholeiite might be explained by percolation of partial melt in vertically elongated eclogite blobs in the center of the plume (chromatographic effect). Enriched signature in K , Ti, and LREE in the Hawaiian tholeiite might indicate that source of recycled component in the Hawaiian plume is not NMORB but is more enriched in these incompatible elements (see Fig.1).

Keywords: Hawaii plume, magma genesis, recyled eclogite, chemistry, REE

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