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Application of Micro-XRF analysis for estimation of igneous mineral compositions from subduction zone meta-peridotites

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Ultramafic rocks in the metamorphic belt have been generally re-crystallized into fine-grained aggregates and the elemental components in the rocks have been re-distributed into newly formed minerals including hydrous phases. In order to discuss the igneous processes related to the origins, we have to estimate such chemical and modal modification. For examples, Ni, Mg and Fe are important indicators of fractional crystallization and partial melting but they are expelled out from olivine and pyroxene into magnetite (Mag), antigorite (Atg) and sulfides (pentlandite (Pn) etc.). The precise modal compositions of the metamorphic constituents are necessary for reproduction of the igneous mineral compositions.

We test an elemental mapping using a Micro-XRF Analyzer (XGT-5000, HORIBA) to determine modal compositions of metamorphic minerals. In this system, an X-ray beam is focused on a polished thin section (30 micron thick) in a diameter of 0.1 mm and fluorescent X-ray maps (512 x 256 pixels for a region of 2 x 1 cm2, for example) of elements with higher atomic number than Ca are gained using an EDS detector.

Analytical samples are ultramafic rocks in Higashi-akaishi peridotite body (HA) in Sanbagawa metamorphic belt, southwest Japan. They have been a part of olivine (Ol)-clinopyroxene (Cpx) cumulate composed of dunite and Cpx-bearing rocks. The present constituent minerals are Ol, Cpx, Atg, Cr-Spl, ferricht Chr, Mag, Pn. The modal compositions of Cpx, Mag, Cr-Spl/ferricht Chr and Pn are determined using Ca map, Fe map, Cr map and Ni map, respectively. Proportions between Ol and Atg are determined by point counting. As a result, modal compositions are determined to one place of decimal, for example: Ol (4.2%), Cpx (32.1%), Spl (0.5%), Mag (2.6%), Pn (0.1%) and Atg (60.5%).

Primary compositions are calculated from the present mode and mineral chemistry assuming a primary assemblage of Ol + Cpx + Cr-Spl, a semi-closed system with additions of H2O and SiO2 and KD(Ol-Cpx) = 0.8. Resultant Mg# and NiO content in Ol show significant effect of metamorphic changes from 0.862 to 0.822 and from 0.17 to 0.11, respectively. Our calculation indicates that a modal composition of Pn should be determined with a precision to two places of decimals. Measuring sizes and numbers of sulfide grains under a reflecting microscope will be the best way to make reliable estimation of primary NiO in Ol instead of a XRF mapping.

Keywords: Micro-XRF analysis, modal composition, pentlandite, subduction zone, meta-peridotites