The redox state of the graphite- and diamond-bearing eclogite xenoliths from Udachnaya kimberlite pipe (Siberian craton): implication for the origin of diamonds

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Oxygen fugacity is one fundamental thermodynamic parameter, together with pressure and temperature, which governs the onset and evolution of different geological processes such as magma genesis, metasomatism, diffusion and stability of carbon polymorphs (i.e. graphite and diamond) in Earth's upper mantle. The reconstruction of the upper mantle oxidation state allows to predict the evolution of the global carbon cycle and graphite-diamond stability in the upper mantle through geological time. Recent experimental studies allowed the calibration of an oxybaromete for diamondiferous eclogite based on measurements of Fe^{3+} content in garnet coexisting with clinopyroxene conducted using Mössbauer spectroscopy [1]. This oxybarometer can be used to estimate the fo_2 of mantle eclogites along with estimates of P-T conditions [2].

Here, we present data on the Fe^{3+}/Fe_{tot} content in garnets coming from 18 diamond-, and diamond-graphite-bearing Udachnaya eclogites by both milliprobe (Sapienza University of Rome, Italy) and synchrotron Moessbauer spectroscopy (ID18 beamline, ESRF – Grenoble, France). This information along with the chemical composition of the coexisting minerals, allowed us to calculate the equilibrium fo_2, P and T as a function of depth, which compared with all mantle xenoliths available in literature and showed a linear correlation of Udachnaya mantle redox state with depth, revealing its stability in the diamond stability field. Notably, very reduced conditions are achieved at about 180-260 km depth where methane (or other more complex C-O-H fluids) might coexist.

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[1] Stagno et al. (2015) Contributions to Mineralogy and Petrology, 169, 16. [2] Beyer et al. (2015) Contributions to Mineralogy and Petrology, 169, 18.