ORIGIN AND HISTORY OF GROWTH OF MACRODIAMONDS FROM YAKUTIAN KIMBERLITES

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Introduction. The internal inhomogeniety of diamonds and its xenogenetic nature in the kimberlites is the reason to use their integrated study. The aim of this article is to constrain the conditions of diamond origin, based on the complete genetic information recorded by their single crystals during the formation.

A selection of samples was done from several thousands of macrodiamonds of Mir, 23d. Party Congress and Udachnaya kimberlitic pipes, all of which have a late Devonian age (Davis, 1977). Diamonds of the peridotitic and eclogitic affinities of octahedral external shape mainly were selected on the basis of their syngenetic mineral inclusions and the different types of internal structure. 90 of them were sawn on the (110) plane to reveal the internal morphology and inclusions location. The internal morphology of diamonds was studied by imaging of photoluminescence (PL) and cathodoluminescence (CL) of their central plates. The distribution of hydrogen (H) and nitrogen (N) in the diamond zones have been studied by IR microspectroscopy. The major element composition of syngenetic inclusions was measured by electron microprobe.

Data. According to the studied features diamonds were divided into the three genetic groups:
1. Diamonds of simple octahedral zonation. About 70% of octahedral peridotitic and eclogitic diamonds revealed an octahedral internal zoning also (Bulanova,1994). They are divided into:
<u>a). Homogeneous (single- stage growth).</u> Peridotitic diamonds of this group consist of a very regular flat octahedral zones without features of resorption, except at the rim zones. They exhibited few features of plastic deformation. Eclogitic diamonds show a features of a slight dissolution during the initial stages of the formation only, and do not revealed any deformation features. Most of these diamonds exhibit blue PL or none at all. Their nitrogen content is generally low and 1aA·1aB aggregation is usually slight (<30%), and decreases toward the rim. The composition of inclusions (Chr and Ol in peridotitic stones and Cpx and Sf in eclogitic stones) does not change in the different zones, indicating, that local chemistry did not change during the growth.
<u>b). Heterogeneous (2 or 3 stages of growth)</u> This group also shows an octahedral zoning, but the PL color of their central zones (yellow or blue) is different from the color of the subsequent growth zones (blue or no PL, respectively). A small degree of resorption is observed in the eclogitic diamonds and peridotitic diamonds show the features of plastic deformation. The major zones are often separated by very thin zones, which are dark in CL, being nitrogen free, as IR data show. Two stones typical of peridotitic and eclogitic suits are considered in detail by Taylor et al. (1995). Both exhibit a central zone which contains some H, and where IR aggregation is complete for relatively high nitrogen content. In some peridotitic diamonds hydrogen is located in the areas of small inclusions (phlogopite, for example).

The compositional change between chromites of different location, within the single diamonds is: Mg $Fe^{3+} \rightarrow Fe^{2+}$Cr, during the time of diamond growth, whilst the T of the diamonds formation decreases from 1260 to 950°C. The evolution of chemistry of Cpx inclusions from the eclogitic diamonds is expressed by the small increasing of Mg# and decreasing of Ca/Ca+Mg, potassium content and jadeite component from central inclusions to those from rim. Small decrease of T (1250-1190°C) during the growth of the eclogitic diamond was identified (Bulanova, 1994).

2. Diamonds exhibiting complex zonation and a change of habit are less common for both paragenetic groups of octahedral diamonds. There are two principal types:

a). Habit change induced by mixed and tangential growth mechanism. For peridotitic diamonds of this type there were identified the internal structures: Cubo-octa. shape ("central cross" structure) →octa; Rounded → octa.; and one case of Cube → octa. For eclogitic ones there were revealed: Cube → rounded → rough-layered octa.→ smooth-layered octa., and very rare type: Cubo-octa shape → octahedron. The PL color of the very small central zones is always yellow, and the remainder of it has a blue PL. Slight dissolution features are found during the intermediate stage of formation of eclogitic stones and on the peripheral stage of peridotitic diamonds. Plastic deformation features were revealed in peridotitic diamonds only. The IR data of peridotitic diamonds with central cross structure exhibited hydrogen located in the cubic sectors and slightly aggregated nitrogen located in the associated octahedral sectors. The typical eclogitic diamond shows: 1aA nitrogen defects, platelets and H in the central cubic zone; 1aA, 1aB and platelets in the rounded intermediate zone; 1aA and platelets peak in the peripheral zone. Thus hydrogen is concentrated in the cubic and rounded zones.

The difference between chromites of different locations within the individual diamonds is expressed by the decrease of $Mg/Mg+Fe^2$ and the increase of Cr/Cr+Al, accompanied by small decrease in temperature during diamonds growth (Bulanova et al,1993).

b). Habit changes and the occurrence of different growth mechanism A few eclogitic diamonds revealed the internal morphology: Complicated uncertain shape (fine grained aggregate?) → rounded (hummocky) → rough-layered octahedron → smooth-faced octahedron. The diamonds show intermediate rounded zones whose shape is determined by the geometry of seed zone. The fine grained and rounded zones were grown by the fibrous mechanism, and the octahedral ones by the tangential mechanism of growth. The PL color of these diamonds is blue, but rounded zones contain a yellow-green component. Slight features of resorption without any features of plastic deformation were found there. IR study of the diamonds exhibited the 1aA defects, small platelets peak and hydrogen in the central rounded zones. The rims zones show 1aA and small content of 1aB defects and platelets.

These diamonds contain numerous sulfide inclusions and two of them belong to the coesitic eclogites. The assemblage of inclusions have been identified: Cpx+Gar+Sf+Cs+"melt" inclusions. The microinclusions of melt composition were found in the diamonds on the boundary of the rounded and octahedral zones. They are presented by polymineralic inclusions : Bt+Po+Ca(with 2wt.% of K) and Sa+Amf+Po or by the homogeneous Na-K-Ca-Mg-Fe-Ti-Al -Si composition. In one diamond the inclusion of calcite was identified, being enriched by Rb, Sr, Y, Zr, Nb, Ba, La, Ce and Th and therefore being very close to the carbonatitic melt.

A few studied coated octahedral diamonds grown by tangential and then by fibrous mechanism were also of eclogitic affinity, as was shown earlier (Bulanova et al, 1993).

3. ***Multistage formed diamonds during the change of conditions, including etching or breakage in the consolidated rock and regrowth.*** A few peridotitic diamonds exhibited the following history of formation: Octa.+ resorption→ Rounded→ Octahedron→ Cubo-octa+etching→ Octa. and Cubo-octa.→ Octa+breakage or selective resorption →Octa.+resorption. Thus, one group of peridotitic diamonds went through a very complicated history of formation. Octahedral zones of the diamonds have blue Pl, whilst cubic sectors show the yellow. No features of plastic deformation were found in the diamonds. The IR of the diamond getting throw the breakage is described by Taylor et al (1995). The diamond had at least three stages of formation. The proton-microprobe analysis of sulfide inclusions show a progressive change in PGE patterns of the sulfide from core to rim of the diamond, which indicates that the environment changed very slowly during the growth. On the other hand, the Pb isotopic composition of the sulfide inclusions changes from zone to zone (Rudnick et al, 1993). The combination of trace-element

and isotopic data suggests that a high-U/Pb fluid caused the resorption of the diamond at the intermediate stages, but that it continued to grow in the same chemical environment after the resorption. The sulfide inclusions near the rim have a Pb-isotope compositions suggesting that they were affected by fluids from the kimberlites at the time of eruption.

Conclusions. *Peridotitic diamonds* having simple octahedral zonation and complex zoning were grown by tangential mechanizm of growth in an unconstrained environments from sulfide-silicate melt or fluid of low degree of carbon supersaturation. The change of composition of syngenetic minerals show the chemical evolution into the more refractory composition and less oxidized conditions, accompanied by a slight decrease of temperature. This melt (fluid) was less viscosious, then the one, from which eclogitic diamonds were formed. Peridotitic diamonds didn't suffer significant resorption during their formation, but did undergo a dissolution on the final stages or after the growth was completed transforming them into dodecahedrons. A common feature of the peridotitic diamonds is plastic deformation, which may be the result of such common events as cataclasis of the deformed peridotites. Hydrogen is confined to the well aggregated octahedral cores, cuboid sectors of the "central cross" structures or the neighborhood of mineral inclusions. Multistage octahedral peridotitic diamonds exhibiting a complicated history of formation, were grown in the liquid environment first. They underwent a high degree of resorption, etching or breakage in consolidated rock, followed by regrowth again. Nevertheless even in these diamonds there were little change in chemistry for the main elements of syngenetic inclusions.

Eclogitic diamonds, having simple octahedral and complex zoning were also grown in the liquid environments, but further from equilibrium conditions. They were slightly resorbed at various stages of formation, but not after the growth was completed. Growth in viscous and supersaturated by carbon environments more often produced cubic, intergrowth and very complicate (fine grained aggregates?) initial shapes of growth in the eclogitic diamonds. Plastic deformation is very rare in eclogitic diamonds. The change of Cpx and Gar compositions and small dropping of PT parameters during the eclogitic diamonds growth suspect their magmatic origin. Hydrogen in the eclogitic diamonds is located in the central cubic and rounded intermediate zones, as a structural impurity. The eclogitic chemistry of inclusions in the cores of coated diamonds suggests that coats only formed on eclogitic stones.

Our data evidenced the similarity of typomorphic features of peridotitic and eclogitic diamonds from kimberlites and those from mantle peridotites and eclogites (Beskrovanov et al,1993). Diamonds in the kimberlitic rocks have poligenetic nature. Diamonds were originated during Precambrian igneous events in the peridotitic and eclogitic rocks, which make up the lithospheric upper mantle beneath the continents. The difference of diamonds from Yukutian kimberlites may be explained by different proportions of eclogitic and peridotitic stones in the pipes.

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