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Orthopyroxene-ilmenite-garnet xenolith from the Grib kimberlite (Arkhangelsk region, Russia): petrography, composition and megacrysts-related origin

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Kimberlites are relatively rare, ultramafic and alkaline igneous rocks that may contain: (i) juvenile magmatic materials, (ii) mantle and crustal xenoliths and xenocrysts, (iii) antecrysts that have been crystallised from evolved kimberlite melts in the mantle (e.g. olivine, phlogopite, ilmenite), and (iv) megacrysts (primarily – garnet, clinopyroxene, phlogopite, olivine, ilmenite and rare orthopyroxene) that maybe get genetic relation with early portions of kimberlite melts (protokimberlite). Orthopyroxene is the second most abundant mineral in the peridotitic mantle, but it is nearly absent from the suite of mantle xenocrysts found in kimberlites. As well as orthopyroxene is a rare mineral among megacrysts. In contrast to other megacrysts, the composition and origin of orthopyroxene are still debated. Here we present petrography and mineralogy of the orthopyroxene-ilmenite-garnet xenolith from the Grib kimberlite (Arkhangelsk region, Russia) that allow us to understand the position of orthopyroxene megacrysts in the kimberlite origin.

The texture of the studied xenolith is heterogranular, porphyroclastic, granoblastic. The rock is deformed and sheared that demonstrated by large garnet porphyroclasts (1-3 mm) in the mosaic matrix of garnet (70 vol.%), ilmenite (20 vol.%) and orthopyroxene (10 vol.%) neoblasts (up to 0.2 mm). These textures are common for sheared peridotite xenoliths from kimberlite. Garnet forms both subhedral neoblasts and rounded porphyroblasts. Orthopyroxene neoblasts are presented by isometric grains of irregular shape. Ilmenite neoblasts have angular isometric or elongated shapes and localise in an interstitium between garnet and orthopyroxene grains. Large garnet porphyroclasts include rounded inclusions (drops) of ilmenite with diameters up to 0.2 mm. Sometimes the drops coalesce with each other. Ilmenite also occurs as veinlets with width up to 4 mm. Garnet grains in contact with ilmenite veinlets look like partially dissolved.

Garnet porphyroclasts and neoblasts have similar composition and characterised by Cr_2O_3 (3.35-3.52 wt.%), CaO (4.82-5.02 wt.%), TiO_2 (0.86-1.06 wt.%) and Mg# (0.81-0.82) as low-chromium and high-Ti garnet megacrysts from kimberlites. Garnets also show typical for kimberlite megacrysts REE trace element patterns: enriched in HREE and depleted in LREE.

Orthopyroxene differs from one in the Grib peridotite xenolith by higher CaO, TiO_2 and lower Al_2O_3 content. This mineral is comparable by Mg# and Al_2O_3, TiO_2, Cr_2O_3 contents with orthopyroxene neoblasts from sheared peridotite xenolith from the Grib kimberlite.

The composition of ilmenite neoblasts is characterised by high concentrations of MgO (13.53-15.30 wt.%) and Cr_2O_3 (2.90-3.62 wt.%). Generally, the concentrations of Cr_2O_3 and MgO in ilmenite increase towards the grain boundary with garnet. Ilmenite from drop-shape inclusions within garnet porphyroblasts has higher MgO concentration in comparison with neoblasts.

The obtained data show that studied xenolith is present by an overgrowth of high-Ti megacrysts such as garnet, orthopyroxene and ilmenite. This overgrowth should be formed during interaction of early portions of kimberlite magma with lithospheric mantle.