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Metasomatic processes in the mantle beneath the Arkhangelsk province, Russia: evidence from garnet in mantle peridotite xenoliths, Grib pipe

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The Arkhangelsk province is located in the northern East European Craton and includes more than 80 bodies of kimberlite, alkaline picrite and other ultramafic and mafic rocks. They erupted through the Archean–Early Proterozoic basement into the Riphean–Paleozoic sedimentary cover.
The Grib kimberlite pipe is located in the central part of the Arkhangelsk province in the Verkhotina (Chernoozerskoe) kimberlite field. The age of the Grib kimberlite is 376+-3 Ma (Rb-Sr by phlogopite).
The Grib kimberlite pipe is the moderate-Ti kimberlites (TiO_2 1-2 wt %) with strongly fractionated REE pattern , (La/Yb)n = 38-87. The Nd isotopic composition of the Grib pipe ranges epsilon Nd from –0.4 to + 1.0 and 87Sr/86Sr(t) from 0.7042 to 0.7069 (Kononova et al., 2006).
Geochemical (Jeol JXA-8200 electron microprobe; SIMS; LA-ICP-MS) composition of clinopyroxene and garnet from mantle-derived xenoliths of the Grib kimberlite pipe was studied to provide new insights into metasomatic processes in the mantle beneath the Arkhangelsk province. Based on both major and trace element data, five geochemical groups of peridotitic garnet were distinguished.
The partial melting of metasomatic peridotite with crystallization of a garnet-clinopyroxene association, and orthopyroxene assimilation by protokimberlitic melts was simulated and a model of garnet and clinopyroxene metasomatic origin was proposed.
The model includes three stages:
1. Mantle peridotite was fertilized by subduction-derived sediment partial melts/fluids at the lithosphere-asthenosphere boundary to yield a CO_2-bearing mantle peridotite (source I).
2. The partial melting of the carbonate-bearing mantle source 1 produced carbonatite-like melts (a degree of partial melting was 1,5 %), which could form the carbonatite-kimberlite rocks of the Mela River (Arkhangelsk province, 50 km North-West of Grib kimberlite) and also produce the metasomatic reworking of (carbonate-bearing) mantle peridotite (mantle source II) and form type-1 garnets.
3. The melting of the reworked carbonate-bearing mantle peridotite (mantle source II, degree of partial melting was 1 %) resulted in the generation of proto-kimberlite melts and type-2 garnet. These proto-kimberlite melts interacted with lithospheric mantle orthopyroxene to produce megacryst garnets and melts that formed the Grib kimberlite. This stage was responsible for the formation of the metasomatic equilibrium clinopyroxene—garnet assemblage (type-3) in lithospheric peridotite and metasomatic transformation of deformed peridotite (type 4 and 5 garnet).
This model suggests that peridotitic garnet originated at the first stage in the presence of subduction-generated melts or fluids.
Kononova V.A., Nosova A.A., Pervov V.A., Kondrashov I.A. (2006). Compositional variations in kimberlites of the east European platform as a manifestation of sublithospheric geodynamic processes // Doklady Earth Sciences. V. 409. Is. 2. Pp. 952-957.