MORPHOLOGY AND GROWTH CONDITIONS OF DIAMONDS IN METAMORPHIC ROCKS

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At present, we know five different earth sources of diamond crystals. The main one is kimberlites, lamproites and alluvial sediments derived from these rocks. These types of diamond arewell known [Orlov, 1984,]. The morphology of diamonds from impactites, ultramafic picrites, and metamorphic rocks are different, and therefore the conditions of their growth must be different, too. Metamorphic diamond microcrystals are known from Kazakhstan and China [Xu et al,1992]. We also encountered them in residues of the thermochemical dissolution of garnet-biotite gneisses from Western Gneiss Region of Norway [Dobrzhinetskaya et al,1993]. They are very small (0,02-0,08mm) and have unusual forms. There are no dodecahedrons and very few octahedrons in metamorphic rocks. We may see the following crystal forms in these rocks: skeletal and spheric, faced (antiskeletal) and edge rays, boxy and tabular forms and very unusual aggregate skeletal crystales formed by coarse - layered blocks.

The origin of metamorphic diamonds is a problem. There are many hypotheses concerning this question [Sobolev, 1990]. In our view, the morphology of metamorphic diamond crystals may answer this question. We investigated different crystals and proposed their morphological classification [Nadezhdina, Posukhova,1990]. The latter has been based on habit and surface texture of the metamorphic diamond crystals. The main type - the irregular aggregate cubic crystals formed by coarse - layered blocks. The second type - the regular cubic habit crystals with imbricated faces. The third type - combined crystals with the faces (111),(100) and (011). Combinations of cube - octahedral forms dominate. The forth type - round-plane crystals, in which octahedron combine with round sphere forms. All cubic crystals have isometric habit. Usually, they are single crystals, often asymmetric. Their faces may be both plane and rounded. The rounded surfaces are rough and hillocky. The surfaces of faces (100) are porous and uneven they have rough microrelief and covered by the tetragonal etch pits. The narrow zone {110} have shaded and hatched surfaces, and replace the edges. The faces (111) of those crystals are smooth and have a relief of inversely oriented triangular pits. This type of crystals possess sector and zone-sector structures and, therefore tend to crack along the boundaries of growth sectors, not along the cleavage plates.

There are three types of skeletal diamond crystals in metamorphic rocks. The first one is tabular crystals. Their forms are hexagonal, with winding contours and sculptured surfaces. The second type is an edge rays. They are formed by thin plates diverging from common centers and, therefore, they are similar to exotic flowers. The faces, edges and tops of this crystals are very unclear, they have isometric forms, rough surfaces and winding contours. Boxed skeletal forms are the hollow cubic crystals, irregular and incompletely filled by thin diamond plates, growing at the angle to the surface. The faces (100) are incompletely developed, their surfaces are dismembered by and rich in deep cavities. Some skeletal crystals have indefinite habit and the on-top growths. The last group of metamorphic diamond crystals - a rounded isometric forms similar to spheres. Edges and corners between the faces are very unclear expressed. Their surfaces are incomplete developed and irregular in shape.

The comparison of metamorphic crystals morphology with that of diamonds from kimberlites shows, that they are very much different. However, some forms of metamorphic crystals are similar to artificial diamonds. Sunagava (1984) and Samoilovith et al(1982) showed, that crystal morphology and surface microtopographies of diamonds were related to growth parameters both under stable (metal solution) and metastable (vapor phase) conditions. Fiber structure of <100> and <111> growth pyramids and particular morphology of the involved growth faces were found to correspond to that of the synthetic crystals, flux-grown in the region of diamond thermodynamic stability. Natural diamonds that grow as deformed cubes and synthetic crystals grown from vapor phases (cuboctahedra and numerous forms of cyclic twins) possess somecommon features in their inner structures. In both cases the determining factors of the growth mechanics were supersaturation and transport rates. Differences among natural cubic faces were observed, which should not develop as smooth interfaces and two types of synthetic crystals of diamond. They may be accounted for on three bases:1) differences in size of growth units, 2) differences in the ability of surface reconstruction of (100) faces among silicate and metallic solutions and vapor phase and 3) habit variation depending on supersaturation.

The similarity between metamorphic and synthetic diamonds permits us to apply the growth theory to explanation of the peculiarities of metamorphic diamond morphology. We know two mechanisms of growth: the tangle mechanism, when crystals grow by layers and the normal mechanism when round atomic-rugged surfaces formed. The first mechanism realizes when crystals grow slowly in weak supersaturation and the second mechanism characterizes strong supersaturation and quick growth. When the solution is supercooled in front of the growth limit, and the projection of crystal comes to this region the cell structure forms and the crystal acquires the form of a hexagon plate. The skeletal forms appear in unmovable solutions due to the capture of impurities. On that platform we compare the morphology of metamorphic diamonds and synthetic ones. Cubic crystals of metamorphic diamonds with block structure formed by very rare mechanism of growth - aggregating of microblocks. Little crystal forms, which are overgrowed on the tops of cubic crystals are the evidence for the interruption in growth and changing in conditions. Such occurrence, wwich is called autoepitaxie, is typical of hydrothermal minerals. Fibrous mechanism of growth is characteristic for the boxy cubic crystals. Transition from tangle (faced) growth to normal (fibrous) mechanism takes place under non-equilibrium conditions when the temperature drops. The deviation from equilibrium results in spherical, isometric forms of diamonds. Skeletal growth of crystals is due to fast deposition of carbon, fast increase in saturation degree and high contents of impurities. As a result, the concentration of nitrogen impurities in skeletal and cubic metamorphic crystals is higher then that in kimberlite diamonds. The impurities increase the speed of growth and make the diamond crystals defective. They acquired sector and zone structure, which is characteristic for most of metamorphic diamonds. Fast saturation (cooling) of mineral solution is the cause of forming a great number of crystal embryos. This explains very small sizes of metamorphic diamonds and the frequent occurrence of twins.

Thus, crystallomorphologic analysis and its comparison with experimental data gives us a fundament to conception about of metamorphic diamonds origin. The structure of small cubic natural diamonds is similar to that of synthetic ones, that were obtained in the course of a spontaneous crystallization. The similarity between the metamorphic and synthetic diamonds warrants application of the growth theory to explaining the specific morphology of metamorphic diamond. We suggest, that the in metamorphic rocks crystallized very quickly during a short time at non-equilibrium conditions at the low temperature and pressure from the supersaturated solutions which were rich in impurities. The faces (100) dominate when conditions were not much different from diamond-graphite equilibrium, and in diamond-stable regions the faces (111) prevailed. During the slow growth, the faces (100) became smooth, while during the fast growth the block structure of the faces formed. Such conditions may be reali zed either during the fast emergence from mantle depths, or in crust conditions, during the spells of tectonic activization which accords for anomalous stresses and temperatures.

References:

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