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Boron in natural type IIb blue diamonds: Chemical and spectroscopic measurements

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Abstract

The presence of boron in the structure of diamond is rare in nature, and even when present, reported values are ≤0.5 ppm. This study used various spectroscopic methods and time-of-fight (ToF-) SIMS to characterize and analyze for boron in natural type IIb blue diamonds, including the well-known Hope and the Blue Heart diamonds, and on one high-pressure, high-temperature annealed natural stone. Infrared spectroscopy measurements reveal uncompensated boron values as large as 1.72 ± 0.15 ppm, which is significantly higher than the previously reported maximum of 0.5 ppm. ToF-SIMS analyses gave spot total boron concentrations as high as 8.4 ± 1.1 ppm for the Hope diamond to less than 0.08 ppm in other blue diamonds. By comparison, a type Ia diamond did not show detectable boron. ToF-SIMS analyses revealed strong zoning of boron in some diamonds, which was confirmed by mapping the uncompensated boron using synchrotron infrared spectroscopy. This greater range of boron concentrations compared to previous studies might be explained by the larger number of natural diamonds analyzed here, 78, compared to <10 samples reported in the literature. The samples in this study are all gem-quality diamonds, including some Intense to Fancy-Deep blue diamonds; color intensity, however, only loosely correlates with the boron content. Boron is also likely responsible for the phosphorescence emissions of type IIb diamonds, in the red at 660 nm and in the blue-green at 500 nm. Our results are consistent with previous work suggesting that the emissions are caused by donor-acceptor pair recombination processes involving boron and other defects. The exact nature of the phosphorescence processes is still not fully understood, but likely involves complex steps of charge carrier trapping and detrapping.

Keywords: Type IIb diamonds, boron, ToF-SIMS, synchrotron FTIR, cathodoluminescence, phosphorescence, plastic deformation