

FEATURES OF DIAMOND AND ITS INDICATOR MINERALS OF KIMBERLITES OF THE M.V. LOMONOSOV DEPOSIT, ARKHANGELSK REGION, RUSSIA

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Introduction

The M.V. Lomonosov diamond deposit, Arkhangelsk region, NW Russia consists of six kimberlite pipes, forming 9.5 km length cluster within the Zolotitskoe Kimberlitic Field. These pipes are composed of the same type petrography varieties of kimberlitic rocks, but based on a number of geological and diamond features this cluster divided into Northern (M.V. Lomonosova, Pomorskaya, Pionerskaya and Karpinskogo-2 pipes) and Southern (Karpinskogo-1, Archangelskaya) Groups (Fig. 1a). The diamond grade in main types of ore – tuffisitic (autolithic) kimberlites of the Southern Group kimberlite pipes is higher (1.2-1.5 ct/t) than in the Northern Group (0.4-0.7 ct/t). Pomorskaya pipe reserves with low diamond grade ores (<0.1 ct/t) estimated as resources presently, because the mining of this pipe is unecomical presently.

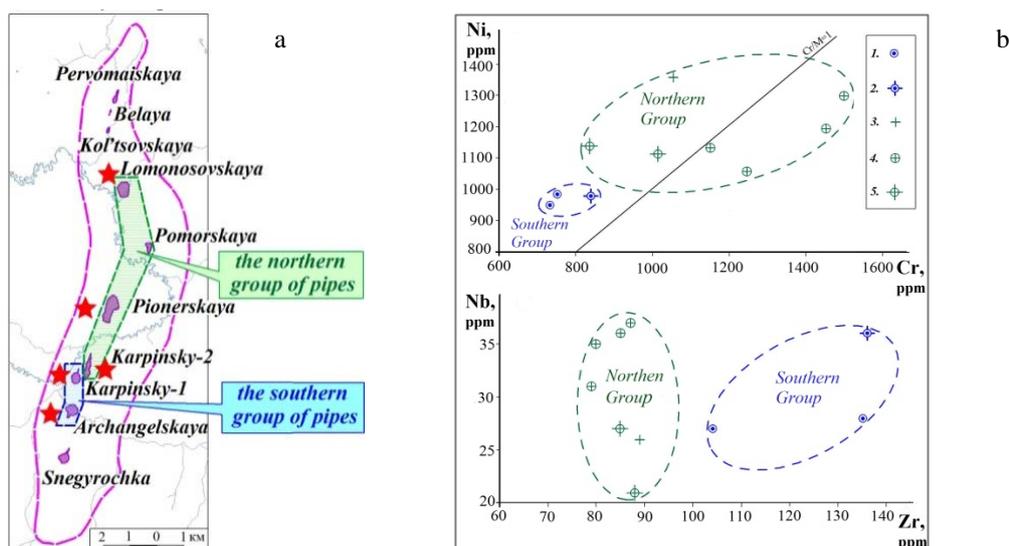


Figure 1: Zolotitskoe Field and M.V. Lomonosov diamond Deposit scheme (a); Cr–Ni и Zr–Nb contents for tuffisitic (autolithic) kimberlites of the Southern (1 - Archangelskaya, 2 - Karpinskogo-1) and Northern (3 - Karpinskogo-2, 4 - Pionerskaya, 5 - Lomonosova) Groups' pipes of the M.V. Lomonosov deposit (Parsadanyan et al., 1996).

The results of present study revealed differences in the chemical composition of diamond indicator minerals (DIMs), morphology, optical properties, internal structure, defect-impurity composition and diamond quality of the Northern and Southern Groups' pipes. The relationship between the diamond characteristics and matter features, diamond grade of main types of diamond-bearing kimberlitic ores was indicated.

Analytical Results

Autolithic kimberlites (AK) of the Southern Group pipes with higher diamond grade are characterized by lower chromium and nickel contents (Fig. 1b) and higher zirconium, strontium, thorium, hafnium contents in comparison with similar rocks of the Northern Group pipes (Parsadanyan et al., 1996).

There are sharply low DIMs (pyrope, chromite and clinopyroxene) content in the Northern Group pipes. In AK of the Southern Group pipes the total number of DIMs is 0.097-0.133 kg/t, and in AK of the Northern Group pipes is 0.035-0.079 kg/t.

DIMs (pyrope, chromite and clinopyroxene) of Northern Group pipes presented by higher chromium varieties corresponding to high-pressure depth subfacies compare to kimberlites of the Southern Group pipes. Pyropes (>5 wt.% Cr₂O₃) are mostly identified in the Pionerskaya (86%) and Karpinskogo-2 (74%) pipes (Northern Group pipes), with lower presence in the Archangelskaya (30%) and Karpinskogo-1 (16%) pipes (Southern Group). Chromite content (60 wt.% Cr₂O₃) in the Pionerskaya (40%) and Karpinskogo-2 (34%) pipes is sharply higher than in Archangelskaya (<11%) and Karpinskogo-1 (17%) pipes, where chromite with 55-60 wt.% Cr₂O₃ is mostly presented (30-33% of total).

However, there is higher content of Cr-spinels and pyropes with higher Ti-content in Northern Group kimberlites in compare with the Southern Group. Chromites with TiO₂> 3 wt.% distributed in the Pionerskaya (14%), Karpinskogo-2 (9%), Pomorskaya (11%) pipes (Northern Group), with lower presence (~5%) in Southern Group pipes. The shares of pyrope with TiO₂>0,4 wt.% for Pionerskaya and Karpinskogo-2 pipes are 24% and 10,5% respectively, but only 4-5% for the Southern Group pipes.

A significant proportion of the pyropes from Northern Group kimberlites also have higher content of Zr (62% grains with Zr>30 ppm), Y and Ga (Sablukov et al., 2009). The collection obtained and published data indicates: the lower diamondiferous kimberlites of the Northern Group related with intensive exposure to the lithospheric mantle by melting metasomatic processes, which caused the destruction of a large part of diamonds in the process of dissolution and a significant increase of the dodecahedrons proportion, especially in large classes.

Despite the low diamond content in the Northern Group pipes, qualitative characteristics of diamond ores are significantly higher in many indicators than for Southern Group pipes. Ultrabasic paragenesis colorless diamonds with high degree of transparency and fiber growth mechanism are dominated in the Pionerskaya and Pomorskaya pipes. Dodecahedrons with high etching and corrosion degree are prevailing. Diamonds have a low content of hydrogen impurity with a large values range. The distribution maximum of CH-centers is identified at 0-5 cm⁻¹, and for the diamonds of the Southern Group pipes at 3-10 cm⁻¹ (Fig. 2b). The Northern Group pipes' diamonds characterized by high presence of nitrogen impurities concentrations (Fig. 2a), and structural centers associated with plastic deformation. Unlike the Southern Group pipes' diamonds, the structural nitrogen is considerably higher aggregated (two maximum allocation %N_B = 10-14 and %N_B = 40-55 according to IR-spectroscopy data; centers P2 and N2 are presented according to EPR), indicating more prolonged exposure in high temperature conditions contributing to oxidative dissolution. Generally, near gem diamonds prevalent (65-70%) in the Pionerskaya pipe. The quality of the Pomorskaya pipe diamonds is significantly lower because of widespread intergrowths and individuals with a low degree of safety, deep etched channels and numerous graphite inclusions.

According to received data, there is lower quality of diamonds in the Southern Group pipes, which is due to inherently defective structure of crystals. The dominant share (60%) of diamonds in the Archangelskaya and Karpinskogo-1 pipes is presented by industrial diamonds. The share of gem-quality diamonds is about 25%. There are mostly dodecahedral and tetrahedral diamonds with zonal-sectorial structure and high degree of internal tension with lots of cracks, graphite and fluid inclusions. The tetrahedral content in all size-classes is 14-27%, but only 5-13% in the Northern Group pipes. Upon that, diamonds of high-nitrogen groups (Fig. 2a) with low degree of defects aggregation are mostly presented there. It is evidence of lower temperatures at genesis of crystals majority and short time post-crystallization annealing. According to FTIR data a large proportion of the Archangelskaya and Karpinskogo-1 pipes diamonds belong to eclogitic paragenesis.

There is a sharp increase in the octahedrons concentration in a small size-class (-1+0.5 mm) identified: 20% for the Northern Group pipes, and 15-17% for the Southern Group pipes (Makhin et al., 1990).

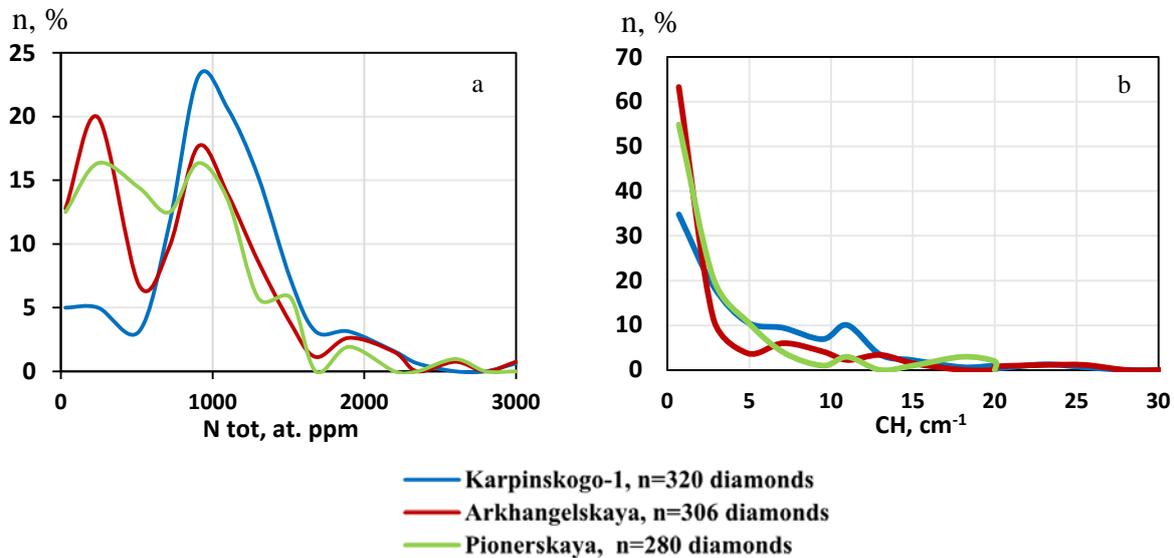


Figure 2: Distribution of diamonds with different total concentration of the defective-impurity centers of nitrogen (Ntot) (a), and with different ratio of the absorption of impurity hydrogen centers CH (3107 cm⁻¹) (b) in the South (Karpinskogo-1 and Arkhangelskaya) and Northern (Pionerskaya) Group pipes of the M.V. Lomonosov diamond deposit

Conclusion

Thus, a significantly higher degree of diamond grade in main types of ore – tuffisitic (autolithic) kimberlites of the Arkhangelskaya and Karpinskogo-1 pipe in connection with the kimberlitic rocks of the Karpinskogo-2 and Pionerskaya pipe is due to lower degree of impact processes of melt of mantle metasomatism, which mostly processed in relation to Northern Group kimberlites. In addition, there is significant higher proportion of eclogitic paragenesis diamonds in most productive Southern Group kimberlites. The common lower diamond quality in the Southern Group pipes is mainly due to more defective crystal structure, which is probably associated with deeper degree differentiation of the initial hypogene substance.

References

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