PINK DIAMONDS FROM AUSTRALIA

By Stephen C. Hofer

During the first few months of 1985, the New York office of the GIA Gem Trade Laboratory examined more than 150 gem-quality fancy pink diamonds, most of which had similar color, spectra, luminescence, color zoning, surface textures, and inclusions. This dramatic increase in the number of pink diamonds offered in the trade recently, along with the fact that a great majority exhibit similar physical properties, suggested a new source of pink diamonds. This observation, together with information received from several diamond dealers to the effect that pink diamonds had been recovered from the Australian deposits, suggests that most or all of the above-mentioned stones originated in Australia. This article reports on the gemological properties of these "new" pink diamonds and describes a number of characteristics that, seen in combination in a stone, are indicative of Australian origin.

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Unless otherwise noted, the photomicrographs are by the author.

Diamonds with a pink body color have long been considered one of the rarest color varieties of diamond. Their rarity is due to the fact that pink diamonds are known to occur in only a few mines throughout the world, and none of these mines has ever proved to be a steady commercial source for gem-quality pinks. The famous alluvial deposits in southern India (stretching eastward from the Deccan Plateau highlands) produced a limited quantity of pinks during the active mining years in the 17th century. The many alluvial deposits throughout Brazil have historically been a notable but infrequent source of pinks, and in recent years Brazil has boasted a small production of pinks from the area around Diamantina (S. Moskal, pers. comm., 1984). Several Russian and African deposits—including the Williamson mine in Tanzania, a kimberlite deposit known as the Mwadui pipe—have also contributed to the sporadic output of pink diamonds worldwide. Usually, though, these deposits have yielded no more than a few carats of gem-quality pink stones at a time. It is therefore quite unusual to encounter parcels of natural pink diamonds. In fact, the number of natural fancy pink diamonds (152) examined in the first three months of 1985 at GIA's New York Gem Trade Laboratory represents more than the total number of pink diamonds examined in any previous year. According to diamond dealers who handled the rough material, the stones were from the recent productions of the newly discovered Argyle deposits in northwestern Australia (A. Arslanian, A. Bronstein, E. Elzas, W. Goldberg, pers. comms., 1985). Their information favored the notion that a significant number of these small stones were being fashioned by skillful cutters from larger, "lower quality" rough pink diamonds. In one example, the author examined a 0.38-ct round brilliant of fancy purplish pink color, heavily included, that was reportedly cut from the "cleanest area available from within a 2.50-ct rough Australian stone" (E. Elzas, pers. comm., 1985).

In an effort to characterize this new material, the author made a number of observations and conducted several

Figure 1. These examples of Australian pink diamonds from the study group illustrate the subtle differences among the characteristic hues. The stones range in size from 0.20 to 0.37 ct. Photo ©Tino Hammid.

gemological tests on 138 of these unusual pink diamonds. While there appears to be no one feature by which these stones can be distinguished, there are several characteristics that, when they appear in combination, indicate that a pink diamond is of Australian origin.

GEMOLOGICAL PROPERTIES

On reviewing the available literature, it became apparent that relevant gemological information on pink diamonds is sparse and often articles or notes on pink diamonds are based on observations of one stone. Therefore, we were pleased that our clients were willing to give us the opportunity to study a large selection of these pink diamonds.

Consequently, several gemological tests were conducted by the GIA Gem Trade Laboratory on 138 pink diamonds (ranging from 0.04 to 2.65 ct) that had been cut from Australian rough. The testing and initial observations of several of these pink diamonds revealed a number of distinctive characteristics, including an unusual body color that can be loosely described as "smoky purplish pink" (figure 1), characteristic spectral absorption patterns, similar fluorescent and phosphorescent reactions, distinctive color zoning, and irregular surface and internal features with a pitted texture that appears "frosted" or "sugary," in addition to well-formed colorless crystal inclusions. The refractive index and specific gravity measurements on all stones in this study were found to be within the normal range for diamonds.

Color. Of the 138 pink diamonds color graded during this study, nearly all had a body color strong enough to be in the "fancy" grade, a small percent were "fancy light," and only a very few were considered "light" pink. The fact that most of the stones—even round brilliants (figure 2)—had a color strong enough to be graded "fancy" is unusual, considering that the majority of pink diamonds examined in the laboratory previous to this study were in the "faint" through "fancy light" grades (R. Crowningshield, pers. comm., 1985).

Diamonds in the pink color family often contain secondary colors in addition to the primary pink color, referred to as modifiers. Modifying colors such as orange, purple, and brown are common in pinks; gray is also seen as a modifier, but less often. The assortment of natural pinks in figure 1 illustrates the variety of color seen in the pinks examined in this study: ranging from pink through purplish pink and including some with brownish overtones.

Most of the 138 stones when viewed separately appeared to contain some purple (again, see figure 1). However, when several stones were viewed side by side and table-down, the differences in color—including the subtle nuances of brown—were recognizable. In many of the purplish pink gems, these hints of brown were so weak and not readily observable face-up that they were not mentioned in the color grade; rather, such stones were graded as purplish pink. In the experience of the Gem Trade Laboratory, this unique combination of a very weak "smoky" brown together with varying

Figure 2. This necklace contains a total of 14.80 ct of Australian pink diamonds, including 143 brilliants. Only the 5.57-ct pear-shaped drop is from Brazil. Photo courtesy of R. Esmerian, Inc.

amounts of purple is not often seen in natural pink diamonds and thus helps the gemologist recognize and differentiate these diamonds from others in the pink color family.

The intensity of the pink color in the diamonds in this study is also unusual and is exemplified by a 0.72-ct fancy purple-pink gem that exhibited such a strong color saturation that it was outside the range of colors normally associated with natural pink diamonds (see cover). In fact, the color is comparable in strength to that seen in treated pinks, which have been referred to as "cranberry" pink. Also included in this study group were two diamonds that were graded as brown-pink that retained an attractive face-up color.

Spectral Analysis. The optical absorption spectra were observed with a Beck hand-held prism spectroscope first at room temperature and then at low temperature by resting the diamonds on an aluminum viewing block cooled with dry ice (Hofer and Manson, 1981). All the diamonds examined in this study showed the familiar 415-nm (Cape) absorption line in the violet region. In addition, a weak "smudge" was observed at about 520 to 580 nm in the green spectral region of two vivid purple-pink stones (figure 3).

Further testing with a Pye Unicam SP8-400 dual-beam spectrophotometer confirmed both absorption features (see spectra A and B in figure 4). The absorption strength of the 415-nm line at room temperature varied from weak to moderate and tended to be stronger in the purple-pinks. The broad absorption feature centered at approximately 550 nm correlates with the position and strength of the "smudge" seen in the hand spectroscope. This band at 550 nm was first noted in the spectra of pink, purple, and brown diamonds from Africa (Raal, 1958). Raal's study of pink diamonds states that "the strength of the band at 550 nm varies considerably and is correlated with the intensity of coloration of the diamond" (p. 846). Examinations and testing of natural pink diamonds at the Gem Trade Laboratory supports and confirms this previously published observation.

Further study of pink-diamond spectra was made by comparing the spectra of the two diamonds in the present study that exhibit the greatest visual color difference (again, see figure 4). The absorption curves are similar in appearance—that is, both resemble spectral absorption curves recorded for diamonds in the pink color family (Raal, 1958). However, it can be stated that the absorption spectra recorded on all pink diamonds

Figure 3. Drawing of the absorption spectrum recorded (at low temperature) from the 0.72-ct fancy purple-pink heart-shaped stone shown on the cover.

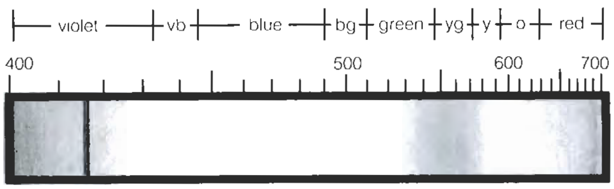
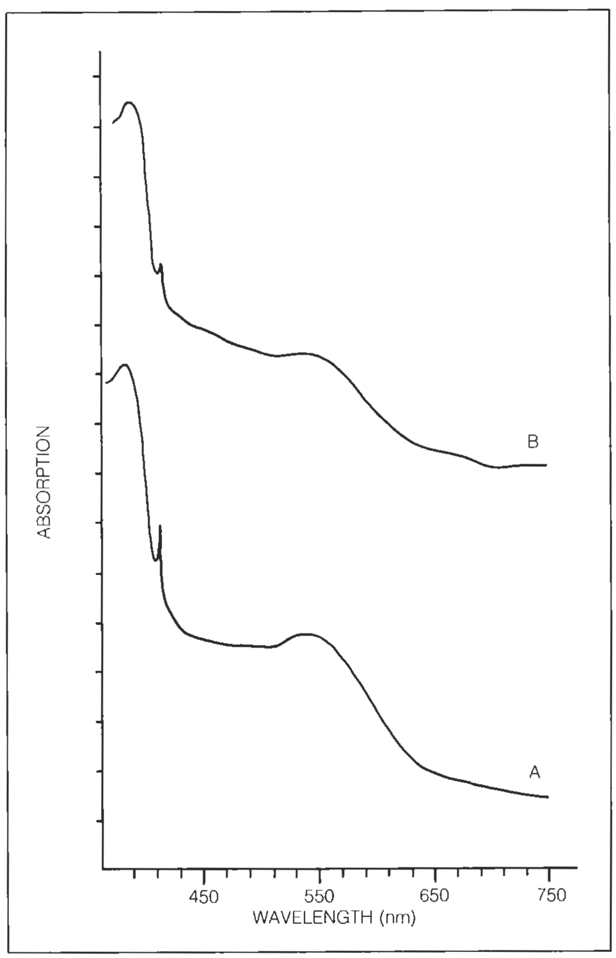


Figure 4. Optical absorption curves of two Australian pink diamonds from the study group. Spectrum A (lower) is recorded from an intense 1.64-ct purple-pink stone. Spectrum B (upper) is from a 1.93-ct brown-pink diamond.



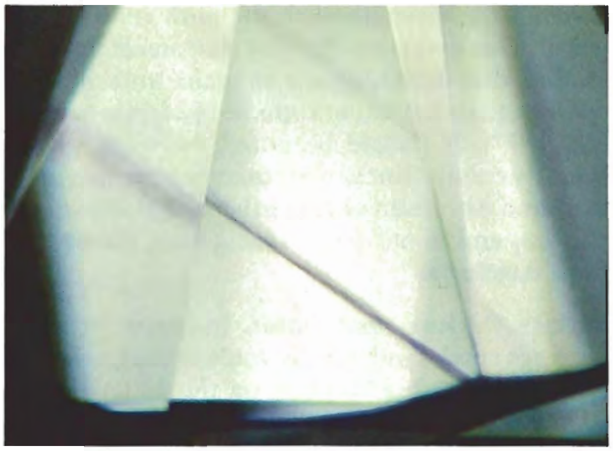


Figure 5. An obvious pink grain line as viewed through the pavilion of a colorless diamond at 10× magnification. Note the difference in appearance as the angle of observation changes. Photo by R. Kane.

Figure 6. This 5× view inside an Australian pink diamond shows the concentrated areas of minute pink grain lines. Note the pink "patches" of color.

from this study are markedly different from the spectra of treated pink diamond as observed in the hand spectroscope (Liddicoat, 1981, p. 193).

Luminescence Reactions. All of the diamonds from the study group were exposed to ultraviolet radiation in a darkened room: for each the color and the strength of the fluorescent glow were noted. The fluorescence varied from a very weak to a very strong blue when exposed to long-wave (366 nm) ultraviolet radiation and from none to a moderate blue when exposed to short-wave (254 nm) ultraviolet radiation. In addition, a yellow phosphorescence was noted in diamonds that fluoresced very strong blue, and virtually no phosphorescence was seen in diamonds that had a weaker blue fluorescence.

EXAMINATION WITH THE MICROSCOPE

A binocular microscope was used to examine all 138 stones at 5× to 75× magnification. The stones were examined for color zoning and distribution of color, birefringence patterns, surface and internal features and their textures, and inclusions.

Color Distribution and Zoning. Generally speaking, the color in pink diamonds is unevenly distributed throughout the body of the stone. The color occurs along narrow directions or zones known as grain lines. When viewed at various angles under magnification, the color in the grain lines (referred to by some diamond graders as "pink graining") appears to be concentrated along parallel, "needle-like" directions that alternate with colorless areas (figure 5; Kane, 1982). In most diamonds, these distinctive color-zoning features are usually very faint or are sparsely distributed throughout the crystal and therefore lack the potential in most cases to impart a strong pink color to the diamond when cut and viewed face-up.

By comparison, the diamonds in this study, the majority of which have a very obvious pink color face-up, have numerous minute pink grain lines that are more closely spaced than has been observed in most diamonds with pink graining examined previously. At low magnification, the pink graining appears very fine and close-knit, occurring throughout the entire stone or, more commonly, with the grain lines grouped together as patchy areas of pink (figure 6). The color in these areas looks similar to strokes of pink watercolor paint on paper and is referred to by the author as "brush stroke" graining. The minute pink grain lines that comprise these "brush stroke" areas are so slender and so closely spaced together that they are extremely difficult to resolve under high magnification. The most satisfactory results in examining these features are obtained by using low-power magnification and a shadowing technique to accentuate the details (Koivula, 1982). The concentrated patches of grain lines (figure 7) produce the overall appearance of strong pink color seen in these diamonds.

An early study (Raal, 1958) proposed that manganese causes the color in pink diamonds, but this theory has since been refuted (du Preez, 1965). Current explanations for the cause of pink color in diamonds involve defects in the atomic structure that result from gliding (the very slight movement of atoms along the octahedral direction) as a result of plastic deformation (Orlov, 1977). To confirm this and correlate these "defects" with the color in the pink grain lines, it is necessary to observe the birefringence pattern of diamonds.

Birefringence. Birefringence, or the strength of double refraction, is virtually nonexistent in strain-free, unincluded diamond (diamond is isotropic). However, most diamonds show some anomalous birefringence as a result of included crystals, various growth irregularities, or because they have been subjected to an epigenetic event such as plastic deformation (exposure to extreme temperature/pressure conditions after formation), as discussed by Lang (1967). Studying birefringence patterns in diamonds gives the gemologist a clue as to how strain is distributed within a diamond.

Birefringence can be examined with a microscope fitted with polarizing filters by holding the diamond in tweezers culet-to-table and viewing through the stone's pavilion at an oblique angle in transmitted or diffused transmitted light. With the diamond so positioned between the crossed polaroid plates, the pattern of interference colors, their strength (low-order grays up through high-order bright colors), and their coincident location around inclusions or grain lines can be observed.

All the pink diamonds in this study revealed a linear pattern of bright interference colors that coincided in strength with the pink graining (figure 8). This confirms the observations of previous studies that birefringence at grain lines is more distinct than any other form of birefringence (Orlov, 1977). It should be noted, however, that a brightly colored linear pattern only indicates that a diamond has strain characteristic of plastic deformation, and is not proof that a pink diamond is from Australia.

Figure 7. Needle-like pink grain lines can be seen cutting across an irregular pale pink color zone in an Australian diamond. Magnified 10×.

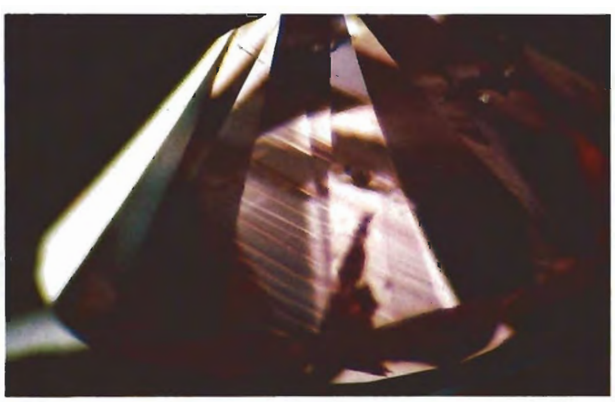


Figure 8. A 10× view inside the same stone as in figure 7, using polarized light, shows the typical banded or linear birefringence pattern that signifies internal strain in the diamond, coincidental with the grain lines.

Surface Textures and Forms. Irregular "frosted" cleavage cracks and narrow voids or channels with a rough or "pitted" texture on the surface of the stone are considered to be very characteristic of the Australian material (figure 9). R. Liddicoat (pers. comm., 1985) saw large lots of rough during a recent visit to Australia and reported that nearly all the rough had an irregular "frosted" surface that resembles etching. This observation was further substantiated by R. Buonomo (pers. comm., 1985), who examined recent productions from the Argyle deposits at the Central Selling Office in London. His description of the Australian material noted the surface textures as appearing "frosted" or "sugary" to the unaided eye. The presence of similar features on the pink diamonds in the study sample is consistent with the Australian origin reported for these stones.

Researchers studying the process of etching have established that very strong heating of diamonds in situ can lead to the action of dissolution (process of dissolving) and consequently etch features (Frank and Puttick, 1958). As dissolution proceeds, the surface-etching textures develop in

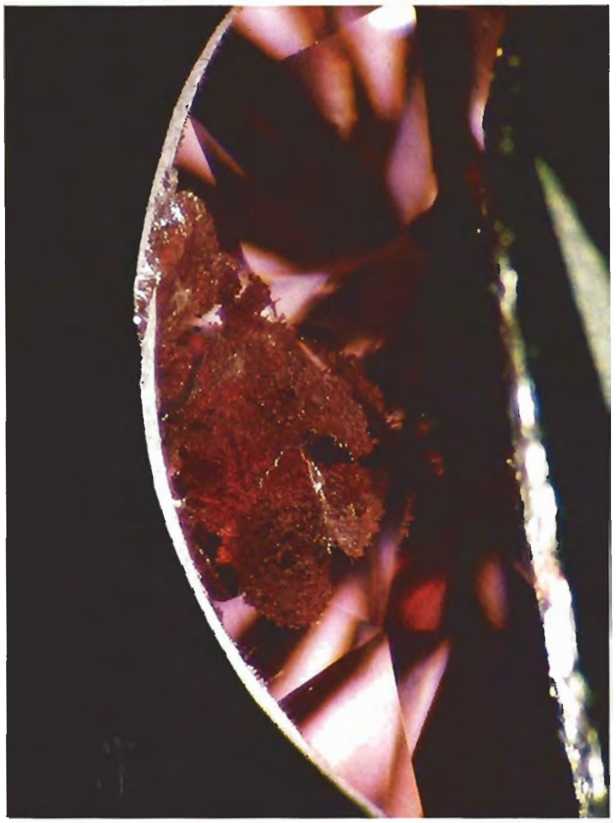


Figure 9. A cleavage crack that has been naturally etched appears "frosted," similar to worn beach glass. Note the extent of the etching inward and the open void at the girdle. Magnified 10×.

Figure 10. The early stages of etching are evident on a flat cleavage plane inside this pink diamond. Note the triangular markings that resemble trigons, which are actually triangular etch pits (Orlov, 1977). Magnified 45×.

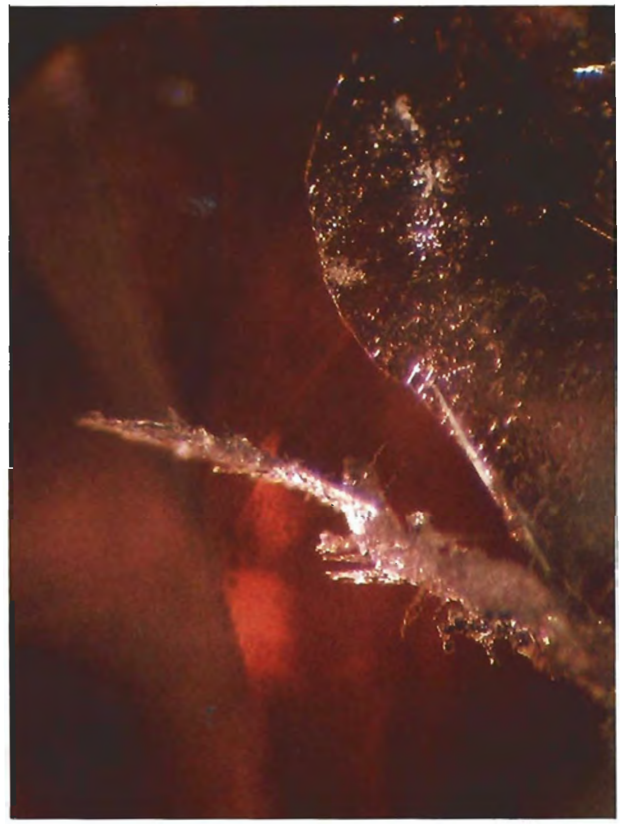


Figure 11. Etching that proceeds along a zone of weakness in a diamond can propagate in many directions inside the gem, resulting in many unusually shaped voids or hollow channels. Magnified 25×.

various stages. Starting as small pits (weak etching), they subsequently develop into frosted planes and eventually, with prolonged heat, result in narrow voids (highly etched channels) resembling cracks (Berman, 1965; Orlov, 1977).

The various stages of etching noted by these workers is similar to that seen in the pinks examined in this study. For example, some of the diamonds had etch features seen on unpolished surfaces (naturals) resembling smooth "frosted" glass that suggest early stages of etching. Various gradual stages up to intensive etching were also seen to occur on the surface and along fractures in several cut diamonds (figure 10). Where etching has proceeded along a cleavage direction, the etching appears to widen and deepen the cleavage. These etch features were thus seen to propagate inward in the diamond, resulting in a network of unusual voids and channels (figure 11). When such channels intersect, they seriously affect the dura-

Figure 12. A part of the original surface on the girdle of this pink diamond shows evidence of "frosted" etching. Note the small amount of dirt or polishing material that has remained intact in the narrow section parallel to the girdle plane. Magnified 20×.

Figure 13. This cluster of colorless, polyhedral, solid crystal inclusions (possibly olivine) in pink diamond appears in moderate to high relief in dark-field illumination. Magnified 20×.

bility of the diamond and often result in breakage. In addition, narrow etch channels open at the surface are commonly filled with a dark material, possibly from the polishing process or simply from dirt, which can darken the appearance of the voids (figure 12).

Other Inclusions. Of the 138 pinks examined in this study, all of which had considerable pink graining and showed evidence of etching, the majority (more than 90%) also contained numerous small, solid, colorless, polyhedral crystal inclusions (figure 13). Microscopic study of these inclusions showed that they did not have a characteristic crystal habit; rather, they assumed the morphology of the host diamond. They are very similar in appearance to the colorless olivine inclusions commonly seen in diamonds found in kimberlite deposits (Mitchell and Giardini, 1953; Hall and Smith, 1984). Because such inclusions are common in diamonds found at various locations, they cannot be considered conclusive proof of Australian origin. However, colorless crystals when observed in a natural pink diamond with the previously described color, spectra, luminescence, graining and surface features can be considered indicative of Australian origin.

CONCLUSION

The author was not able to obtain information on the abundance and availability of these Australian pink diamonds. It has been reported in the literature, however, that deposits at the Argyle project in northwest Australia "produce a characteristic pink diamond, which is likely to be the signature of the mine over the next few years" (McIlwraith, 1984).

The sudden occurrence of increased numbers of natural pink diamonds in the gem market reinforces the idea that continued mining and recovery efforts may significantly augment the traditionally limited supply of natural fancy-colored diamonds annually recovered.

The gemological and microscopical findings reported in this article suggest that there are several features that are characteristic of pink diamonds from Australia: their intense purplish pink color, the concentrated patches of "pink graining," luminescence, birefringence, a "frosted" surface, and included small, colorless crystals. While no one or two of these features alone would provide proof of the stone's origin, the occurrence of several of these features in a pink diamond would strongly suggest that the stone came from the Australian mines.

Editor's Note: *In August 1985, the GIA Gem Trade Lab in New York was informed that certain brownish pink diamonds from Australia improve in color with repeated heat treatment (not identifiable by known gemological tests). Somewhat similar behavior in brownish pink diamonds has been reported previously (Gem Trade Lab Notes,* Gems & Gemology, *Vol. 19, 1983, p.44). At the same time, it was reported that the Australian material has become much scarcer during the past four to five months.*

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