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Contradictory links between high-T mantle xenoliths and carbonate-rich melts – Siberian craton example

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Carbonates in Siberian cratonic mantle have been reported as melt inclusions in kimberlitic and xenolithic olivine (e.g. Golovin et al., 2007, 2018), as mineral inclusions in diamond, garnet and other minerals (e.g. Bulanova & Pavlova, 1987; Sobolev et al., 2009; Nikolenko et al., 2017), and as interstitial minerals (e.g. Sharygin et al., 2012). The origin of such carbonates is controversial and has been associated with subduction of carbonaceous sediments, with a deep mantle origin, and with kimberlitic and carbonatitic melts.

We investigated a suite of garnet-clinopyroxene-rich mantle xenoliths from the Udachnaya kimberlite that intruded the Siberian craton lithosphere. The samples comprise lherzolite, olivine websterite and clinopyroxenites. Each sample contains fine-grained aggregates of carbonates (aragonite, calcite paramorphs after aragonite, dolomite, magnesite, siderite), djerfisherite, ilmenite, Ba-rich mica, magnesioferrite, sodalite, high-Mg olivine (Fo 95-97), apatite, rarely serpentine, and graphite. Reaction rims surround the aggregates, which are thought to represent melt pockets.

Garnets are pyropic in composition and have comparatively high contents of TiO_2 (0.48-0.77 wt%) and Zr (40-121 ppm), moderately high contents of Na_2O (0.06-0.13 wt%), and low contents of Cr_2O_3 (<2.39 wt%). CaO and Cr_2O_3 concentrations often vary between cores and rims of coarse garnet and garnet inclusions in clinopyroxene. Rare-earth element disribution patterns of garnet are normal, and those of clinopyroxene are convex-upward. The REE partitioning between garnet and clinopyroxene in the suite of samples is uniform and resembles that reported from megacrysts and low-chromium sheared peridotites (e.g. Solov'eva et al., 2008; Agashev et al., 2013). Thermobarometry suggests our Udachnaya samples to have equilibrated at T >1100 ˚C that is typical for sheared peridotites.

Observed xenoliths heterogeneities are supposed to have formed at contrasting P–T–$f O_2$ conditions on a separate stage of rocks history. Disequilibrium on a sample scale is related to: a) the previous presence of fluid/melt and probably fast crystallization rates of imposed minerals; b) limited time for re-equilibration of the whole rock; c) difference of element partitioning between and diffusivities in the minerals. Trace-element chemistry of garnet and clinopyroxene evidences their formation to be linked to crystallization from high-Mg silicate melts. Xenoliths mineralogy indicates late-stage treatment of the rocks by carbonate-rich liquid(s), hinting to their affinities with kimberlite melt.

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