

Reaction experiments between peridotite and melts in process of the mantle circulation

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Introduction

In order to elucidate the chemical fractionation during the material circulation of the mantle and the origin of the source heterogeneity, it is necessary to understand the effect of reaction process between the mantle peridotite and crustal materials. We have carried out reaction experiments on peridotite and basalt at the uppermost upper mantle conditions.

Experiment

We used two materials, JP-1(Horoman Peridotite) and JB-1(Kitamatsuura basalt) for the reaction experiments. The weight ratios of materials are JP-1: JB-1=2:1 and these are encapsulated into graphite heater so that a JB-1 layer is sandwiched by two JP-1 layers. We carried out reaction experiments at pressure of 3GPa and temperature of 1373K using a multi-anvil high-pressure apparatus (MAX90) at Kyushu University. The temperature was monitored with a W3%Re-W25%Re thermocouple. After reaction experiments of desired durations, we examined the polished section of the recovered sample with an energy dispersive X-ray micro-analyzer combined with JEOL PC-SEM 5800LV at Kyushu University.

Result and discussion

In the present experimental condition, stable phase assemblage of basalt composition is known to be partial melt plus crystals, while subsolidus recrystallization progresses in peridotite. We have planned to observe compositional variation of basalt melt, formation of crystals and possibility of infiltration of melt into peridotite matrix at and through the interface of the two materials.

As a results of two experiment with different heating durations (10min and 1hour), both samples shows symmetric layered structures consisting of partial melting basalt, interface zone, and recrystallized peridotite from the center to the end. At the partial melted basalt layer garnet+clinopyroxene is present and the peridotite layer olivine + orthopyroxene +clinopyroxene. At the interface zone, orthopyroxene with a unique composition ($Mg\# = \text{about } 88$, where $Mg\# = \text{molar } 100 * Mg / (Mg + Fe)$) ranged in 15 micron widths close to the peridotite matrix, where that in peridotite is $Mg\# = 91$. Garnet adjacent to orthopyroxene zone and coexisting with basalt partial melt shows pyrope-rich composition, compared to the core regions of basalt partial melt layer.

From these observations, Fe-fertilized orthopyroxene layer is formed by reactions between basalt melt and peridotite at the interface, and pyrope-rich garnet crystallized from Mg-fertilized basalt melt. Orthopyroxene layer and pyrope-rich garnet layer may act as a barrier of the rapid melt intrusion and the element transfer through this zone is expected to keep slow under the control of the volume diffusion in orthopyroxene and garnet. However, as we can anticipate effect of fast grain boundary diffusion of incompatible elements in peridotite matrix even under subsolidus conditions, analysis to verify the possibility is in progress.