INCLUSIONS IN NATURAL DIAMONDS OF DIFFERENT HABITS

Tal'nikova S.B.

Yakut Institute of Geosciences, Siberian Branch, Russian Academy of Sciences, 39 Lenin av., Yakutsk, 677891 Russia

Comprehensive study of syngenetic inclusions in natural diamonds of different morphologies from different kimberlite pipes in Yakutia has revealed the following.

Inclusions of both ultrabasic and eclogitic parageneses in octahedral diamonds from different kimberlite pipes are similar in the set of their composing minerals but differ in distribution.

In general, compositions of inclusions in diamond octahedra from the Udachnaya pipe are similar to those of analogous minerals of diamond paragenesis, except sulphide inclusions. Sulphides in diamonds from Udachnaya are characterized by a monophase composition, except one sample with pentlandite composition. An extensive isomorphism between iron and nickel indicates that sulphide material found as inclusions in these diamonds was a monosulphide solid solution based on iron and nickel with an insignificant copper admixture. Compositional differences of sulphide inclusions are indicative of specific conditions of diamond growth in each particular pipe.

In diamonds of intermediate habit, there are inclusions of syngenetic minerals showing morphologies typical of octahedral diamonds. The chemical composition of inclusions in diamond dodecahedroids is consistent with that of inclusions of similar minerals in octahedral diamonds. On the whole, similarities in the set, shape and composition of syngenetic inclusions in octahedral and dodecahedral diamonds evidence that some diamonds of intermediate habit could have resulted from resorption or anti-skeletal growth of octahedral crystals.

Yellow diamond cubes of Habit II (in Yu.L.Orlov's mineralogical classification) have shown unusual syngenetic inclusions that differ much from typical minerals of eclogitic and peridotitic parageneses in diamond octahedra. The unusual foreign particles are microinclusions of complicated, variable composition with high potassium contents. The microinclusions show significant variations of SiO_2, Al_2O_3, FeO, MgO, Na_2O, P_2O_5 and Cl_2. The microheterogeneity of the studied inclusions, unusual composition, presence of volatiles, and behavior under electron microprobe suggest that they have originated from a melt. Probably, they represent either a partially crystallized melt with dissolved volatile components or a fine mixture of several minerals (Tal'nikova, Pavlova, 1993).

Because large mineral phases, like inclusions in octahedral diamonds, have never before been encountered in cubic diamonds of the above mentioned habit, a find of two inclusions of different parageneses in one diamond cube (from Z.V.Spetsius' collection) is of interest. X-ray spectral analysis of one of the inclusions (an intergrowth) showed the presence of the mineral association serpentine+ chromite+calcite+silphides of the system Fe-Ni-Cu-S. It was supposed that the intergrowth of unusual mineral association was probably protogenic and entrapped from a kimberlite melt during final growth of diamond in the earth's crust. Further polishing of the cube exposed the other inclusion of omphacite composition with low potassium concentrations. Thus, the studied diamond cube contains both ultrabasic and eclogitic inclusions (there are few examples for the co-existence of inclusions of different parageneses in octahedral diamonds in literature). Most probably, this particular diamond nucleated and grew in eclogitic environment under upper mantle conditions. However, the final growth of the crystal took place in a kimberlite melt that transported it to the surface. This is evidenced by the following: 1. The omphacite inclusion is closer to the center of the crystal than the intergrowth. 2. The lack of cracks from the inclusions to the diamond surface suggests that the inclusion of chromite+calcite+sulphide+serpentine composition is not epigenetic and at the time of entrapment was a calcite+serpentine seudomorph after olivine with a chromite inclusion. Also interesting is a find in another cubic diamond of an inclusion which is a calcite+phlogopite intergrowth, with the phlogopite being situated in its center. The phlogopite is consistent with the lherzolite paragenesis, as established by N.V.Sobolev and coauthors (1988).

Interestingly, found in the central parts of the yellow diamond cubes were octahedral areas with inclusions of foreign matter at their borders indicative of a hiatus in the crystallization process, which is a proof of two generations of diamond. Therefore, a change of habit in a single diamond does not evidence a change of growth conditions during continuous crystallization. The latter could result from sudden increase of oversaturation, with kinetic regime giving way to diffusional one (normal growth at high rate). Maybe, cubic diamonds with the octahedral central areas are similar in their nature to coated diamonds.

Inclusions, found in the central parts of our studied coated diamond crystals, correspond in composition to eclogite ceries rocks. Only one intergrowth of phlogopite and native iron found so far in a core of a coated diamond from the Aykhal pipe corresponds in mica composition to the ultrabasic paragenesis. Finds of native iron in octahedral diamonds are known (Sobolev et al., 1981; Bulanova, Zayakina, 1991).

Grey cubic diamonds of Habit III contain abundunt, tiny, opaque particles of which only few are suitable in size to microprobe analysis. Pyrope-almandine and rutile were found previously in such diamonds (E.S.Efimova, personal comm.). Of the inclusions which are typical of octahedral diamonds, an omphacite inclusion has been found quite recently in two cubic diamonds from the Aykhal pipe, as well as two syngenetic chromite inclusions in a clear cubic diamond from the Zarnitsa pipe (Tal'nikova, Spetsius, unpublished data). Notably, the latter crystal differs in concave faces from typical diamond cubes. As shown previously by X-ray and cathodoluminescence topography (Welbourn et al., 1989), concave cubes result from mixture of normal octahedral growth in narrow sectors with so-called cuboid growth (areas of hummocky non-crystallographic surface with the <100> orientation) in-between the sectors. Therefore, the find of chromite inclusions in one of the studied cubic diamonds suggests that they form in both eclogitic and ultrabasic environments. The few of the analyzed microinclusions in grey diamond cubes are a fine mixture of several minerals with predominant calcite.

Diamonds of different morphologies also differ in the inner structure, as indicated by colored cathodoluminescense data . Octahedral diamonds show a more complicated growth pattern as compared to cubic ones. The latter experience insignificant changes of the inner structure only during final crystallization stages.

Bulanova, G.P., Zayakina, N.V. 1991. Doclady AN SSSR. 317, N 3, 706-709 (in Russian).

Sobolev, N.V., Efimova, E.S., Pospelova, L.N. 1981. Geologiya i Geophisica, N12, 706-709 (in Russian).

Tal'nikova. S.B., Pavlova, L.A. 1993. Geologiya i Geophisica, N 7, 194-197 (in Russian).

Welbaurn C. et al. 1989. Journal of Crystall Growth . 94 (1), 229-252.