GROWTH HISTORY OF NATURAL DIAMOND

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Growth history of Type Ia and IIa diamonds of octahedral, rhombo-dodecahedral, and cubic habits from Yakutia has been studied. 72 plane-parallel plates cut along the (II0) and (I00) of crystals different both in habit and type have been thoroughly investigated. To study their anatomy and following methods were: Lang's X-ray topography, polarizing optical method, UV-ray and cathode ray excited luminescence, UV-visible absorption in a narrow spectral range. Locally the plates and whole crystals were studied by IR- and UV-spectroscopy at room and nitrogen temperatures.

All the diamond studied were inhomogeneous. Some crystals contained identical structural imperfections and impurities present in different amounts, while others included defects differing both in type and content. The former will be referred to as tentatively homogeneous (or simply homogeneous), while the latter - as inhomogeneous. The first group includes cubic Type Ia and Type Ia+IB crystals, as well as Type IIa and Type III diamonds. Type Ia octahedra and dodecahedra of the second group, in addition to zonal-sectorial inhomogeneity, have revealed 3 areas within their volume: central, intermediate and peripheral. The same areas in different crystals have similar physical and morphological properties. Different areas differ in these characteristics.

The central area is a small region within a genetic center of a crystal formed during the nucleation stage. Its properties are: a) high density of structural defects responsible for X-ray scattering and extremely high birefrigence; b) yellow-green or orange photoluminescence; c) tendency towards sterility with regard to B2 defects and to a lesser extent with regard to N3 defects. Other properties of central area vary from crystal to crystal. Two crystals have revealed cubic-shaped central areas with physical properties characteristic of whole diamond cubes. The same properties are typical of I00 pyramids in sectorial crystals. Most common are Type III central areas. One specimen have shown a Type IIa central area containing 578 and SI systems in the photoluminescence spectrum.

The intermediate area is inhomogeneous and contains interbedded Type Ia and Type IIa zones. It is characterized by: a) alternating high and low birefrigence zones, not luminescent or with blue luminescence; transparent and opaque at a definite UV-wavelength; b) higher plate-type defect content along the (IOO); c) a step-like profile of octahedral growth zones.

The peripheral area has the following characteristics. It does not scatter X-rays; it has a low birefrigence, if any at all; it does not luminesce and absorbs UV-light at 300 nm.

Type Ia flat-sided sharp-edged octahedra contain all the three areas mentioned. Type Ia and Type Ia+III coarse-layered octahedra contain the central and intermediate areas but lack the peripheral one. Tentatively homogeneous crystals show properties similar to those characteristic of one of the central area types in inhomogeneous crystals. A close similarity has been established between Type IIa central areas and Type IIa crystals, between Type III central areas and Type III crystals, between cubic-shaped central areas and cubic structured crystals. Two genetic types of rhombododecahedra have been established, In dodecahedra rectilinear octahedral zones are cut by a secondary rounded surface. In nearly flat-sided rhombododecahedra growth zones along the (IIO) have been first recognized in diamonds.

The data obtained suggest the following model for the evolution of conditions in which natural diamonds crystallized (schematic representation of the model is given in the figure). It is inferred that natural diamonds had a 3-stage growth history. The stages differed in their physical-chemical conditions, primarily in the degree of supersaturation of the crystallizing environment. At the early stage initiation and growth of the central area under high supersaturation occurred. Supersaturation provided high growth rate and largely normal growth mechanism. Diamonds that ceased their growth at the early stage belong to tentatively homogeneous crystals. These are Type Ia, Type IIa and Type III diamonds. It is at the early growth stage that a boart variety formed. The intermediate stage was marked by repeated changes in physical-chemical parameters of crystallization reflected in octahedral zoning of the intermediate area within crystals. Supersaturation was lower at the time than that at the early stage, growth rate and the proportion of normal growth lowered too. Diamonds that ceased their growth at this stage are represented by coarse-layered octahedra with blue luminescence. The final growth stage of natural diamonds occurred in stable near-equilibrium conditions. Crystals that ceased their growth at the final growth stage are flat-sided sharp-edged octahedra. Right on the scheme you can see reconstructed crystal forms, all occuring in nature as diamond habits. This accounts for a great variety of morphological and physical properties of natural diamond.

Relationship between the shape and properties of a diamond and its size is well-known. The smaller diamond size, the lower proportion of non-luminescent sharp-edged octahedra and the greater amount of coarse-layered octahedra with blue luminescence. Small stones are largely cubic-shaped with yellow-green luminescence (Yurk et al., 1973). They are predominated by Type IIa and Type III diamonds. In terms of the hypothesis suggested this is explained by the fact that the role of the intermediate area and then of the central area successively increases with decreasing diamond size.

The evolution trend could be perturbed by supersaturation fluctuations. Sharp increases in supersaturation resulted in the coated diamond formation. The coat material properties are common to those of the central area material. As the coat thickened, the octahedral habit turned into the cubic one (Yu.L.Orlov, 1973). Decreasing supersaturation resulted in partial crystal dissolution, i.e. octahedra turned into dodecahedroids.

References.

Orlov, Yu.L. Mineralogy of diamond, M, Nauka, 223p.

Yurk, Yu.Yu., Karkarov, I.F., Polkanov, Yu.A., et al., 1973, Diamonds from sandy deposits of the Ukraine, Kiev, Naukova dumka, 167 p.

Tolansky, S., 1973, Distribution of Type I and Type II in South African diamonds, Diamond Res., pp. 28-31.

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