INCLUSIONS EXPLAINED

Although generally undesirable, in some rare instances, diamond inclusions may be considered beautiful.

BY DR. ERIC EREL

From the earliest time, flawless diamonds have been the most coveted of gemstones. But these perfect stones are the exception, not the rule. The majority of diamonds contain internal characteristics, such as feathers or mineral inclusions, which keep them from meeting the ultimate standards of perfection.

The mineral inclusions found in diamonds were embedded within the stones millions of years ago during their growth in the earth's upper mantle, approximately 120 miles below the surface. They are a product of the formation of rocks known as peridotite and eclogite. Later, the diamonds were transported toward the earth's surface in volcanic magmas from two different rocks: the kimberlite and the lamproite.

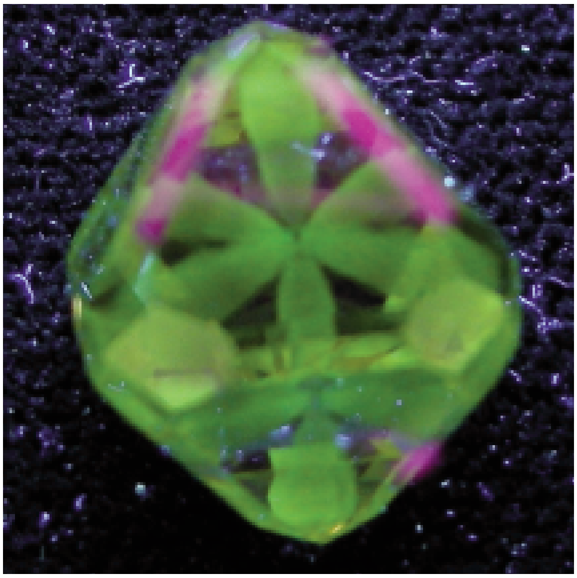

Figure 1

TYPES OF INCLUSIONS

Some of the most renowned mineral inclusions in diamonds may be those referred to as carbon spots. This term is used to describe black inclusions in diamonds that are sometimes large enough to be visible by the naked eye. In addition to graphite, which is composed of carbon, chromites — a member of the spinel group — and sulfides are the most common dark inclusions found in diamonds. More colorful mineral inclusions can also be encountered in diamonds. Among the most beautiful are the red-to-pink chromian pyrope garnets, the orange almandine-pyrope garnets and the emerald green chromian diopsides that occasionally are found as inclusions in diamonds.

These inclusions, like the majority of mineral inclusions found in diamonds, are very small and require microscopic observation to be revealed. A mineral inclusion of 0.3 to 0.4 millimeter in size is considered a large example. In addition to these crystal inclusions, much smaller internal characteristics such as pinpoints can also be observed. A pinpoint is not large enough to be distinguishable as a crystal inclusion, even with the highest magnification power available with a gemological binocular. When isolated as single pinpoints, they can be very difficult to find. If aggregated, however, they form a so-called cloud inclusion, which may be hazy or milky in appearance. Clouds can be present in small areas or spread throughout the stone. They can be randomly structured or display distinct outlines, and even some fascinating geometric structures.

Among the rarest and most beautiful cloud structures are cuboids — also called sugar cube clouds — octahedral and hexagonal forms, as well as more complex shapes, like Maltese cross, stars and even amazing flower-shaped clouds, such as the example described below and pictured on these pages.

MACROSCOPIC AND MICROSCOPIC DESCRIPTION

A 7.39-carat octahedral-shaped diamond has been polished and slightly faceted in accordance with the original morphology of the rough (see figure 1, above). Eight octahedral faces have been polished and the six extremities of the octahedron, as well as the 12 facet junctions, have been faceted in order to enhance the appearance of a very unusual and large cloud inclusion. This flower-type cloud, composed of six petal-like parts, is localized in specific areas of the diamond and originates from the center of the crystal. Each ellipsoid-shaped petal has a black coloration and points in the direction of the crystal's six corners (see figure 2, right).

Careful observation under magnification reveals that the whole symmetrically shaped cloud is centered on a small, near-colorless core, which looks octahedral and is located in the middle of the crystal. Furthermore, each petal appears three-dimensional and is composed of numerous extremely tiny, grayish pinpoints. When each petal is observed individually from one of the six faceted corners down to the center of the stone, it reveals a cuboid section.

This observation allows the viewer to imagine the shape of the rough and the complex growth history of the diamond, a product of mixed cuboid and octahedral growth sectors. The lobe shape of the petals can then be explained by the relative variations of growth rates between each cuboid and octahedral sector. However, those relative growth rates between growing sectors don't explain why the pinpoints are preferentially located in cuboid sectors.

Figure 2

Figure 1, opposite: *Under longwave ultraviolet (UV) illumination, the flower-shaped cloud emits a faint green-yellow fluorescence, whereas the other parts of the 7.39-carat diamond are inert.*

Figure 2, above: *The 7.39-carat faceted diamond displays a six-petaled flower cloud of black coloration. The ellipsoid-shaped petals originate around an octahedral colorless core located in the middle of the diamond crystal and extend outward in the direction of the six corners of the crystal.*
All photos by Dr. Eric Erel, stone courtesy Great Diam.

FLUORESCENCE

When illuminated with a longwave ultraviolet (UV) light source, the flower cloud located in cuboid sectors emits a faint green-yellow luminescence, whereas the rest of the diamond is inert. A much weaker reaction is also observed under shortwave UV radiation. However, it's not possible to localize which growth sectors emit the very faint orange fluorescence.

After both longwave and shortwave UV lamps were shut down, no phosphorescence reaction was observed.

SPECTROSCOPY

Infrared absorption measurements show that the diamond is of type Ia, with a very high concentration of nitrogen. Nitrogen is the most common chemical impurity in a diamond. In a type Ia diamond, nitrogen is usually present in two different kinds of aggregates. The A aggregate results from the association of two nitrogen atoms and the B aggregate results from the association of four nitrogen atoms and one vacancy — a missing atom in the diamond crystallographic structure. Besides nitrogen, the infrared spectrum also shows that this diamond contains hydrogen atoms. Multiple and intense hydrogen-related peaks are detected, so this diamond can be considered hydrogen-rich.

Ultraviolet-visible (UV-Vis) absorption spectrum performed at room temperature shows that the brownish yellow color of the diamond results mainly from an absorption continuum starting around 650 nanometers (nm) and increasing continuously until 300 nm. In addition, a weak peak at 415 nm, associated with the N3 color center, is also observed. The N3 color center, composed of three nitrogen atoms and one vacancy, is commonly observed in type Ia natural diamonds. ✦

Dr. Erel, who wrote this article during the time he worked at the Gübelin Gem Lab in Lucerne, Switzerland, is now the director of Carat Gem Lab, a full-service independent laboratory he established in France in 2009.