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VIII ВСЕРОССИЙСКАЯ НАУЧНО-ПРАКТИЧЕСКАЯ КОНФЕРЕНЦИЯ С МЕЖДУНАРОДНЫМ УЧАСТИЕМ, ПОСВЯЩЕННАЯ 50-ЛЕТИЮ ОСНОВАНИЯ ИНСТИТУТА ХИМИИ НЕФТИ

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TRANSFORMATIONS OF KIMBERLITE MINERALS AND NATURAL DIAMONDS STRUCTURE AS THE RESULT OF PULSED ELECTROMAGNETIC IRRADIATION

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The current technology for mining and processing diamonds from primary deposits in Russia damages the diamond crystals at a rate of 25–75%, leading to an average weight loss of 12% (Chanturiya, Goryachev,2008). Diamonds are usually damaged during the autogeneous grinding of kimberlites, and up to 29% of all diamonds disintegrate. Therefore, in processing of diamond-bearing kimberlites the actual problem of prime importance is development of new effective processes feasible to provide a higher grade concentrates due to softening of kimberlite, to preserve diamond crystal safety in autogenous ore grinding circuits. The efficiency of enriching diamond-bearing ores can be improved by developing and introducing new energy-saving methods aimed at increasing the quality of concentrates via kimberlite softening, the selective identification and withdrawal of diamond crystals in milling ores, and finding new distinctions and enhancing the contrast between the properties of diamonds and other rock-forming minerals. One of such methods is hight-voltage nanosecond pulses (HPEMP).

The studies were conducted on crystals of natural diamonds with a grain size of -2...+1 mm from the Triassic placer of the Bulkur site in the Nizhne-Lenski District, minerals specimens ground down to $-100 + 63$ μm, and polished sections $1 \times 1 \times 0.45$ cm in size. Samples were conducted with nanosecond high-voltage video pulses (τ (pulse front), ~1–5 ns; τ (pulse duration), ~50 ns; U (pulse amplitude), ~25 kV; E ~ 107 V m^{-1}; pulse repetition frequency, 100 Hz, pulse energy, ~0.1 J; duration ttreat of electric pulse treatment, 10–150 s; HPEMP number $N_{pulse} \sim (1 - 15) \times 10^3$). The phase and structural impurities were examined using IR Fourier spectroscopy (FTIR). Changes in the morphological properties of mineral surfaces were examined by analytical electron, and optical microscopy. The microhardness of kimberlite rock-forming minerals in the initial state and after HPEMP treatment was measured using Vickers method (HV, MPa).

Figure 1 presents the relationships (histograms) between relative variations in microhardness of minerals under HPEMP-irradiation versus the pulsed treatment time: $\Delta HV_i / HV_{0i}$;%, where HV_{0i} is the microhardness of its specimen in initial state; HV_i is the microhardness of its specimen after electric pulse treatment, and indenter morphology on the surface of minerals. The experimental data obtained show the softening of rock-forming mineral-dielectrics under high-voltage nanosecond electromagnetic pulse irradiation. Microhardness variations for rock-forming minerals correspond to the results of our spectroscopic investigations (Bunin et.al., 2015).

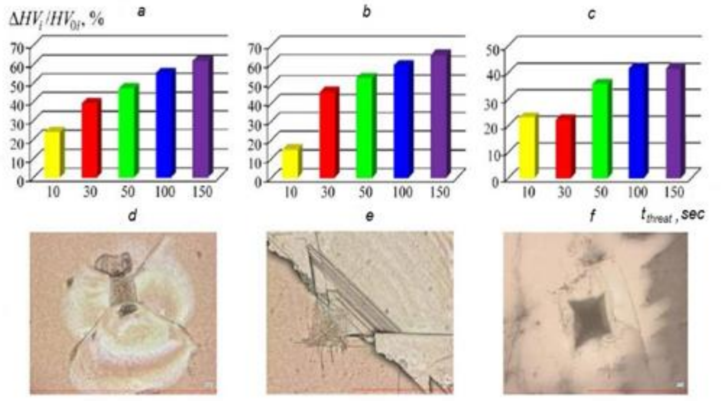

Fig. 1. The relative change in microhardness ($\Delta HV_i / HV_{0i}$ %) of olivine (a), calcite (b), serpentine (c) versus time (t_{threat}) of processing; indenter morphology (Vickers diamond pyramid) on the surface of minerals (d) - (f); LCSM, width of scanning window ~ 100 um

A gradual process of mineral selective disintegration was the main mechanism behind the dissipation of energy in a high-voltage pulse electric field: the opening (loosening) of intercrystalline boundaries, the formation and propagation of cracks along the cleavage surfaces, and the formation of microcrystal fragments upon extending the pulse action to $t_{treat} \geq 50$ s.

At the same time, nonthermal HPEMP treatment didn't produce micro flaws and micro cracks in diamonds (this was monitored by microscopy diagnostics), because the breakdown voltage of an electric field is about 10^9 V m^{-1} for diamonds, that two orders higher than strength of electric field component E in the interelectrode space of the pulse generator (Khmelnitskii, 2015).

Based on FTIR, there was no deep structural rearrangement of the diamond crystals under the influence of electromagnetic pulses, but the absorption coefficient of the line ~1365 cm^{-1} grew consistently, which indicated an increase in the concentration of platelet defects B2 (platelets) (Fig. 2), represented by interstitial carbon atoms. It is characteristic that all these crystals belong to the group with moderate nitrogen content and a higher than normal degree of nitrogen aggregation %N(B). As a result of the study of microhardness of diamond crystals exposed to deformation in a natural setting, in (Naletov et.al., 1979) it was found that B-centers increase the dispersion strength of natural diamonds compared to the original state by a factor of 1,7.

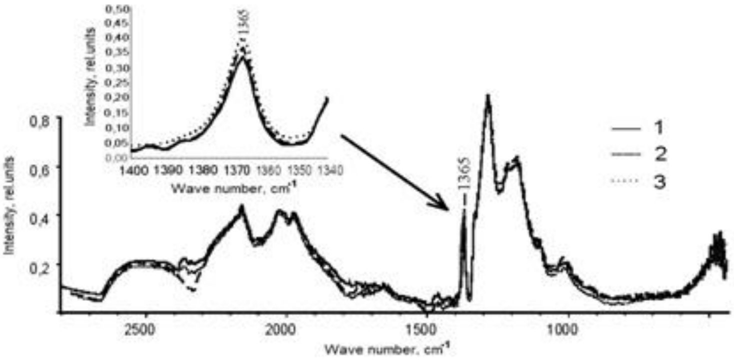

Fig. 2. Spectrum of diamond before and after treatment: 1- without treatment,
2 – 50 sec, 3 – 150 sec.

Conclusions

The effect of multidirectional change in mechanical properties (microhardness) of rock-forming minerals of kimberlite (olivine, serpentine, calcite) and diamond crystals under conditions of nanosecond HPEMP was established. It consists in surface layer softening of rock minerals and reduce of their microhardness as a whole by 40-60% due to the formation of structural defects and the simultaneous increase in B2-defects (platelets) concentration in the crystal structure of diamonds, which, presumably, causes an increase in the strength properties of diamond crystals. The obtained result indicates the possibility of applying of pulsed energy impact to improve the softening efficiency of rock-forming minerals of diamond-bearing kimberlites without damaging diamond crystals and ensuring their preservation by the subsequent grinding of ores.

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