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EVOLUTION OF THE HOROMAN PERIDOTITE COMPLEX AND ITS IMPLICATIONS FOR THE ORIGIN OF HETEROGENEOUS MANTLE

Tomoaki Morishita and **Shoji Arai**

Department of Earth Sciences, Faculty of Science, Kanazawa University, Kakuma-machi, Kanazawa, Japan.

ABSTRACT

Mantle heterogeneity is very important for magma genesis within the upper mantle. Melting of the heterogeneous mantle consisting of peridotite and mafic (or pyroxenite/eclogite) rocks will yield voluminous and compositionally diverse magmas upon a melting process because of selective fusion of the mafic layers (e.g., Yasuda et al., 1994; Hauri, 1996; Takahashi et al., 1998). Melting experiments using heterogeneous mixtures of peridotite and MORB as a starting material, for example, have just started to examine this problem (Yaxley and Green, 1998; Kogiso et al., 1998). Mantle heterogeneity demonstrated by layered structure of peridotites and mafic (or pyroxenite/eclogite) rocks is conspicuous in many orogenic lherzolite massifs. We need to know how and when the inhomogeneous mantle materials have been produced.

The Horoman Peridotite Complex, Hokkaido, northern Japan, has two specific features; one is the presence of symplectite, possibly of garnet origin, and the other is a symmetric layered structure characterized by an arrangement of cumulus peridotite and mafic rock in the middle of a series of residual peridotite with increasing melt component outward. The symmetrical layered structure repeats several times with intervals of several meters to a few hundred meters in the complex (Niida, 1984; Obata and Nagahara, 1987; Takahashi, 1992).

Symplectite-bearing rocks in the Horoman complex are divided into three types based on petrography. The first, and the most abundant, is a kind of mantle restite, that is clinopyroxene-rich spinel lherzolite and plagioclase lherzolite. The second is a pyroxenite alternating with cumulus peridotites. The third is pyroxenites, which occur as thin layers in the mantle restite. Mineral assemblages and chemical compositions of the symplectites suggest that they were generally formed by the decompression reaction between pyrope-rich garnet and olivine. The presence of symplectite in cumulus peridotite and pyroxenite suggests the garnet was involved in the formation of cumulates at about 2 GPa or more.

The mafic rocks in the Horoman complex have been divided into several types. One of these mafic layers, which is called Type II layer of Takazawa et al. (in press) or GB II of Niida (1984) and Shiotani and Niida (1984), restrictedly occurs in the cumulus peridotite which is located in the middle of residual peridotite with the symmetric layered structure. Some textural characteristics of the Type II mafic rocks are similar to those of the symplectite-bearing pyroxenites in the cumulus peridotite. The Type II mafic rocks have the same origin as symplectite-bearing pyroxenites, that is the subsolidus breakdown product of garnet-bearing pyroxenites of high-pressure origin to the gabbroic rock at lower-pressure conditions. On the other hand, their geochemical signatures indicated that the Type II mafic rocks were originally formed at lower-pressure conditions (Shiotani and Niida, 1997; Takazawa et al., in press). Textural characteristics of a corundum-bearing Type II mafic rock (Morishita and Kodera, 1998) show that corundum was not stable at the latest P-T conditions of the Horoman complex and require that it had experienced heating and/or decompression.

A possible P-T history for the Type II mafic rock is as follows. (1) Type II mafic rock was formed as a cumulate at lower-pressure conditions from the melts responsible for the formation of the cumulus peridotite. (2) The protolith of Type II mafic rocks had been metamorphosed to garnet-bearing pyroxenite at high P-T conditions during compression due to subduction or convection within the mantle. (3) The complex ascended from the garnet stability field to the plagioclase peridotite stability filed as a diapir. The Type II mafic rocks as a member of the diapir were formed from garnet-bearing pyroxenite through symplectite-bearing rock due to breakdown of garnet and corundum at low pressures.

The Type II mafic rocks have a complex P-T trajectory after it was formed as a member of the layered structure. We favor the possibility that the symmetrical layered structure in the Horoman complex have been repeated by deformation processes (Toramaru, 1997), not by the melting process along multiple parallel cracks (Takahashi, 1992). The melting process, however, had an important role in formation of a stratified lithological unit composed of cumulate rock, residual peridotite and primitive peridotite.

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