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Composition of the lithospheric mantle in the Siberian craton : New constraints from fresh peridotites from the Udachnaya-East Kimberlite

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Peridotite xenoliths from the Udachnaya kimberlite pipe represent the major source of lithospheric mantle samples beneath central Siberian craton. An important problem with the availble data [1], however, is that the Udachnaya xenoliths, like many other kimberlite-hosted peridotite suites worldwide, are extensively altered due to interaction with host magma and post-eruption alteration. This alteration causes particular dificulties for whole-rock studies including microstructures, modal estimates and chemical compositions.

We report petrographic data and major and trace element compositions for whole-rocks and minerals of some 30 unusually fresh peridotite xenolith from the Udachnaya-East kimberlite. Our study has two goals. The first is to present and discuss trace element data on rocks and minerals from Udachnaya, whose composition remains little known. The other one is to explore how the availability of the fresh peridotites improves our knowledge of petrology and geochemistry of cratonic mantle in relation to published data on altered samples [1].

The xenoliths are spinel, garnet-spinel and garnet facies peridotites including garnet- and cpx-rich lherzolites, garnet and spinel harzburgites and dunites. Thermobarometric estimates for garnet bearing rocks yield T = 800-1350°C and P = 20-70 kbar, low-T spinel facies rocks may originate from shallower levels. Thus, the suite represents a lithospheric profile from the sub-Moho mantle down to $\sim$210 km. The deeper peridotites commonly have porphyroclastic microstructures with mainly neoblast olivine, opx porphyroclasts and cpx and garnet with broadly variable morphologies whereas rocks of shallow origin are commonly protogranular.

Trace element compositions in bulk rocks appear to be affected by host magma contamination with enrichments in highly to moderately incompatible elements as well as in alkalis. Nevertheless, the kimberlite-related contamination cannot explain a combination of low Th and U and high Sr contents. The broad range of heavy REE appears to be controlled by the presence and the abundance of garnet and is also related to microstructures such that granular spinel harzburgites have lower HREE contents than “fertile” porphyroclastic garnet lherzolites. Trace elements in cpx and garnet have equilibrated patterns in porphyroclastic peridotites and complex sinusoidal shapes in granular peridotites.

Bulk-rock major element compositions show important variations in Mg# (0.89 – 0.93), SiO2 (41.5 – 46.6%), Al2O3 (0.3 – 4%) and CaO (0.3 – 4%). As for compatible trace elements, the major element compositions appear to be related to microstructures. Calculated modal compositions show highly variable opx contents (4.5 – 24%), which are generally lower than in Kaapvaal peridotites but are similar to those from the North Atlantic craton [3]. Overall, modal compositions and the contents of low-mobility elements, are consistent with an origin by variable degrees of partial melting of fertile mantle [1–3]. The range in FeO contents (6-8.5%) may indicate either variable melting depths [2] or post-melting enrichments. Enrichments in SiO2 show some similarities to those in supra-subduction xenoliths [4]; enrichments in highly incompatible elements can be explained by metasomatism with possible involvement of subduction-related fluids. Strong correlations between chemical compositions and microstructures indicate the involvement of tectonic processes in melt percolation and metasomatism.

We suggest that the cratonic lithosphere in Siberia was formed in three stages: (1) formation of proto-cratonic mantle by high-degree melting at variable depth, (2) accretion of the proto-craton domains in subduction-related settings, (3) metasomatism commonly accompanied by deformation.

[1] Boyd et al (1997) Contrib. Mineral. Petrol. 128, 228-246. [2] Herzberg (2004) J. Petrol. 45, 2507-2530. [3] Wittig et al (2008) Lithos 71, 289-322. [4] Ionov (2009) J. Petrol. In press