Metamorphic Olivine Formed after Orthopyroxene in Mantle Wedge during Serpentinization from the Khantaishir Ophiolite, Western Mongolia

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Dehydration of serpentine in subducting zone is thought to be associated with various subduction zone processes, including intermediate-depth earthquakes, slow earthquakes and arc magmatism. Metamorphic olivine is direct evidence of dehydration of serpentine. In this study, we report a novel texture of metamorphic olivine found from the Khantaishir ophiolite in western Mongolia, and discuss its mechanism and tectonic implications.

The Khantaishir ophiolite is located in the western Mongolia, which belongs to the Central Asian Orogenic Belt. This ophiolite composed of ultramafic rocks, pyroxenites and gabbro, sheeted dikes, pillow lavas, and pelagic sediments is strongly sheared and thrusted, but well preserved ophiolitic sequence is partly preserved. Geochemical study of igneous rocks of the Khantaishir ophiolite in the Altai area suggested signatures of suprasubduction-zone origin such as boninite (Matsumoto and Tomurtogoo, 2003). In this study, we investigated the ultramafic body, the Naran massifs in the Altai region. Although a small ophiolite body in the Chandman area, occurred ca.180 km away from Altai, is cropped out close to eclogite bodies, relationship between metamorphism and ultramafic bodies is still unclear.

Most of the ultramafic rocks in the Naran massif are highly serpentinized. The most dominant one is antigorite in matrix, lizardite and brucite mixtures occurs as vein-filling of primary olivine, and chrysotile occurs as veins, cutting the all textures. About half of the samples within the Naran massif contained olivine as well as serpentines, spinel, magnetite, and brucite. Two types of olivine were found; primary and metamorphic origins, respectively. Metamorphic olivine is widely distributed in the Naran massif, and show higher Mg# (0.94-0.98) compared to the primary ones (Mg# = 0.92-0.93). A plot Mg# of primary olivine vs Cr# (0.70-0.82) of spinel suggests that the ophiolite was formed at fore-arc setting.

It is notable that metamorphic olivine commonly exists as fine-grained aggregates with aggregate size of ca.5mm, and showed aligned fractures filled with high Cr-richer antigorite, and a subtle amount of clinopyroxene was formed. These microstructural features indicate that such olivine was originated from orthopyroxene. Plümper et al., (2012) reported similar textures, and proposed two stages of bastite formation after orthopyroxene (hydroration) and then the olivine formation by dehydration reaction. In contrast, the samples with metamorphic olivine do not contain any evidence of talc formation; so, it is reasonable to consider that that metamorphic olivine was directly formed by silica-releasing reaction after orthopyroxene, which is coupled with the silica consuming reaction of primary olivine to produce antigorite. This indicates that metamorphic olivine was formed during serpentineization (hydration). Petrological analyses implies that the breakdown of orthopyroxene to form olivine without talc formation could occur at high P- T condition (i.e., >1.5 GPa, ca 600˚C). Such conditions may be consistent with P-T condition (2-2.25 GPa, 590˚C-610˚C) of the eclogite body related to the Khantaishir ophiolite, ca.180 km away from the Altai area. At the margin of the Naran massif in the Altai area, we found amphibole-bearing metamorphic rocks, which contain albite, K-feldspar, with lessor amount of biotite, sphene, calcite, quart, chlorite and iron oxides. Amphibole shows a prominent compositional zoning; from actinolite at core to magneseoriebeckite at the rim, which is consistent with the wedge mantle condition at high P metamorphism. The metamorphic olivine after orthopyroxene in the Naran massif indicates the hydration of wedge mantle under unmature arc during the development of CAOB.

Keywords: Mantle wedge, Metamorphic olivine, Serpentinization

