ARKHANGELSK DIAMOND INCLUSIONS

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Two hundred unaltered inclusions represented by different mineral phases have been extracted out of 174 diamonds from five kimberlitic pipes of Zolotitsa field from Arkhangelsk kimberlite province. Geologic position of this field is briefly described by Sinitsyn et al. (1994). Both microdiamonds (less than 1 mm) and macrodiamonds (1-3 mm) are represented in the available collection approximately in equal proportion in general, but variable for each individual pipe. Octahedral crystals are dominating among microdiamonds and dodecahedral crystals are the most typical of larger samples. Most of studied diamonds contain one phase only as inclusion, however some two, three and even four mineral assemblages of inclusions are detected.

Table 1 presents the results of an estimation of inclusions abundance from diamonds of five studied pipes based upon electron probe analyses and some published information (Kvasnitsa et al., 1993; Yefimova et al., 1989; Zakharchenko et al., 1991).

Table 1. Abundance of studied inclusions in diamonds from several Arkhangelsk kimberlite pipes

Pipe	n	ultramafic						eclogitic			
		ol	chr	ga	en	cpx	phl	ga	omf	cs	ky
Lomonosov (L)	51	26	22	5	-	-	-	-	-	-	-
Pionerskaya (Pi)	34	24	11	3	1	-	1	-	-	-	-
Karpinski I (K)	42	21	14	-	5	2	-	9	-	-	-
Pomorskaya (Po)	41	23	4	3	6	-	-	10	3	1	-
Snegurochka (Sn)	6	1	3	-	-	-	-	-	1	-	1
Total	174	95	54	11	12	2	1	19	4	1	1

Note: n = number of studied diamonds with inclusions.

Garnets are found in 30 diamonds from four pipes. Their composition is extremely variable (see Table 2). The most unique sample (Po-99) is represented by a garnet of creamy color characterized by a silica excess (Si = 3.175) and alumina deficiency indicating a presence of a **pyroxene solid solution** similar to that described by Moore and Gurney (1985) and Wilding et al. (1991). However Pomorskaya pipe sample is different from Group B garnets from Monastery mine. It is close in compositional features to websterite-pyroxenite garnets (Sobolev, 1974) containing low CaO and low Fe/Fe+Mg (17.0) mol.%) along with Cr presence.

Typical low Ca Cr-pyropes of dunite-harzburgite paragenesis (Sobolev, 1974) are detected in studied diamonds. Selected analyses are represented in Table 2. Eclogitic garnets contain variable CaO demonstrating a wide range in compositions. Additional support of possibilities of presence of kyanite eclogite paragenesis with Ca-rich garnet is a find of a kyanite inclusion (see Table 1). All eclogitic garnets contain higher sodium on an average

compared with eclogitic garnet inclusions worldwide with an exception of Argyle inclusions only (Sobolev, 1974; Sobolev et al., 1991).

Pyroxenes of ultramafic (peridotitic) type are represented by typical chrome diopsides and enstatites (Meyer, 1987). However eclogitic pyroxenes have indications of a high systematic potassium abundance shown (see Table 2) for all available samples from two pipes.

Olivines are similar in their composition to all diamond inclusions (Meyer, 1987). Typical analyses from intergrowths with chromite grains are presented in Table 2.

Table 2. Selected analyses of inclusions

Sample	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Total
Garnets											
Po-99	45.1	0.71	16.6	1.22	8.47	0.23	23.1	4.01	0.23	nd	99.66
Po-4	41.9	0.06	15.8	9.33	6.93	0.36	20.2	5.20	0.02	nd	99.80
Pi-52	40.4	0.08	11.4	15.7	6.31	0.38	19.5	4.20	0.05	nd	98.02
Po-79	41.3	0.12	22.5	0.02	17.5	0.32	15.1	2.74	0.20	nd	99.80
Po-15	39.6	0.57	21.6	<0.02	17.2	0.30	7.10	13.0	0.31	nd	99.68
Pyroxenes											
K-I-71	57.6	<0.02	0.54	0.49	3.90	0.08	35.6	0.43	0.10	nd	99.64
Po-36	56.0	0.56	15.5	0.02	3.37	0.02	5.69	9.47	7.67	0.41	98.71
Po-45	56.1	0.60	12.9	<0.02	4.76	0.06	6.68	11.1	6.51	0.72	99.43
Po-10	55.2	0.58	12.8	0.05	4.51	0.06	6.97	11.2	6.84	0.79	99.00
Sn-7	56.1	0.64	13.5	<0.02	4.00	0.06	6.77	11.1	6.63	0.65	99.45
Olivines											
Pi-52	41.5	<0.02	<0.02	0.05	6.85	0.11	51.5	0.02	0.33*	nd	100.36
L-267	41.5	<0.02	<0.02	0.07	6.53	0.10	51.6	0.01	0.35*	nd	100.16
Chromites											
Pi-52	0.25	0.18	6.66	64.2	13.7	0.23	13.9	0.10*	nd	nd	99.22
L-267	0.03	0.06	4.48	65.3	15.5	0.22	13.0	0.09*	nd	nd	98.69
Phlogopite											
Pi-52	41.5	0.41	12.8	2.00	2.68	0.03	24.8	0.10	0.06	9.98	94.36

Note: * - NiO, nd - not determined.

Chromites are similar in their composition to the absolute majority of inclusions in diamonds (Meyer, 1987; Sobolev et al., 1989). Seven diamonds from available collection contain each 2-5 chromite grains as inclusions and in all the samples the differences in compositions of different grains are fixed. Four grains extracted from K-I-69 diamond contain from 5.87 to 7.80 wt.% Al_2O_3, from 63.1 to 65.2 wt.% Cr_2O_3, from 13.2 to 14.0 wt.% FeO (Tot) and from 13.9 to 14.4 wt.% MgO. Sample Pi-28 contains the following range of all listed oxides in the same order (5 grains): from 3.27 to 4.76 wt.%, from 65.2 to 66.5 wt.%, from 15.1 to 16.8 wt.% and from 11.7 to 13.4 wt.%. It is possible to conclude that the former sample is characterized by wider range in Al_2O_3 and Cr_2O_3 and narrower range in FeO and MgO contents. An opposite trend with a wider range in FeO and MgO contents is typical of sample Pi-28.

Phlogopite is considered as one of the rarest inclusion in diamonds and uncertain in respect of its primary or secondary origin (Meyer, 1987). However, phlogopite from sample Pi-52 coexisting with low Ca Cr-pyrope, olivine and chromite (see table 2 for analyses) is characterized by low FeO, TiO_2 and high Cr_2O_3 contents and is typical of dunite-harzburgite paragenesis as was earlier described by Sobolev et al., (1988).

Coesite was found together with eclogitic garnet and one **kyanite** inclusion was detected (see Table 1).

Temperature estimate for 50 kbar pressure (O'Neill, Wall, 1987) shows the range from 1040 to 1260°C with an average close to 1120°C.

Diamonds from Lomonosov and Pionerskaya pipes representing 50% of all collection do not contain eclogitic inclusions at all. This might be explained by a general smaller size of available crystals from these pipes. As shown by Gurney (1989) and Sobolev et al. (1989) larger diamonds both of Finsch and Yakutian pipes contain much more eclogitic inclusions compared

with smaller size diamonds. However, taking into account such a trend is possible to conclude that a general proportion of eclogitic diamonds in Arkhangelsk pipes is higher compared with Yakutian mines and is close to that of alluvial diamonds from the north of the Siberian Platform (Yefimova, Sobolev, 1977).

The stable indications of very high pressure origin of some studied samples including the unusual websterite-pyroxenitic type garnet containing pyroxene solid solution are of special importance. Stable high Na in eclogitic garnets and K in pyroxenes are indicative of diamond facies as was firstly noted by Sobolev (1974). Arkhangelsk diamonds occupy transitional position between Yakutian and West Australian occurences in relation of maximal depth of their origin.

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