Redox events in cratonic mantle underneath Obnazhennaya kimberlite, Yakutia – chemical records in pyroxenites

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Metasomatism is omnipresent in subcontinental lithospheric mantle (SCLM). Whatever a distribution scale in the SCLM, it has a strong link to changes in oxygen fugacity ($f_{O_2}$) [1]. It is also known that $f_{O_2}$ of Earth’s interior controls speciation within the C–H–O–S–N system and stability of C-bearing phases (diamond, graphite, carbonates, carbides, volatile-bearing fluid and melt; [2]). Our new geochemical, Mössbauer and Raman spectroscopic results suggest no less than one episode of mantle metasomatism related to the formation and preservation of elemental carbon minerals within Siberian SCLM, while later events are connected to interaction of rocks with hydrous and carbon dioxide components.

We studied a graphite-bearing mantle xenolith from the diamond-free Obnazhennaya kimberlite pipe, Republic of Sakha (Yakutia), Russia, that represents a garnet websterite consisting of garnet (Grt), clinopyroxene (Cpx), orthopyroxene (Opx), graphite, rutile, ilmenite, pyrrhotite, pentlandite, secondary serpentine, phlogopite and carbonates (calcite). Cpx hosts Opx and Grt lamellae. Grt cores contain scarce but oriented mineral inclusions (silicates and Ti-oxides) that we interpret to be exsolved from a Si- and Ti-rich precursor. Linearly distributed melt and fluid inclusions in silicates are thought to postdate the exsolutions. Both major and trace elements of rock-forming silicates match that of peridotites and pyroxenites with exsolutions in Grt and pyroxenes from Obnazhennaya and worldwide. Pressure and temperature estimates ($T \sim 910 \, ^\circ\text{C}, P \sim 3.5 \, \text{GPa}$) also fall into the range in which alike rocks have been equilibrated in the SCLM.

Microstructural and chemical data allowed to propose crystallization of the garnet websterite from high-$T$ Mg-rich magmas similar to komatiite [3], which forms in deep Grt-bearing depleted mantle sources with low oxygen fugacity [4]. Subsequent metasomatism of the reduced websterite by oxidising C-O-H fluids caused graphite precipitation through redox freezing [5], and such reactions constitute an important part of Earth’s hidden carbon cycle. Infiltration of hydrous and CO$_2$-rich fluids likely postdated this episode.
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