The initial stage traces of melt extraction and stagnation observed in the Mariana Trough peridotites

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Basaltic magma transport through the upper mantle peridotite has been discussed on dunite channel formations. Quick (1981) proposed tabular dunite formation as a restite, Kelemen et al. (1995) discussed on extraction of MORB from the upwelling mantle, and Suhr (1999) proposed a model of dunite growth by porous flow-dominant melt migration. Here, we examine to understand an initial stage of melt extraction and stagnation in the upper mantle, using the Mariana Trough peridotite samples collected by JAMSTEC KR02-01 (Arima et al., 2002).

Chiba et al. (2008) reported that the upper mantle residual peridotites beneath the Mariana Trough are composed of lherzolite to lherzolitic harzburgite. These rocks attain 71% of 129 samples examined. The residual peridotite shows a protogranular texture composed of olivine (70-86%), orthopyroxene (10-28%), clinopyroxene (0-8%) and spinel (0.2-1.8%). The major element chemistry of the primary cores of olivine (Mg#=90.0-91.7, NiO=0.31-0.48 wt%), orthopyroxene (Mg#=90.2-91.5, Al_2O_3=2.76-4.58 wt%), clinopyroxene (Mg#=91.0-93.9, Al_2O_3=3.69-5.57 wt%), and spinel (Mg#=67.0-74.6, Cr#=24.0-42.5, TiO_2=0.06-0.22 wt%) indicates a small to moderate degree of partial melting for the residual mantle peridotites.

A careful observation has been done on 11 ultramafic samples of olivine websterite, extremely pyroxene-rich lherzolite and harzburgite, which represent samples indicating initial melt extraction and stagnation within the mantle. These rocks occur as veins 1-5 cm wide and pools more than 3 cm wide, showing an irregularly sutured contact with the wall peridotite. These rocks are composed olivine (34-51%), orthopyroxene (35-47%), clinopyroxene (3-28%) and spinel (0-6%), and are characterized by a porphyroclastic texture. Wall rocks have same modal composition to the above residual peridotites.

The pyroxene-rich ultramafic rocks contain olivine (Mg#=89.7-92.2,NiO=0.30-0.45 wt%), orthopyroxene (Mg#=89.9-92.0, Al_2O_3=2.82-5.61 wt%), clinopyroxene (Mg#=91.0-93.3, Al_2O_3=3.32-5.91 wt%), and spinel (Mg#=55.0-73.3, Cr#=20.9-47.0, TiO_2=0.02-0.22 wt%). It is suggested from the compositional overlapping with those of residual peridotite that the pyroxene-rich rocks are possibly equilibrium with the upper mantle peridotite.

Origin of the pyroxene-rich rocks from the Mariana Trough can be explained as follows. Partial melting was generated in the upper mantle beneath the Mariana Trough as a result of pressure decrease by back-arc basin opening. A part of generated initial melts migrating in the residual peridotite stagnated as the pyroxene-rich ultramafic rock veins and pools. This suggests that the modal variation of pyroxenes was due to amount of the initial melt stagnated in the wall peridotites.

Dunite and gabbro in the wall harzburgite beneath Hess Deep is considered as a product of late stage melt evolution and transport in shallow mantle (Dick and Natland, 1996). By contrast, the pyroxene-rich ultramafic rocks indicate an initial stage of partial melt extraction and migration, as reported from the Mid-Atlantic Ridge (Juteau et al., 1990).

References

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