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Deformation history of the Horoman peridotite complex decoded from fine-grained aggregates without spinel

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Deformation of peridotites is controlled mostly by deformation behavior of olivine, the main constituent, but is affected by pyroxene and spinel depending on their distribution. The Horoman peridotite complex in the Hidaka metamorphic belt, Hokkaido, Northern Japan, experienced strong deformation and is extremely fresh, providing the best research target to investigate deformation of peridotite. There are several researches on the deformation of the Horoman peridotite, such as Niida (1975) and Sawaguchi (2004). Sawaguchi (2004) particularly made extensive study and recognized several deformation zones on the basis of lattice preferred orientation of olivine, and proposed a deformation scenario of the complex. In this study, we focus on fine-grained aggregates containing pyroxenes, which might have influenced deformation behavior of the Horoman peridotite complex in spite of its lower abundance than the major olivine.

The Horoman peridotite complex is composed mainly of plagioclase lherzolite, spinel lherzolite, and harzburgite. All rock types show strong deformation texture characterized by coarse-grained olivine aggregates (grain size: 250˜1000 micron meter) and fine-grained aggregates containing pyroxenes (grain size: 50˜250 micron meter). The latter occupies 20˜40% volume% of rocks. Elemental maps obtained by EPMA allow us to divide fine-grained aggregates with pyroxene into those associated with and without spinel grains. Fine-grained aggregates with spinel is composed of Sp, Opx, Cpx, +-Ol, +-Pl, whereas fine-grained aggregates without spinel is composed of either Cpx + Ol or Opx + Ol. Takahashi and Arai (1989) and Ozawa and Takahashi (1995) clarified that the former represents a breakdown reaction product of garnet. The latter has not been noticed, but is present in all rock types and it may have affected the deformation behavior of the peridotites. The fine-grained aggregates without spinel is mixed with olivine grains and usually traced back to a pyroxene porphyroclast. These features require grain size reduction of pyroxenes and its mixing with olivine. Grain size reduction is attributable to the following mechanisms: (1) cataclasis, (2) decomposition reaction of pyroxene, (3) dynamic recrystallisation. Though (1) can account for both grain size reduction and mixing, it is not plausible because the grains are rounded. (2) can also explain simultaneous grain size reduction and mixing, but is not consistent with the fact that it is composed only of olivine and pyroxene with the same chemical composition as the rim of porphyroclasts. (3) is a grain size reduction by dynamic recrystallisation of pyroxene porphyroclasts. It is consistent with observation that some porphyroclasts is composed of subgrains. This mechanism requires mixing with olivine grains during or after recrystallisation. EBSD analyses of lattice orientations of pyroxene porphyroclasts and of fine-graind pyroxene grains occurring near the porphyroclast demonstrate the similarity in their orientation. By contrast, random orientations are observed in fine-grained pyroxene occurring for apart from the porphyroclast. This result indicates that fine-graind pyroxene grains detached from the host porphyroclast underwent quick mixing with olivine by grain boundary gliding. The timing of this process can be constrained by M-shaped Al zoning in pyroxenes (Ozawa, 2004). The Al poor interior is in contact with olivine along the rim in the direction of lineation, suggesting that the detachment took place after the formation of Al maxima near the margin, which corresponds to a stage when temperature rapidly dropped in the plagioclase stability field. The fine-grained aggregates composed of pyroxene and olivine may have played an important role in deformation of the peridotite complex during its ascent through the mantle and emplacement into the lower crust.