

## Peculiar orthopyroxenites from Ray-Iz peridotite massif in the Polar Urals: Fossil path of CO<sub>2</sub>-bearing aqueous fluids in the upper mantle

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Orthopyroxene (= opx) is one of the main component minerals in the upper mantle and its modal proportion in a residual peridotite usually decreases with increasing the degree of melting.

Orthopyroxenites or opx-rich rocks in the mantle can be formed by igneous, i.e., fractional crystallization from relatively Ca-poor magma (Kurshiro, 1969), or metasomatic processes, i.e., interaction between peridotite and SiO<sub>2</sub>-rich or opx-oversaturated melts (Arai et al., 2006; Ishimaru et al., 2007) or SiO<sub>2</sub>-rich aqueous fluid (Nakamura & Kushiro, 1974; Arai et al., 2004) at the shallow mantle. In addition, another type of orthopyroxenite, composed of opx and carbonate, has been also known, and is called

“sagvandite” (e.g., Pettersen, 1883). Interaction process between peridotite and CO<sub>2</sub>-rich fluid has been widely accepted for genesis of the sagvandite (e.g., Gahlan et al., 2015).

The Ray-Iz massif, the Polar Urals, is an allochthonous tectonic block, 400 km<sup>2</sup> in area, and that is thrust over the Paleozoic sedimentary rocks of the East European Platform (Shmelev et al., 2014). It is mainly composed of lherzolite–harzburgite complex, dunite–harzburgite complex and metaperidotites. The presence of orthopyroxenite and sagvandite (carbonate-bearing orthopyroxenite) has been reported in the Rai-Iz peridotite massif (Shmelev et al., 2014), but no detailed petrographical and geochemical data are presented. Detailed petrographical and geochemical descriptions of the sagvandite give us information about the active fluid metasomatism during the formation of metaperidotite and its importance as well.

The Ray-Iz sagvandite is a small block (20 x 20 x 10 m), which is surrounded by a metaperidotite (secondary harzburgite) with a minor garnet amphibolite. The sagvandite is composed of huge radial aggregates of opx within a matrix composed of serpentine (antigorite), olivine, chlorite, tremolite, chromite and talc. The carbonate is only a trace in amount, and then, this rock is not sagvandite in definition, but rather carbonate-bearing olivine orthopyroxenite. A carbonate-rich rock is available at a distant point (≈ 500 m) from the orthopyroxenite block, but is not orthopyroxenite but opx-rich harzburgite. The opx showing radial aggregates replaces in part olivine in the orthopyroxenite. The opx-rich harzburgite contains both the radially aggregated opx and stout porphyroclasts. The opx in the orthopyroxenite show high Mg# (= Mg/(Mg + total Fe) atomic ratio) (0.91-0.92) with extremely low contents of Al<sub>2</sub>O<sub>3</sub> (< 0.1 wt.%), Cr<sub>2</sub>O<sub>3</sub> (< 0.1 wt.%) and CaO (< 0.15 wt.%), irrespective of their shapes. The Mg# of coexisting olivine shows constant and almost the same as that of opx (0.905-0.912), although the NiO content is varied (0.23-0.76 wt.%) in the olivine. All of the carbonates in orthopyroxenite and metaharzburgite are magnesites. All chromite is ferritechromite. Mineral assemblage of the orthopyroxenite and surrounding metaperidotite, and mineral compositions of the associated garnet amphibolite indicate that they were metamorphosed at ≈700 °C and ≈1 GPa. Based on the isothermal section of magnesite-bearing ultramafic rocks, the fluid composition which formed the carbonate-bearing orthopyroxenite and harzburgite was aqueous fluid containing ≈15 % of CO<sub>2</sub>. This is consistent with the low amount of carbonate within the orthopyroxenite, and the fluid also possibly contained an appreciable amount of SiO<sub>2</sub> to form opxs replacing olivine. The opx-rich lithology of Ray-Iz is possibly representative of

a path of CO<sub>2</sub>-bearing aqueous fluid in the peridotite within the uppermost mantle wedge.

Keywords: orthopyroxenite, metaperidotite, H<sub>2</sub>O-CO<sub>2</sub> fluid, mantle wedge