Cathodoluminescence of Diamonds in Metamorphic Rocks

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The purpose of this study is to explore the effects of metamorphism on cathodoluminescence (CL) of diamond. Diamond displays a supreme resistance to chemical and mechanical weathering, ensuring its survival through complex and prolonged crustal processes, including metamorphism and exhumation. For these reasons, volcanic sources and secondary and tertiary collectors for detrital placer diamonds, like Yukon diamonds, may be difficult to determine. If metamorphic processes leave their marks on diamond, they can be used to reconstruct crustal geologic processes and ages of primary diamondiferous volcanics.

Four diamond suites extracted from metamorphic rocks have been characterized using optical CL, infrared and CL spectroscopy, and photoluminescence (PL) at liquid nitrogen temperatures. The studied diamonds are from sedimentary conglomerate and lamprophyric breccia metamorphosed in the greenschist facies (Wawa, Southern Ontario, Canada), and from the ultra-high pressure terranes of Kokchetav (Kazakhstan) and Erzgebirge (Germany). Wawa diamonds (Type IaAB and Type II) displayed green, yellow, orange, and red CL colours controlled by the CL emittance at 520, 576 nm, and between 586 and 664 nm. Liquid nitrogen temperature PL for the Wawa diamonds showed peaks at 503 nm, 512 nm, 575 nm, 637 nm, and 660 nm. The UHP diamonds show much weaker CL; few luminescent stones show CL peaks at 395, 498, 528 nm and a broad band at 580-668 nm. Liquid nitrogen temperature PL results constrained peaks to be at 504 nm, 575 nm, 637 nm, and 659 nm. In contrast, most common diamonds found in unmetamorphosed rocks (octahedrally grown Type IaAB stones) luminescence blue, emitting light at ~415-440 nm and 480-490 nm.

There is a noticeable difference between cathodoluminescence of metamorphosed and unmetamorphosed diamonds. The studied diamonds that experienced metamorphism show a shift of CL emission to longer wavelengths (above 520 nm) and to green, yellow and red colours. This shift is comparable to the CL effect of the high pressure - high temperature (HPHT) treatment of diamonds, although the reason for this phenomenon is yet to be found. Our data show that the CL characteristics superimposed by metamorphism could survive through 2.7 billion years of the geological history. Thus, a low abundance of octahedrally grown Type IaAB diamonds with blue CL colours among detrital diamonds may indicate that the stones may have once been a part of a metamorphic terrane. This record of metamorphic processes within the diamond crystal lattice and in its physical properties provides an opportunity for a better reconstruction of the diamond crustal history and for provenance studies.