Discovery of platinum-group-element micronuggets in mantle peridotite using synchrotron radiation microbeam X-ray fluorescence

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Concentrations and isotopic ratios of platinum-group elements (PGEs) in the Earth's mantle are strongly controlled by chemical differentiation processes involving both silicate and metallic phases, such as the core segregation event during the formation of the Earth, and subsequent chemical interactions between the core and the mantle. Thus, PGE geochemical data in the mantle are key indices for understanding formation processes of the fundamental layered structure of the Earth's interior and its chemical evolution during the Earth's history. However, interpretation of the geochemical data of PGEs has been equivocal because the main host phases for PGEs in the mantle are not well constrained. PGEs can be hosted by sulfide and metal minerals in the mantle, but PGE-bearing sulfides and metals have rarely been found in mantle peridotite, implying that PGEs are concentrated in tiny grains (so-called micronuggets) that are difficult to identify mineralogically.

We have been trying to develop a method for non-destructive detection of PGE-bearing micronuggets in rock samples using synchrotron radiation X-ray at SPring-8, and finally found PGE-bearing micronuggets in a lherzolite sample from Horoman ultramafic complex, using microbeam X-ray fluorescence technique at the beam line BL47XU: a 0.1-mm-thick thin section of the lherzolite sample was scanned by a 1-micrometer X-ray beam of 15 keV, and fluorescence lines emitted from the sample were detected by a silicon drift detector. The PGE micronuggets we found were included in sulfide grains. The size of the micronuggets ranges from less than 1 micrometer to over 10 micrometers. The combinations of elements in the PGE micronuggets are Pt-Au, Pt-Bi, Os-Ir-Pt, Os-Ir, etc. Assuming that the PGE micronuggets are metal or sulfide phases, the amounts of PGE in the micronuggets correspond to whole rock concentrations of the order of 1 ppb, which are comparable to the whole rock PGE concentrations in this sample (e.g., Os: 3 ppb). This indicates that most PGEs in mantle peridotite are concentrated in micronuggets. Among over 30 grains of sulfides and chromite we investigated in the sample, only two sulfide grains contained PGE micronuggets, suggesting that the distribution of PGE micronuggets in mantle peridotite is ubiquitous but quite inhomogeneous in centimeter-scale.