Observations on GE-Processed Diamonds: A Photographic Record

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Observations made at GIA on 858 GE-processed diamonds revealed several interesting features that may be diagnostic of this kind of diamond. Specifically, a significant percentage exhibited a slightly hazy appearance, noticeable internal graining, and other unusual internal features.

Editor's Note

On June 23, at the Third International Gemological Symposium, representatives of GIA and the GIA Gem Trade Laboratory held a special session to provide an update on the situation regarding the diamonds processed by General Electric to improve their color (i.e., closer to colorless). This article follows up on that special session with the statistical results and a photographic record of GIA's examination of a large number of such diamonds.

As of August 1999, GIA staff members had examined 960 natural diamonds that had undergone a new process, developed by the General Electric Company (GE), that removes some or all of the color of a diamond. Distributed exclusively by Pegasus Overseas Limited (POL), an Antwerp-based subsidiary of Lazare Kaplan International (LKI), the diamonds are referred to as GE POL or Pegasus diamonds in the trade. These GE-processed diamonds look like untreated diamonds; however, careful examination has revealed that some of them exhibit subtle features that usually are not present in natural-color diamonds. This article presents demographic information on 858 (of the 960) GE-processed diamonds that had been incorporated into the GIA Gem Trade Laboratory database as of July 15, 1999, and describes some of the unusual internal features that were seen. As recently stated by GE, the procedure used involves high pressure and high temperature and, to date, is effective only on certain high-purity and high-clarity diamonds (J. Casey, pers. comm., 1999; see Box).

BACKGROUND

Earlier this year, Pegasus Overseas Limited announced to the jewelry industry that GE scientists had developed a new process to improve the color and other characteristics of a select group of natural diamonds. According to these announcements, the diamonds would be sold only through POL, and every direct purchaser would be informed in writing by POL that they were purchasing a GE-processed diamond. Such sales began in June 1999.

In press releases (e.g., March 1, 1999) and other public statements, POL representatives claimed that this process was designed to improve "the color, brilliance, and brightness" of qualifying diamonds, and that the results were "permanent and irreversible." They stated that it did not involve any conventional diamond treatment methods (such as irradiation, laser drilling, surface coating, or fracture filling), but rather it was merely an extension of the manufacturing of rough into polished diamonds. Nor did the processed diamonds require any "special care and handling." Last, they also reported that these GE POL diamonds would "be indistinguishable" from natural-color diamonds by jewelers and gemologists using standard gem-testing equipment and techniques.

Since the initial announcement, representatives of GE, POL, and GIA have held a series of useful and ongoing discussions to address the concerns of the jewelry trade, and ultimately the consuming public, about this new GE process. These discussions resulted in specific steps taken by GE to laser inscribe the girdle surface of all of their processed diamonds with

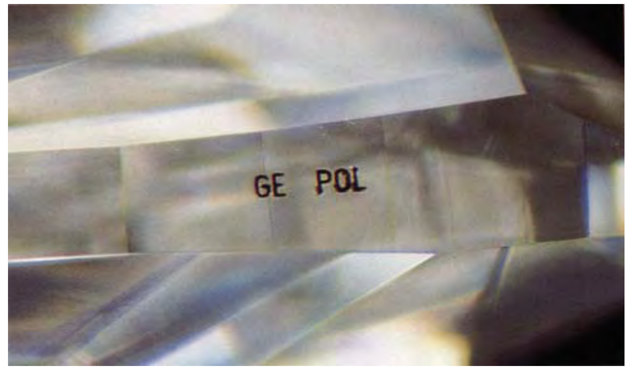

Figure 1. The laser-inscribed "GE POL" is readily visible on the girdle surface of this 1.25 ct marquise-shaped diamond. Photomicrograph by John I. Koivula; magnified 40×.

the letters "GE POL" (figure 1), and by POL to then submit these diamonds to the GIA Gem Trade

Research on Diamonds At the General Electric Company

Research at the General Electric Company on the properties of diamond as an industrial material extends back more than 50 years. One result of this ongoing research program was the discovery of a new process that improves the color of a select group of rare natural diamonds. Specifically, exposure of certain high-purity diamonds to high temperature and high pressure removes their extrinsic color centers (i.e., those caused by the external forces that affected the diamonds after they formed in the earth's mantle), so they display their optimum intrinsic color (i.e., as they originally grew). (For more information on the cause of color in diamonds, see Field [1979] and Fritsch [1998].)

The new process simulates the high pressures and temperatures to which natural diamonds were subjected while they were deep in the earth's mantle (see, e.g., Kirkley et al., 1991). The diamonds that respond to this method represent in volume significantly less than 1% of "run of mine" diamonds. After processing, most of the diamonds are in the D through G color range, and most require repolishing.

This discovery evolved through years of scientific and technical work. The General Electric Company is currently working with the jewelry industry to develop practical means of identification and to educate the industry's members about these processed diamonds.

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The General Electric Company

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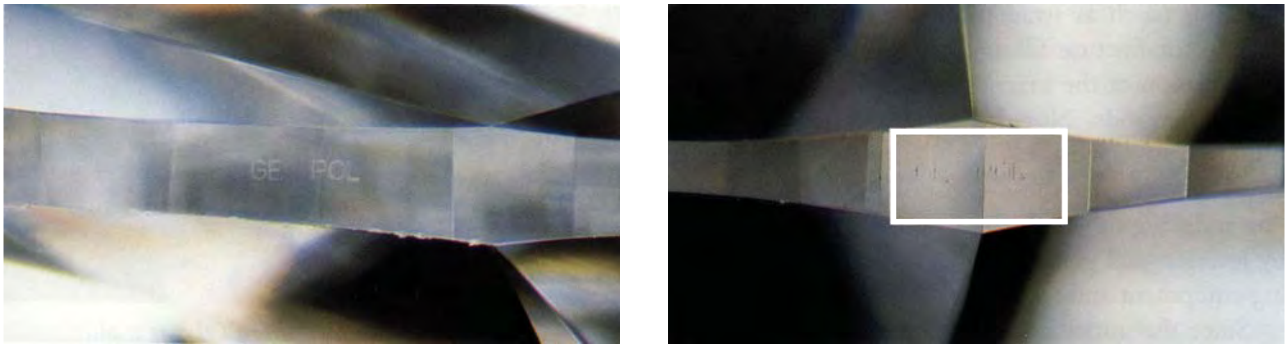


Figure 2. In several instances, GE-processed diamonds have been resubmitted to the GIA Gem Trade Laboratory, by individuals other than Pegasus representatives, with the "GE POL" inscription partially or completely removed. The database of information on the GE-processed diamonds we examined helped us detect these stones. In the photo on the left, the black appearance of the inscription has been removed, so that the "GE POL" is less visible. In the photo on the right, only small portions of the original inscription are still visible. Photomicrographs by Shane F. McClure; magnified 40×.

Laboratory for reports that would identify that these stones had undergone the GE process. This inscription provides an immediate, practical means of recognition throughout the trade. In addition, GIA makes the following comment on grading reports for all such diamonds sent to the GIA Gem Trade Laboratory by POL: "'GE POL' is present on the girdle. Pegasus Overseas Limited (POL) states that this diamond has been processed to improve its appearance by General Electric Company (GE)." GE and POL officials also have expressed support for GIA's efforts to develop additional means of identifying these diamonds.

During the three-month period from early May through July 1999, POL submitted 960 laser-inscribed diamonds to the GIA Gem Trade Laboratory for reports. They were examined by experienced diamond grading, identification, and research staff at GIA's offices in New York and Carlsbad. This

Figure 3. As illustrated here, most of the 858 GE POL diamonds examined by the GIA Gem Trade Laboratory weighed less than 2.00 ct.

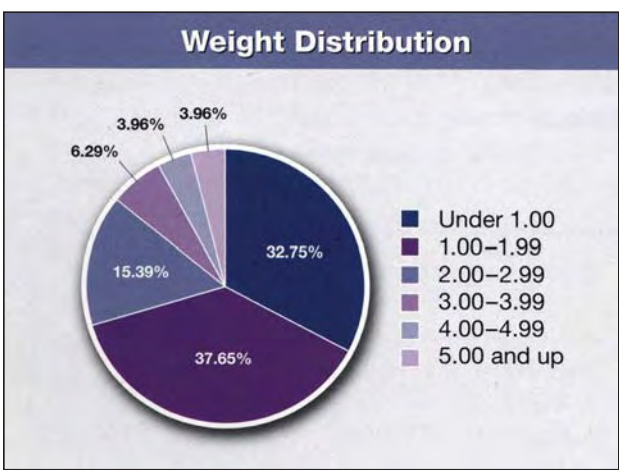
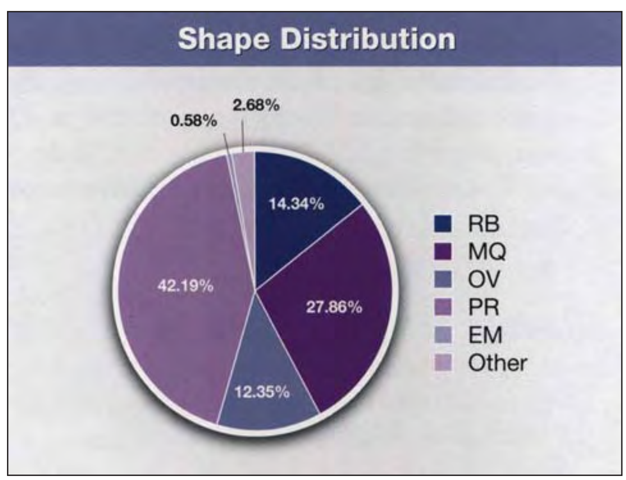


Figure 4. The majority of these diamonds were fashioned in one of several fancy shapes (most frequently marquise or pear shapes). (RB = round brilliant; MQ = marquise; OV = oval; PR = pear shape; EM = emerald)



examination of a large group of known GE-processed diamonds—using both standard identification and grading techniques and, for some of the samples, advanced spectroscopic methods—gave us the unique opportunity to collect data on each diamond. This database has already proved of value by allowing us to recognize several of these diamonds that were subsequently resubmitted to GIA but with the "GE POL" inscription partially or completely removed (figure 2).

We have compiled certain demographic data on this group of GE POL diamonds. These are presented below, together with a description—and illustrations—of the various unusual internal features we observed.

DEMOGRAPHIC DATA

Diamond Type. Diamonds are classified into four major categories—referred to as types Ia, Ib, IIa, and IIb—according to the presence or absence of the trace elements nitrogen or boron in their crystal structure. These four categories of diamonds can be distinguished on the basis of ultraviolet transparency and visible and infrared absorption spectra, among other characteristics.

Whereas most near-colorless diamonds seen in the GIA Gem Trade Laboratory are type Ia, the vast majority (99%) of the 858 GE POL diamonds were type IIa. This was determined by their transparency to short-wave ultraviolet radiation and internal features, such as crosshatched ("tatami") strain patterns.

Size. The 858 diamonds in our sample ranged from 0.18 to 6.66 ct, with an average weight of 1.69 ct. The majority weighed less than 2.00 ct (figure 3). Note, however, that more than two-thirds (577) were 1.00 ct or more.

Shape. As illustrated in figure 4, 86% of these diamonds were cut in one of several "fancy" shapes—mainly oval, marquise, and pear; most of the remainder were round brilliants. This is consistent with the recent POL statement that they choose fancy shapes to obtain maximum value from the original rough ("GE/LKI support disclosure . . . ," 1999).

Color. A high proportion (80%) of the GE-processed diamonds were described as "colorless" or "near-colorless" (from grades D through G; see figure 5). In

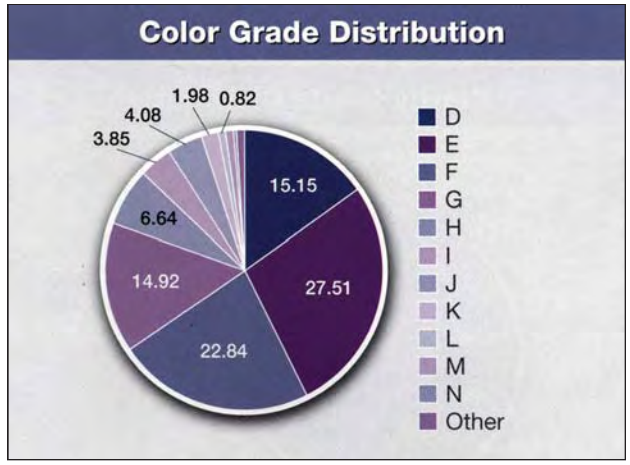


Figure 5. Although the entire range of color grades (from D through Z) were represented by the 858 GE-processed diamonds, most of these diamonds were in the colorless to near-colorless range (D through G). A few were distinctly yellow, and fell in the color grades between O and Z.

28% of the samples, however, members of our grading staff commented that the diamonds had a slightly brownish or grayish color appearance when examined with the GEM Diamondlite™ or a gemological microscope. LKI president Leon Tempelsman recently commented that most of the diamonds are "top brown" before the process is applied, "with others generally within the brown family" (Donahue, 1999).

Of the 20% that fell below "near-colorless" on the color-grading scale, the largest portion (16% of the total group) were in the H–K range and 3% of the total group were in the L–N range. The remainder were highly colored: Several were distinctly yellow, two fell in the O–P range, two in the S–T range, two in the U–V range, and one in the Y–Z range.

Clarity. Consistent with the recent GE statement that only high-clarity diamonds are chosen for processing, the majority of the GE POL diamonds (61%) were graded as being IF or VVS_1. Most of the remaining diamonds were distributed over VVS_2, VS_1, and VS_2, with very few in the SI or I categories (see figure 6). GE has confirmed that they select high-quality stones for economic reasons (J. Casey, pers. comm., 1999).

Ultraviolet Fluorescence. We found that 79% of the sample diamonds did not fluoresce to either long-

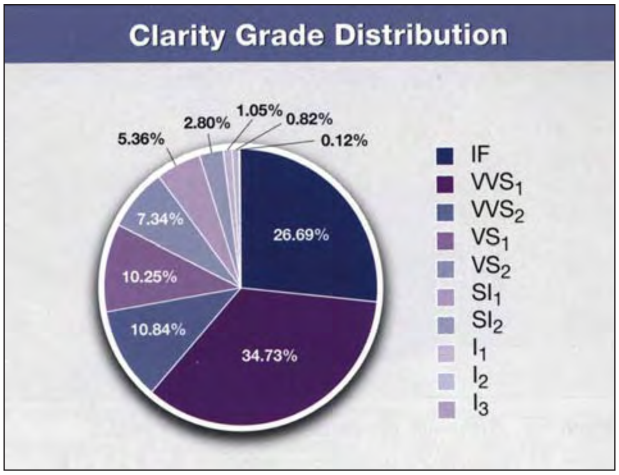


Figure 6. In general, the clarity of the sample diamonds was higher than normally would be expected in a general population of untreated colorless to near-colorless diamonds, with 61% clarity graded as IF or VVS_1.

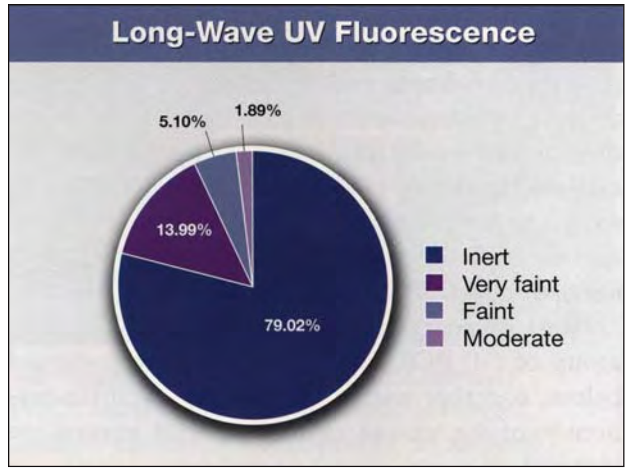


Figure 7. The vast majority of the GE POL diamonds were either inert, or displayed very faint fluorescence, when exposed to long-wave ultraviolet radiation.

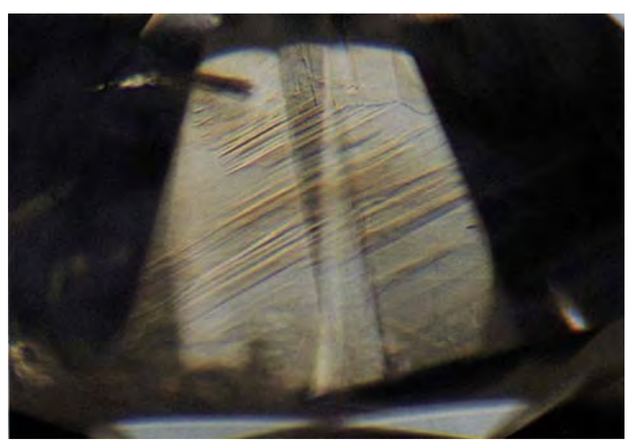
or short-wave ultraviolet radiation (figure 7 presents the results for long-wave UV). All of the remaining 21% fluoresced blue, most with an intensity of very faint to faint. This fluorescence reaction corresponds to that of natural-color type IIa diamonds.

Figure 8. Graining was seen in a large number of GE-processed diamonds, and was one of the most prominent internal features of these stones. In some cases, the graining appeared whitish. In those diamonds where the graining was most intense, it seems to have contributed a slightly hazy appearance to the overall stone. Photomicrograph by John I. Koivula; magnified 35×.

INTERNAL FEATURES

GIA's examination of this large number of GE POL diamonds, in some cases at high (up to 200×) magnification, revealed a variety of unusual internal features, such as graining (figures 8 and 9) and inclusions (figures 10–16). This section expands the photographic record of the visual features we observed in the GE-processed diamonds (see, e.g., Shigley et al., 1999, for an earlier report), to help members of the industry better distinguish such diamonds. Further work is in

Figure 9. Also observed was brown graining, often in a parallel banded pattern. Photomicrograph by Shane F. McClure; magnified 40×.



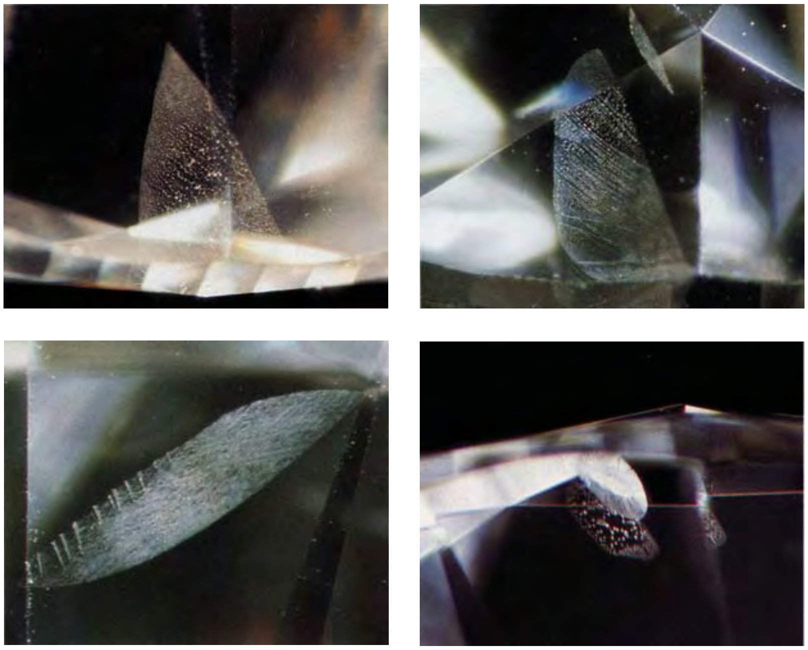


Figure 10. "Partially healed" cleavages were seen in a number of the GE POL samples. Some, as on the top left and right (magnified 13× and 18×, respectively), were similar in appearance to the "fingerprint" inclusions seen in some colored stones. Others had an unusual network-like appearance (bottom left, 18×), and one showed a partially healed cleavage next to a granular/glassy cleavage similar to those described in figure 11 (bottom right, 32×). The first three photomicrographs are by Shane Elen; the last is by Shane F. McClure.

progress to see if any—or a combination—of these visual features will provide conclusive evidence that a diamond has been exposed to GE's or a similar high pressure/high temperature procedure.

Graining. Internal graining was seen in more than 75% of the GE POL diamonds. Our graders described the graining as very subtle to obvious, sometimes with a "whitish" appearance (figure 8), but occasionally brown (figure 9). Graining also occurs in natural-color type IIa diamonds, though less frequently.

The GIA grading staff noticed that 45% of the diamonds displayed a slightly hazy appearance, especially when viewed with the microscope at 10× magnification. This may be due to graining or to some other light-scattering effect. Some of the diamonds did not

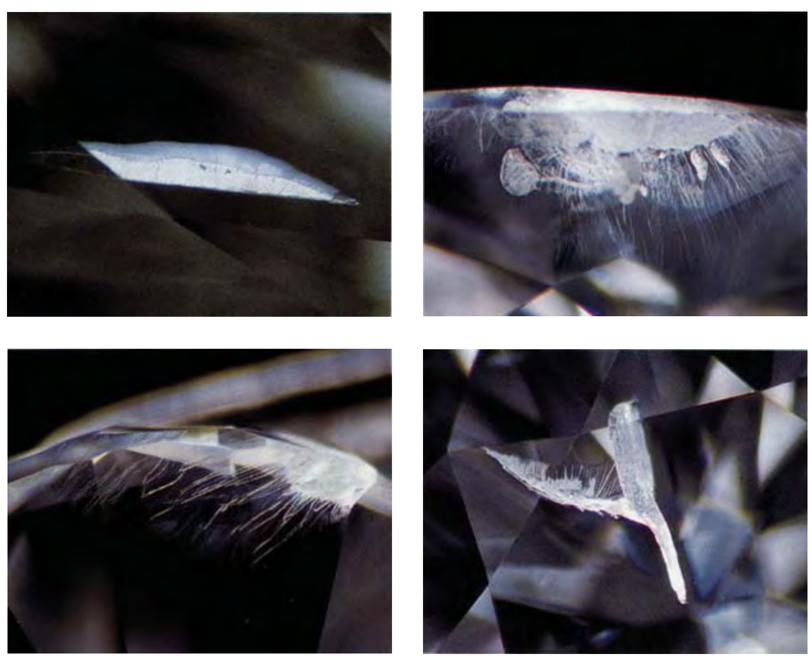


Figure 11. These cleavages appear granular and reflective (i.e., more opaque) where they intersect the surface of the diamond, and are glassier and more translucent deeper within the separation. Top left—photomicrograph by John I. Koivula, magnified 40×; top right and bottom—photomicrographs by Shane F. McClure, magnified 40× (top right and bottom left) and 33× (bottom right).

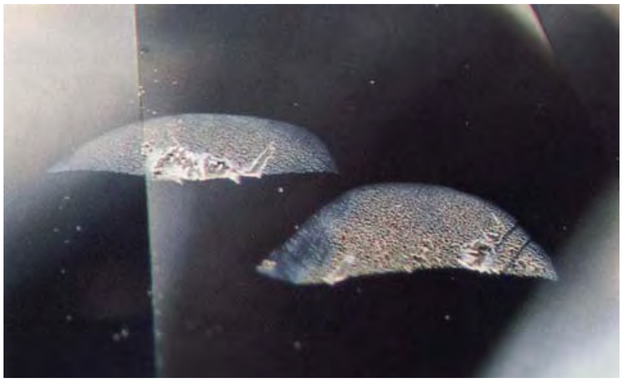


Figure 12. Each of these two partially healed cleavages has a black area similar to one identified as graphite in another sample by Raman analysis. Photomicrograph by Shane Elen; magnified 18×.

Figure 13. This small solid inclusion surrounded by a stress crack is an example of a feature seen in 103 of the GE POL diamonds. Photomicrograph by Vincent Cracco; magnified 63×.

exhibit the "crisp," transparent appearance typical of natural untreated diamonds of similar color, clarity, and type.

Other Features Seen with Magnification. One or more of the following internal features were observed in more than 30% of the samples: (1) surface-reaching cleavages or feathers; and (2) included crystals, typically with strain cracks or halos.

Many of the surface-reaching cleavages appeared to be "partially healed"; that is, they resembled the "fingerprint" inclusions that are seen in sapphire and ruby (figure 10). In other cleavages, we noticed that close to the surface of the diamond they had a frosted or granular appearance; but deeper within the stone, they became glassier (figure 11). A black area was seen in some of the cleavages (figure 12); laser Raman microspectrometry identified the material in one feather as graphite. Although cleavages are seen in some natural-color diamonds, we have not observed this distinctive combination of features in surface-reaching cleavages or feathers in untreated near-colorless diamonds.

We noted included crystals that were surrounded by stress cracks (figure 13) in 103 samples. In a number of instances, we observed black patches of what also appeared to be graphite that were surrounded by a translucent halo of tiny cracks radiating outward (figure 14). As is the case with colored gems such as ruby and sapphire, this radial cracking may be due to the differences in thermal expansion of the inclusion and the host diamond during heating to high temperature. A circular cleavage forms around the inclusion along the octahedral plane to relieve the resulting stress within the diamond.

Other inclusions consisted of one or more areas of

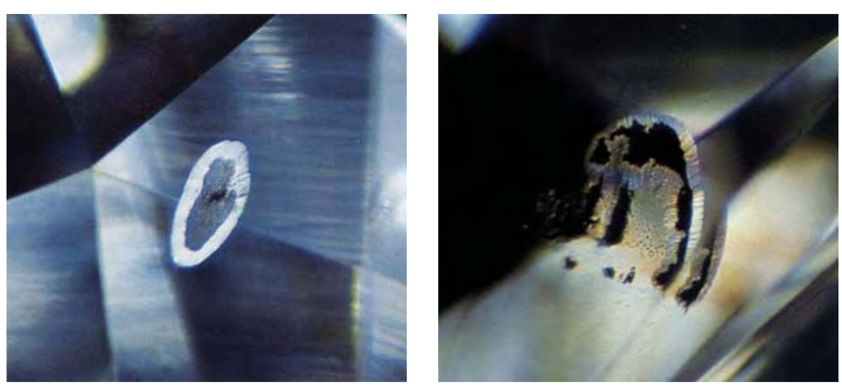


Figure 14. In most of the 103 samples that had solid inclusions surrounded by a stress crack, a black inner area (graphite) was surrounded by a brighter halo of outward radiating cracks (left; also evident here is the banded internal graining seen in a number of the GE POL diamonds). In some instances, there were several areas of graphite (right). Photomicrographs by John I. Koivula; magnified 40×.

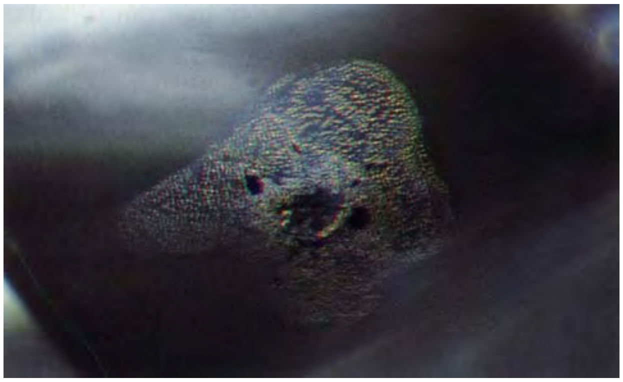


Figure 15. This inclusion contains several areas of what appear to be graphite, which are surrounded by mesh-like zones of tiny cracks. Photomicrograph by John I. Koivula; magnified 40×.

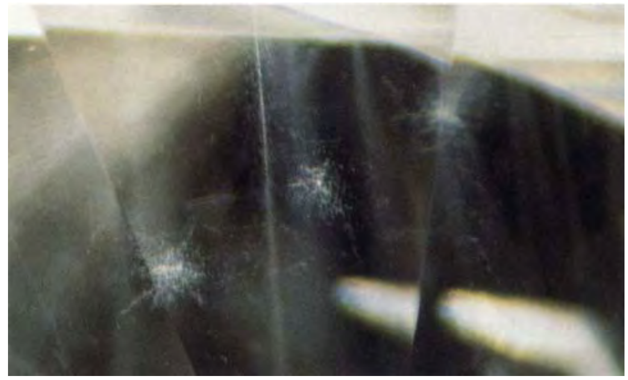


Figure 16. Approximately 2% of the GE POL diamonds exhibited unusual localized clouds and stringer-like clouds. Photomicrograph by Shane F. McClure, magnified 40×.

what appeared to be graphite, surrounded by a mesh-like region of small cracks (figure 15). Again, these inclusions are unlike the included crystals or cracks that are typically seen in untreated near-colorless diamonds.

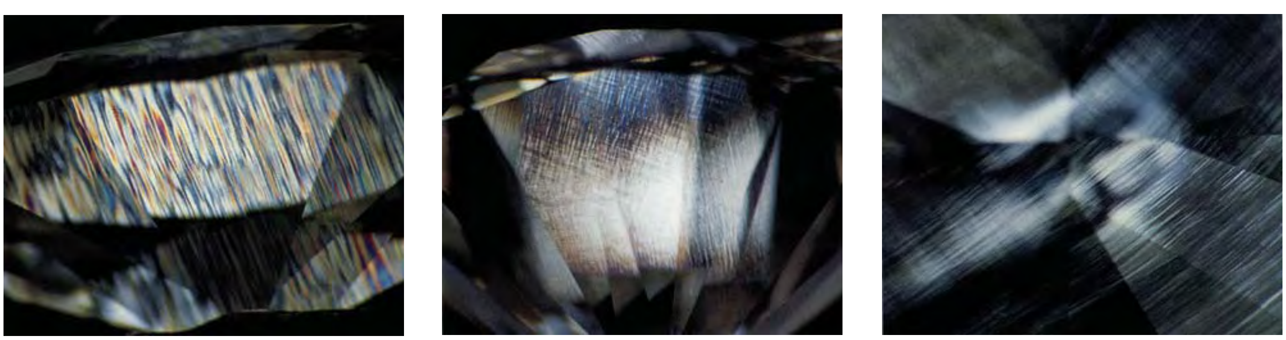
Some solid opaque inclusions did not exhibit these radial cracks, but instead showed a melted or flow structure. These may have been sulfide inclusions, which are seen in some natural diamonds.

Unusual localized clouds or cloud-like formations (which resembled the stringers sometimes seen in ruby) were present in approximately 2% of these diamonds (figure 16).

Strain. Most of the GE POL diamonds exhibited moderate-to-strong strain patterns (with crosshatched ["tatami"], banded, and/or mottled arrangements; see figure 17) when examined between crossed polarizing filters with a polariscope or gemological microscope. In the majority of these samples, the strain colors were first- and second-order gray, blue, or orange. In comparison, natural-color type IIa diamonds (which can show similar strain patterns) usually exhibit less-intense gray and brown interference colors (Lang, 1967).

Discussion. Although the internal features noted here were usually subtle in appearance, the fact that they

Figure 17. When viewed with cross-polarized light, most of the GE POL diamonds exhibited banded (left) or crosshatched (center and right) strain patterns. Although some stones did reveal low-intensity interference colors (right), for the most part these diamonds showed moderate- to high-intensity interference colors (center and left), notably stronger than what is normally seen in untreated diamonds of similar color. Left and center photomicrographs by Shane F. McClure, magnified 20×; right photomicrograph by John I. Koivula; magnified 20×.



were observed in many of the 858 diamonds reinforced our belief that these features were (1) produced in the diamonds as a result of this process, or (2) preexisted in the kind of diamond selected for processing. In either case, we have rarely encountered the precise features described here in the colorless to near-colorless type IIa natural-color diamonds submitted over the years to our laboratory for grading reports.

To date, we have not established any definitive identification features in GE POL diamonds that can be detected by instrumental measurement (e.g., an absorption band produced in type IIa diamonds by the GE process, which could be recorded by a spectrophotometer). Thus, visual features (especially the use of a laser inscription on the girdle, as mentioned above) may offer the jeweler or gemologist the best way at this time to recognize a GE POL diamond.

CONCLUSIONS

For the most part, the 858 GE-processed diamonds that formed the database reported here: (1) were type IIa diamonds, (2) weighed an average of 1.69 ct, (3) were fashioned in fancy shapes, (4) fell in the D-to-G range of color grades, (5) had high clarity grades, and (6) did not fluoresce to UV radiation. In addition, many of these diamonds showed a slightly hazy appearance, often with noticeable internal graining—characteristics that were far more common in this group of diamonds than in a similar population of natural-color diamonds. Other internal features (cleavages, feathers, and solid inclusions) were also somewhat different in appearance from what we have previously observed in untreated near-colorless diamonds. None of the GE-processed diamonds exhibited any evidence of "traditional" diamond treatments (such as irradiation, fracture filling, surface coating, or laser drilling). On the basis of the diamonds we have examined to date, we believe that it is possible to detect at least a portion of these GE POL diamonds using standard gemological observation techniques and equipment.

GIA has undertaken a research program to better understand the techniques used to improve diamond color and also to learn what color changes can be produced and how extensive these modifications may be. Results of these experiments will be published as they become available. If we can reproduce some of the same apparently characteristic features seen in the GE-processed diamonds examined to date, then such features may provide a way to identify that the color of a diamond has been altered by this method.

However, it is also possible that further development work could minimize or eliminate some of the unusual internal features we have noted in these diamonds. It is likely that various organizations will continue to experiment with this type of treatment, and that greater numbers of such diamonds will find their way into the jewelry trade. Although every effort is being made to keep up with these new technologies, we cannot guarantee that practical means will be found to recognize all of these diamonds.

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