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Luminescence of diamonds from metamorphic rocks

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Abstract

This study explores the effects of metamorphism on luminescence of diamond. Four diamond suites extracted from metamorphic rocks were characterized using optical cathodoluminescence, FTIR spectroscopy, photoluminescence at the liquid nitrogen temperature, and cathodoluminescence spectroscopy. The studied diamonds are from sedimentary conglomerate and lamprophyric breccia metamorphosed to the greenschist facies (Wawa, Canada), and from the ultrahigh-pressure (UHP) terranes of Kokchetav (Kazakhstan) and Erzgebirge (Germany). The majority of studied diamonds that experienced metamorphism have distinct cathodoluminescence and photoluminescence when compared to diamonds from unmetamorphosed rocks, i.e., kimberlites or placers. Diamonds in metamorphic rocks do not show the prevalent blue cathodoluminescence emittance at 415–440 and 480–490 nm typical of common kimberlite and placer diamonds. Ultrahigh-pressure diamonds are mostly non-luminescent, whereas diamonds from greenschists display green, yellow, orange, and red cathodoluminescent colors emitting light at 520 and 576 nm, and between 586 and 664 nm. The shift of cathodoluminescence in octahedrally grown Type Ia diamonds metamorphosed in the greenschist facies results from the presence of optical centers with zero-phonon lines at 575 and 637 nm detected via photoluminescence spectroscopy. The centers may have formed due to irradiation of diamonds in the upper crust followed by annealing at $T > 500$ °C. This process creates vacancies that diffuse through the diamond lattice and get trapped at N sites, creating NV^o and NV^- optical centers. The distinct luminescence of metamorphosed diamonds can persist for billions of years in the crust, but is annealed in the mantle.

Keywords: Diamond, cathodoluminescence, photoluminescence, ultrahigh-pressure terrane, greenschist facies metamorphism, optical center