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ORIGIN OF HIGHLY REFRACTORY PERIDOTITES: IMPLICATIONS FOR DIVERSITY OF HIGH-MG ANDESITE MAGMA GENESIS

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ABSTRACT

Highly refractory peridotites are defined here as peridotites more depleted in melt components than abyssal peridotite, i.e. peridotites with spinel showing Cr# (Cr/(Cr+Al) atomic ratio) higher than 0.6. These correspond to the type III peridotite defined by Dick and Bullen (1984) and are reported from forearc regions, such as Izu-Ogasawara, Mariana and Tonga trenches (e.g. Bloomer and Hawkins, 1983; Bloomer and Fisher, 1987; Ishii et al., 1992) and from the Kamuikotan belt, the central axial zone of Hokkaido, northern Japan (e.g. Katoh and Nakagawa, 1986; Makita and Arai, 1997). These peridotites are, however, not common in the upper mantle and their genesis has not been explained thoroughly. We discuss the genesis of highly refractory peridotite from three complexes, the Takadomari, Iwanai-dake and Nukabira, in the Kamuikotan belt, Japan, and its bearing on the process of high-Mg andesite magma genesis.

The Kamuikotan belt is a tectonic melange zone composed of metamorphic rocks, ultramafic rocks, greenstones and sedimentary rocks. The metamorphic rocks are of typical high-pressure/low-temperature type and ophiolitic rocks which recorded low-pressure ocean-floor metamorphism are distributed in the Horokanai area, northern part of the belt (Ishizuka et al., 1983). Ultramafic rocks form the basal member of the ophiolite in the northern part and are exposed as peridotite complexes of various size in the southern part of the Kamuikotan belt. They are generally in fault contact with surrounding Kamuikotan metamorphic rocks, sediments and mafic volcanic rocks (e.g. Niida and Katoh, 1978). The peridotite complexes mainly consist of harzburgite and dunite which suffered serpentinization to various extent.

The Takadomari complex from the northern part, and the Iwanai-dake complex from the southern part of the belt consist of harzburgite, dunite and small amounts of orthopyroxenite. The Nukabira complex (southern part of the belt) consists of lherzolite and harzburgite with dunite and pyroxenites. Podiform chromitite deposits sometimes accompany dunite in the latter two complexes. Primary hydrous minerals are sometimes included in chromian spinel of the former two complexes. The Cr# of chromian spinel and Fo (forsterite) content of olivine in peridotites from the Takadomari complex are high (Cr#=0.64-0.92, Fo=91.9-94.0), and are higher in dunite than in harzburgite on average. The Cr# and Fo are also high (Cr#=0.43-0.87, Fo=90.8-93.5) in the Iwanai-dake complex and have wider ranges (Cr#=0.18-0.86, Fo=89.0-93.2) in the Nukabira complex. The Cr# of spinel and Fo of olivine in dunite complexes are sometimes similar to or even lower than the values in harzburgite from Iwanai-dake and Nukabira complexes. The mineral chemistry of dunites in the Iwanai-dake and Nukabira complexes depends on their thickness within harzburgite or lherzolite bodies. Thicker dunite layers tend to show higher Cr# of chromian spinel and Fo content of olivine. In addition to this, there are clear systematic variations in lithology across dunite layers and surrounding peridotites. In the case of thick dunite layers, the Cr# of chromian spinel and the Fo content of olivine gradually increase from the surrounding peridotite to the central part of the dunite layer (Cr#>0.6 and Fo>91.5 in dunite). In contrast to this fact, these values in thin dunite layers are similar to the surrounding peridotite, lherzolite or harzburgite (Cr#=0.4-0.6 and Fo=89-91). These values are generally lower in thinner dunite layers than in the thick ones compared at the center.

The harzburgites and dunites in the Takadomari complex are interpreted to be a series of refractory residue after extraction of high-Mg andesite magma; partial melting of the fertile peridotite possibly occurred under hydrous conditions. Harzburgite and lherzolite are mostly simple residue in the Iwanai-dake and Nukabira complexes but their dunites are not simple residue because the Cr# and Fo content are not systematically higher in the dunite than in the harzburgite (e.g. Arai, 1987; 1994). The dunite may be produced by a reaction between wall peridotite and a melt formed at higher pressures (e.g. Quick, 1981; Fisk, 1986; Kelemen, 1990). The differences in thickness and mineral chemistry of dunite layers are due to the difference of the melt/wall peridotite volume ratio. Supplying a large amount of melt caused formation of thick dunite layers and generated high-Mg andesitic magma by the reaction process.

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