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Geochemistry of clinopyroxene megacrysts from the Grib kimberlite pipe, Arkhangelsk province, Russia: metasomatic origin and genetic relationship with clinopyroxene-phlogopite metasomatic xenoliths

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Kimberlite is a composite rock that contains juvenile magmatic material and xenoliths of crustal and mantle rocks, including metasomatically reworked rocks and megacrysts. In spite of nearly 40-50 years of continuous study of kimberlites and SCLM, some aspects of their origin remain controversial. In particular, it is unclear yet whether the megacrysts are magmatic or metasomatic in origin and how they are related to kimberlite magmas.
In this contribution, we compare the major (EMPA) and trace element (SIMS, LA-ICP-MS) compositions of clinopyroxene megacrysts from the Grib kimberlite (Arkhangelsk province, Russia) with clinopyroxenes from metasomatic clinopyroxene-phlogopite xenoliths and garnet peridotite xenoliths.
The Grib kimberlite (376±3 Ma, Larionova et al., 2016) is located in the central part of the Arkhangelsk province (the northern part of the East European craton) in the Chernoozero kimberlite field. The geochemical composition of the kimberlites is similar to widespread South Africa group I kimberlites . The Grib kimberlite is well known for hosting a variety of mantle xenoliths, e.g., garnet peridotite, sheared peridotite, eclogite, metasomatised mantle material, as well as megacrysts of clinopyroxene, garnet, olivine, phlogopite, and ilmenite.
The clinopyroxene megacrysts occur as rounded or angular grains up to 2 cm in size. They are usually surrounded by ultrafine kimberlite rim. The xenoliths of the metasomatic clinopyroxene-phlogopite rocks reach up to ∼6 cm in size and have a granoblastic texture. They consist of clinopyroxene (55 vol. %), phlogopite (45 vol. %) and minor calcite, barite, perovskite. Some clinopyroxene grains contain inclusion of relict olivine that is similar in composition to olivine from mantle-derived peridotite xenoliths within the Grib kimberlite (Sazonova et al., 2015). This suggests that these xenoliths could be formed by metasomatic reworking of SCLM peridotites.
The megacryst clinopyroxene is compositionally similar to the clinopyroxene found in metasomatic xenoliths and corresponds to diopside. As compared to the typical clinopyroxene megacrysts worldwide, it has higher Mg# (>0.92), Cr# (0.21-0.62) and Ca# values (0.47-0.49) and lower Ti (659-1966 ppm) composition. The clinopyroxenes have (La/Sm)CI values from 0.58 to 1.57, and trace element patterns with deep negative Ti and shallow negative Zr-Hf anomalies. The major and trace-element compositions of these clinopyroxenes are very close to those of clinopyroxenes from garnet peridotite xenoliths in the Grib pipe (Kargin et al., 2016) that could be formed during the ascent and interaction of kimberlite mamas with a surrounding lithospheric mantle after crystallization of garnet and ilmenite megacrysts. Calculations showed that metasomatic agents in equilibrium with clinopyroxene megacrysts are similar in composition to kimberlite, which is consistent with proposed model.
To sum up, we suggest that the formation of clinopyroxenes of megacrysts and mantle-derived clinopyroxene-phlogopite metasomatic xenoliths from the Grib kimberlite was related to the late-stage metasomatic reworking of SCLM by kimberlite magmas.
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