MINERAL INCLUSIONS IN DIAMONDS FROM KOMSOMOLSKAYA AND KRASNOPRESNENSKAYA PIPES, YAKUTIA: EVIDENCE FOR DEEP LITHOSPHERIC HETEROGENEITIES IN SIBERIAN CRATON

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INTRODUCTION

Komsomolskaya and Krasnopresnenskaya pipes are located in the Daldyn-Alakit diamondiferous region of Yakutia, consisting of two kimberlitic fields: Alakit-Markha and Daldyn fields. Both these fields occur near the Arctic circle. Two major diamond mines belong to the Daldyn field: Udachnaya and Zarnitsa; and three mines are located within the Alakit-Markha field: Aykhal, Yubileynaya, and Sytykanskaya. Both the Komsomolskaya and Krasnopresnenskaya pipes belong to the Alakit-Markha field and represent a part of 63 known kimberlite pipes of this area (Kharkiv et al., 1998). This is the first report on mineral inclusions in diamonds from these two pipes.

GEOLOGICAL POSITION

The two kimberlite pipes that are the subject of this paper are located relatively close to the Yubileynaya mine. Both are cut by doleritic sills and covered by Permian-Carboniferous sediments. This pre-Permian age is more accurately defined by U-Pb zircon ages of Yubileynaya (358 Ma) and Sytykanskaya pipes (344 Ma). This places the date of kimblerlite intrusions in this field as Upper Devonian (Davis et al., 1980). Diamond grades of both pipes are relatively low compared with other Yakutian mines, but the average gem-quality of the diamonds is higher. Regular mining of the Komsomolskaya pipe is planned for the near future.

DIAMONDS

About 500 diamonds were selected for major element study of mineral inclusions (DIs). Minor part only of this collection is represented by Krasnopresnenskaya diamonds. It includes 12 macrodiamonds (> 1 mm) and 2 microdiamonds (< 1 mm). 26 microdiamonds with inclusions were selected from Komsomolskaya pipe. All diamond morphological features, in general, are typical of diamonds from known Yakutian mines (Orlov, 1977), with dominant sharp-edged octahedral crystals. All studied macro-diamonds have an average weight of about 10 mg and are between 1 and 2 mm in size. The average weight of the microdiamonds is about 1 mg.

ANALYTICAL METHODS

Mineral inclusions were released from diamonds both by crushing and burning as well as by polishing host diamonds until inclusions were exposed. Inclusion grains, as well as polished fragments of diamonds with exposed inclusions, were mounted on epoxy resin and polished for analysis. Major elements were analyzed with a Cameca SX-50 electron microprobe at the University of Tennessee and a CAMEBAX electron microprobe at Novosibirsk. The analyses were performed at 15 kV, with a 20 nA beam current, and a 1-5 μm spot size. Counting times varied from 20 s for major elements to 100 s for trace components.. All analyses EMP data were fully corrected by the Cameca PAP (~ZAF) software.

MINERAL INCLUSIONS

As with all Yakutian diamond mines, chromite is the most typical DI, occurring in about 60% of the diamonds, followed by olivine, sulfide, garnet, pyroxenes, kyanite, and rutile. Routinely, both U/P-type and E-type inclusion suites have been reported from Yakutian diamonds (Sobolev, 1974; Meyer, 1987; Gurney, 1989). Because of the common compositional features of DIs from both the pipes in this present study, their characteristics are presented jointly. Visual examination of the entire available collection led to the preliminary estimation of a ratio of U/P-type versus E-type inclusions as 85/15.

PERIDOTITIC INCLUSION SUITE

The majority of the DIs examined are from the peridotite (ultramafic) suite. They are mainly represented by a single inclusion per diamond or multiple inclusions of the same mineral (e.g., olivine). Rare occurrences of polymineralic DIs are present, as assemblages of Chr + Ol, Prp + Ol, Prp + Chr, and Prp + Chr + Ol.

Over 95% of the **chromite DIs** in this study have specific features that are typical for the vast majority of chromite inclusions from diamond deposits worldwide (Sobolev et al., 1975; Sobolev et al., 1997; Meyer, 1987; Griffin et al., 1994). These features include very-low TiO_2 contents (0.02-0.21 weight %), very-high Cr_2O_3 contents (62.3-66.9 weight %) and low Al_2O_3 contents (4.1-7.4 weight %), all accompanied by a relatively broad range of Mg# (55-75).

Olivine is studied in 35 diamonds from Komsomolkaya and in 4 diamonds from Krasnopresnenskaya pipes. General range in Fo is broad enough: 90.8 – 94.5, but absolute majority of studied samples have much narrower range of Fo 92.5 – 93.5. Average Fo 92.8. Ni contents is rather high: 0.37 – 0.40 wt.% and Cr_2O_3 contents vary from 0.03 to 0.10 wt.%. Four Krasnopresnenskaya olivines have practically similar composition with Fo = 92.8, NiO = 0.36 wt.% and Cr_2O_3 = 0.04 – 0.05 wt.%

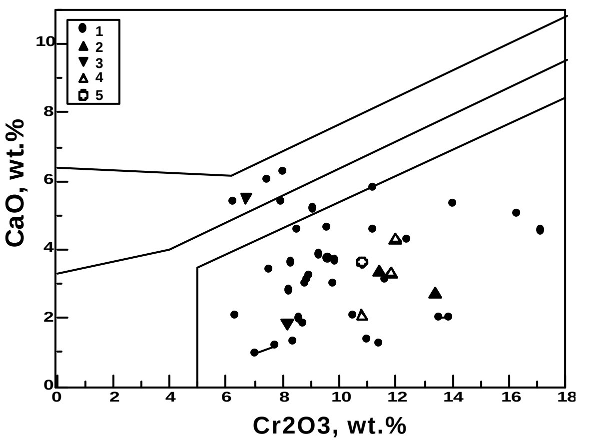

Figure 1 : Cr_2O_3 vs CaO plot (Sobolev, 1974) for Cr_pyropes from diamonds of Komsomolskaya (1), Krasnopresnenskaya (2, 3) pipes, Pyropes with diamond inclusions from Krasnopresnenskaya pipe (4) and pyrope from polycrystalline diamond aggregate, Komsomolskaya pipe (5). Data source: 1, 2, 3 – authors data; 3, 4 – after Barashkov, Zudin (1997).

Pyrope. Preliminary visual examination of available collection from Komsomolskaya led to observation about 40 Cr-pyrope DIs. 33 of them including a pyrope from polycristalline diamond aggregate (PDA) have been analyzed and their Cr_2O_3 and CaO contents are plotted in Fig. 1. For Krasnopresnenskaya pipe the number of available pyrope DIs including intergrowths with diamonds is very limited. There is important to note (see Fig. 1) that the overwhelming majority of plots of studied pyropes Dis from both pipes occupy the lower part of Cr_2O_3-CaO diagram indicating their harzburgitic paragenesis. Two of these DIs have extreme compositions containing 16.4 and 17.1 wt.% Cr_2O_3 which is extremely rare for pyrope Dis worldwide (e.g. Sobolev, 1974; Meyer, 1987).

Enstatite was found in one Krasnopresnenskaya diamond as two isolated grains of slightly different composition with significant difference in CaO 0.20 and 0.40 wt.% and Na_2O: 0.08 and 0.16 wt.%.

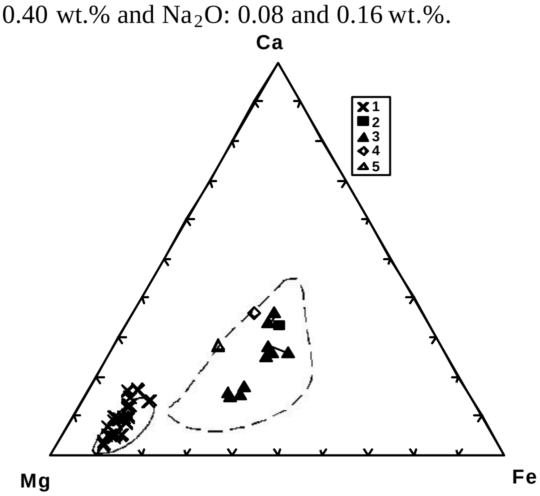

Figure 2: Composition of garnets associated with Komsomolskaya and Krasnopresnenskaya pipe diamonds in terms of Mg-Ca-Fe (at.%). Symbols are for U-type garnets of both pipes (1), for E-type garnets (2-5) including majoritic garnets from Komsomolskaya (2) and Krasnopresnenskaya (4) microdiamonds and "normal" garnets from both pipes resp. (3,5). Dotted and solid lines surrounded 95% of E-type and U-type garnets populations from diamonds respectively (modified from Meyer, 1987). Two garnet grains of different composition from the same diamond are connected by solid line.

ECLOGITIC INCLUSION SUITE

Approximately 15% of studied diamonds contain E-type DIs. **Garnet** is dominant DI. Three groups of garnet compositions, with different CaO contents may be considered. Two E-type garnets from both pipes are of special significance because of the presence of pyroxene solid solution (majoritic component). Both are characterized by the following compositional features respectively: Si (pfu) 3.13 and 3.05; TiO_2 wt.% 1.9 and 0.4 ; CaO wt.% 12.2 and 12.9; Na_2O wt.%

0.93 and 0.43; Mg# 49.6 and 54.2. In both garnets Na exceeds Ti (pfu), respectively 0.028 and 0.039.

Omphacite was detected in three Komsomolskaya diamonds. Na_2O contents vary from 2.46 to 5.43 wt.% (from 17 to 38 mol.% jadeite component) and K_2O contents vary from 0.04 to 0.23 wt.%

Kyanite and **rutile** were also found in E-type diamonds.

DISCUSSION AND CONCLUSIONS

Dominant abundance of harzburgitic garnets exceeding the average for worldwide diamond deposits (e.g. Sobolev, 1974; Meyer, 1987) along with similar features of chromite composition and availability of enstatite testify the specific role of harzburgitic paragenesis DIs in both studied pipes. Variable eclogitic (E-type) diamonds are present in representative Komsomolskaya pipe collection and in limited Krasnopresnenskaya pipe collection in equal proportion close to 15% rel. compared with U/P-type diamonds. This is more than one order of magnitude higher compared with E-type diamonds proportion established for all known Yakutian diamond mines for similar diamond size fraction. Majoritic garnets of E-type are found in microdiamonds from both pipes, which along with high CrCa majoritic garnet inclusion from Yubileynaya microdiamond (Sobolev et al., 2002) represent the first discovery of majoritic garnets in Yakutian diamonds. Both listed features may be considered as new evidence for deep lithospheric heterogeneities in Siberian craton and very deep origin of some microdiamonds (more than 300 km).

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