Melting and upwelling process of lherzolite in the upper mantle:evidence for polybaric melting in the Horoman peridotite complex

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The Horoman peridotite complex, Hokkaido, Japan has remarkable compositional layering and is thought to have formed by melting processes in the upper mantle. The symplectite-bearing seam, which consists of symplectite and fine-grained aggregate, is regarded as a reaction product after garnet. Composition of symplectite-bearing seam should have information about composition of garnet, which could have been overprinted by subsolidus diffusion or other open-system processes during upwelling of the complex. The whole-rock composition, mineral composition, and composition and distribution of symplectite-bearing seam are analyzed in a 100m long section along the Horoman River to understand the melting and upwelling processes of the complex.

Analyzed samples are divided into two groups, one is plagioclase-bearing lherzolite (denoted as PLLH) and the other is spinel lherzolite (denoted as SPLH), which is free from plagioclase. The lower half of the studied section is composed only of PLLH, while the upper half consists dominantly of SPLH with sporadic appearance of PLLH. They are distinguished by the presence or absence of plagioclase in the symplectite-bearing seam. Plagioclase in PLLH is considered to have formed at a shallower lever during the final decompression. The presence of plagioclase is controlled by the whole-rock Na2O content, which needs to be higher than 0.08 wt%.

The bulk composition of symplectite-bearing seams does not coincide with garnet composition, even if the amount of olivine involved in the reaction is taken into consideration. Symplectite-bearing seams contain too large amount of spinel, and the opx/(opx + cpx) ratio does not agree with the expected ratio for a possible grossular content in garnet. This suggests open-system reaction in the transformation of garnet to symplectite-bearing seam. The composition of original garnet was estimated from that of symplectite-bearing seam by assuming influx of enstatite or outflux of spinel. The estimated garnet mode is consistent with that calculated from the whole-rock composition by assuming that the reaction from garnet to symplectite began at ~1100C and 16.5kbar.

The whole-rock oxide contents vary systematically with Mg#, and show spatial variations along the studied section. When rocks with the same Mg# are compared, the whole-rock compositions of the lower half composed exclusively of PLLH are notably different from those of the upper half dominated by SPLH irrespective of the presence of PLLH in the upper half. The difference is attributable to discrepancy of melting condition, particularly pressure. Each melting condition is constrained by the whole-rock trace element composition by applying simple melting models. The melting stoichiometry was estimated from the whole-rock major element composition, which was cast into the peridotite norm in the projected CMAS system. The correction between Mg# and Yb concentration in the lower half is reproduced by batch-melting at 4GPa, and that of the upper half by fractional melting at 3GPa. The distinct difference in the melting condition indicates that the Horoman peridotite complex experienced polybaric melting.