Inclusions in large, gem-quality, natural Type II diamonds

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Large and exceptional gem-quality diamonds, like the famous Cullinan and Hope diamonds, tend to have a common set of characteristics that have led many researchers to regard them as a distinct family. The most noted characteristic is a low nitrogen concentration, such that these diamonds are often simply termed Type II's, although not all Type II diamonds necessarily belong to this family. More broadly, diamonds that are Cullinan-like tend to be large, inclusion poor, relatively pure, irregularly shaped, and highly resorbed. These diamonds are especially valuable as gemstones and difficult to access for research. Even when made available, the inclusion poor nature of these diamonds has maintained a long-standing barrier to their study.

In order to investigate this problem, diamonds from the routine grading operations of the Gemological Institute of America's New York laboratory were systematically screened over several months to select Type II diamonds with inclusions. Inclusions were then studied using Raman spectroscopy. This approach produced multiple examples of what are otherwise extremely rare diamonds.

After analysing more than fifty diamonds, including many diamonds greater than 5 carats, a few recurring inclusion phases emerge and two in particular establish a prominence. The first is CaSiO3 walstromite, interpreted as former calcium-silicate perovskite. Some diamonds with CaSiO3 walstromite also contain orthopyroxene inclusions, interpreted as former magnesium-silicate perovskite, together suggesting a lower mantle origin. The second prominent inclusion type is a metallic phase, unidentifiable by Raman spectroscopy. Careful inspection reveals that the metallic inclusions are often elongate and/or grouped in chains that trend along a <111> direction. The chains are spatially associated with curvilinear features in cathodoluminescence, which are interpreted as healed cracks of {110} orientation that intersect along the chain-defining <111> vector. The features of these unusual metallic inclusions suggest their present distribution is related to deformation of the host diamond. Overall, the inclusions portray a clear deviation from the more common mineral assemblages of lithospheric diamonds. Instead, many large, gem-quality Type II diamonds may originate from the sublithospheric mantle and constitute a genetically distinct diamond variety.