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Pyrope lherzolite assemblage of Ti-bearing olivine macrocryst from Udachnaya ultrafresh kimberlite, Yakutia (Russia)

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Olivine (Fo 86-94) is the principal mineral of kimberlites, their peridotite xenoliths and diamond inclusions. However, in absolute majority of kimberlites it is completely altered and unavailable for a study. Udachnaya kimberlite represents one of unique exception of an availability of olivine macrocrysts and phenocrysts without any trace of serpentine in a carbonate-chloride matrix [1, 2]. The olivine I and olivine II populations are clearly distinguished [2]. The cores of olivine II are compositionally similar to olivine I with Fo [100Mg/(Mg + Fe)] 86-94 , but rims of olivine II and partly preserved rims of olivine I have almost constant Fo values about 89-90. We report here the results of major and minor elements analyses by EPMA of one large (more than 1.2 mm in longest dimension) olivine I macrocryst by high precision approach [3] to minor elements including Ti, Al, Cr, Ca, Mn, Ni, Zn, using the high sample current and high counting time, which was found optimal to obtain limit of detection about 10 ppm. Special attention is drawn to TiO_2 precise measurements. Thin rim which is preserved only in part, contains 8.8 wt.% FeO (Fo 91.1). Two profiles (130 points) across a core of studied olivine I grain demonstrated homogeneous distribution of FeO (Fo 88.7-88.9), TiO_2 (330-360 ppm), MnO (1340-1370 ppm), CaO (220-240 ppm), NiO (2850-2900 ppm), ZnO (80-100 ppm). The studied olivine I grain contains clusters of Cpx (33 grains) and Prp (6 grains) inclusions., having a range in Cr_2O_3 (1.52- 2.36 wt%) , Al_2O_3 (0.99-5.53 wt%) and Na_2O (1.45-5.96 wt%) for Cpx and Cr_2O_3 (3.51-4.42 wt%) and CaO (5.64-6.61 wt%) for Prp, showing disequilibrium in homogeneous olivine I core. The presence of listed inclusions confirms pyrope lherzolite assemblage of studied olivine and thus its high pressure origin. This is completely different from any peridotite xenoliths, confirming the uniqueness of this assemblage. The homogenous TiO_2 contents of studied olivine containing low T (Ca# 43.3-48) Cpx and Prp inclusions confirm the differences from all olivines from peridotites and diamonds [4]. Earlier, similar TiO_2 abundance was reported only for olivines from dunite nodules in Greenland kimberlites [5]. We suggest that Ti-bearing olivine represents a part of high pressure pyrope lherzolite assemblage, which was formed and grew during the formation and early evolution of kimberlites.

[1] Kamenetsky M.B. et al. (2004) Geology 32, 845-848. [2] Kamenetsky V.S. et al. (2008) J Petrol 49, 823-839. [3] Sobolev A.V. et al. (2007) Science 316, 412-417. [4] Sobolev N.V. et al. (2009) Lithos 112, 701-713. [5] Arndt N.T. et al. (2010) J Petrol 51, 573-602.