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Evaluating the effects of natural radiation exposure on green diamonds

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Energy from natural radiation (α-, β-, and Î³-particles) in the earth's crust displaces carbon atoms in the diamond lattice. This creates vacancies, including the General Radiation 1 (GR1) defect, that absorb light in the red portions of the visible spectrum and manifest as green body color and surface "stains." The intra-crystal distribution of interstitials, displaced from their normal lattice sites, is not well understood and may contribute to green color. In this study we apply Fourier transform infrared (FTIR) and photoluminescence (PL) spectroscopy to 10 natural Type Ia (FTIR detectable nitrogen) green-stained diamonds. For all diamonds we determine nitrogen concentrations and acquire PL emission spectra for exteriors and interiors (≥ 20 μm deep) exposed by mechanical fracturing. We document the depth distribution of interstitial defects and use multivariate statistics to evaluate the data. The resulting dataset enhances our understanding of the processes influencing green color in natural diamonds.

Geologically, radiation stains are significant because they record direct interaction between a diamond and its environment, including changing geological conditions during residence in the crust. It is generally accepted that the defects related to green radiation stains form on the diamond surface ≤ 20 μm deep due to direct exposure to high-energy α-particles. In contrast, using a 457 nm laser we find that 484.4 nm peak intensity > 20 μm deep in some green-stained diamonds is stronger than on the surfaces of stain-free diamonds. Raman-normalized 484.4 nm peak intensity decreases across the surface and with depth away from green radiation stains. This indicates radiation damage beyond the penetration depth of α- particles. Other peaks including TR12 (470 nm) are intense on and directly adjacent to radiation stains, but are much weaker or undetected > 20 μm from a radiation stain. The TR12 defect in Type Ia diamonds relates to local defect structures possibly associated with α-particle exposure.