

COMPOSITIONAL EVOLUTION OF SYNGENETIC
INCLUSIONS OF ULTRABASIC ASSOCIATION
IN YAKUTIAN DIAMONDS

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Syngenetic inclusions of ultrabasic association from growth zones of diamond crystals have been studied. The inclusions were exposed to the surface by progressive polishing technique. To study their composition JXA-50 A and Camebax-Micro microanalysers were used.

According to the precipitation sequence of diamond associated minerals the inclusions have been divided into 4 groups. These are seed-minerals and minerals from the central, intermediate and peripheral areas (made of small zones) of diamond crystals. Comparison was made between chemical compositions of inclusions from different areas within the same single diamond crystal and of those from the same areas in different crystals.

The following seed-inclusions have been recognised: olivine, enstatite, garnet, as well as ore minerals such as taenite, pyrrhotite, carbon iron and Zn-Fe spinel, representing inhomogenous fine mixtures of polycrystalline phases. Besides, in the initial growth centers of some single diamond crystals, monocrystalline graphite has been found.

Zonal distribution of inclusions was studied on olivines from I2 single crystal diamonds. Olivines from different areas within the same crystal have revealed normal zoning. Average FeO-content of olivines from different diamond crystals also increases from central areas (6.5 wt.%) through intermediate (6.8 wt.%) to peripheral ones (7.4 wt.%), which probably reflects high temperature conditions at the nucleation stage of single diamond crystals and some temperature drop during their subsequent growth.

One of the diamond studied in addition to olivine intermediate and peripheral areas, contained mineral pairs which can be used as geothermometers. Distribution of inclusions within diamond is schematical-

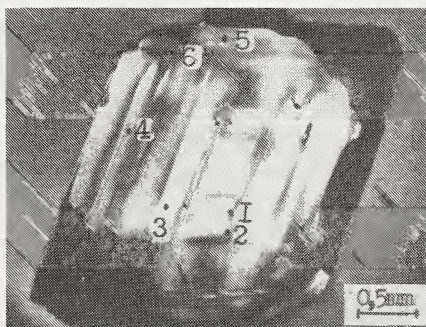


Fig. Zonally distributed inclusions in a diamond plate cut along the (100) of diamond I525; 1,2,3,4, 5 - olivines; 3 - garnet; 6- three-phase inclusion: magnesite+enstatite+clinopyroxene.

ly represented in the figure, while their compositions are given in the table.

Composition of inclusions from diamond I525.

Compo- nents	central area		intermediate area			peripheral area		
	olivi- ne-1	olivi- ne-2	garnet -3	olivi- ne-4	olivi- ne-5	ensta- tite-6,1	clino- pyro- xene-6,2	magne- site-6,3
SiO ₂	40,68	40,78	42,09	41,14	41,34	58,81	55,46	-
TiO ₂	0,03	-	0,05	-	0,03	0,07	0,07	-
Al ₂ O ₃	-	-	17,80	-	0,01	0,44	2,86	-
Cr ₂ O ₃	0,07	-	9,18	0,14	-	0,35	5,24	0,01
FeO	6,50*	6,36*	5,27	6,30*	6,59*	3,96	2,47	3,41
MnO	0,10	0,09	0,26	0,14	0,10	0,10	0,09	0,12
MgO	51,29	51,79	14,02	50,99	51,37	35,84	12,64	39,39
CaO	-	-	2,27	0,01	0,03	0,26	16,20	0,61
Na ₂ O	0,02	0,02	0,02	-	0,06	0,17	3,64	-
K ₂ O	-	-	0,01	0,01	0,02	0,01	0,07	-
CO ₂	-	-	-	-	-	-	-	56,6**
Total	98,69	94,04	100,98	98,74	99,53	99,00	98,74	100,00

* - average of 20 measurements; ** - calculated CO₂

Olivines from different areas insignificantly differ in their FeO-content. FeO - content of olivine 1 and olivine 5 is practically the same, it is somewhat lower in olivine 2 and olivine 4. Compositional peculiarities of garnet 3 enabled us to refer olivine 2 + garnet paragenesis 3 to the harzburgite-dunite one.

Inclusions 6 in the form of a single crystal 100x18 m in size from the outer zone of the crystal turned out to be three-phase when exposed to the surface. It is largely composed of enstatite; a narrow marginal zone is made of clinopyroxene, and another one made of magnesian-iron mineral with stoichiometry corresponding to magnesite. C-presence was supported by direct measurements of C K α - emission on a wavelength spectrometer.

By its mineral composition the association mentioned can be referred to the lherzolite one, but the harzburgite-dunite association is likely to contain very small amounts of clinopyroxene too. By its chemical composition clinopyroxene 6.2 corresponds to a ureyite-rich variety rarely occurring as diamond inclusion. It is more common in intergrowth with diamond and occurs rarely in ultrabasic xenoliths. Natural clinopyroxenes of similar composition are likely to belong to the magnesite-peridotite paragenesis. Magnesite has preserved in diamond sole-

ly due to its being entrapped by diamond and isolated from the environment, while in xenoliths it suffered secondary alteration.

Crystallization temperature of olivine 2 and garnet 3 from the intermediate area was estimated at 1190°C using O'Neill and Wood's geothermometer (1979), while that of the enstatite - clinopyroxene + magnesite association from the peripheral area was estimated at 1000°C using a two - pyroxene geothermometer by Wood and Banno (1973). Pressure was estimated at 50 kbar from the Al_2O_3 -content of enstatite co-existing with clinopyroxene.

Thus geothermometry in one diamond crystal supported data on temperature drop during the single diamond crystal growth obtained as a result of investigating zonal distribution of olivines in different diamonds.

Gradually increasing iron content of olivine inclusions with distance from the center of a host diamond is well accounted for by crystallization differentiation of the melt during the temperature drop in a closed magmatic system. Another reason for the melt evolution may be oxygen fugacity variations reflected in the composition of inclusions in diamonds. For example, central diamond zones contain phases indicating f_{O_2} that corresponds to the wustite-iron buffer, while in the peripheral area f_{O_2} roughly corresponds to the quartz-fayalite-magnetite buffer. The final growth stage of diamond crystals probably occurred in the conditions close to the diamond-carbonate monovariant equilibrium curve.

The finding of a magnesite inclusion syngenetic with diamond supports the possibility of kimberlite melt formation and diamond growth in natural conditions as a result of the realization of processes described by model systems (Ryabchikov, 1980; Wyllie, 1980).

References

Bulanova G.P., Varshavsky A.V., Leskova N.V., Nikishova L.V., 1984, Central inclusions as indicators of conditions of natural diamond nucleation. Tezisy dokladov na 27 sessii MGK, Moscow, T. Mineralogia, p.193.

Ryabchikov I.D., 1980, Nature of kimberlite magmas. Geologia rudnykh mestorozhdeniy, N 6, pp.18-26.

O'Neill M.S.C., Wood B.J., 1979, An experimental study of Fe-Mg-partitioning between garnet and olivine and its calibration as geothermometer. Contr. Mineral. Petrol., v.70, pp.59-70.

Wood B.J., Banno S., 1973, Garnet-orthopyroxene and orthopyroxene-clinopyroxene relationships in simple and complex systems. Contr. Mineral. Petrol., v.42, N 2, pp.109-124.

Wyllie P.J., 1980, The origin of kimberlite. Journal of Geophysical Research, v.85, N B-12, pp.6911-6918.