GEM TRADE LAB NOTES

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DIAMOND

Laser Drill Holes or Natural Inclusions?

Natural inclusions in diamond may resemble laser drill holes, and laser drill holes can have a very unusual appearance. Sometimes, only very careful observation with a microscope can reveal the inclusion's true identity. Recently, the East Coast laboratory encountered four such inclusions.

The first was in a 0.24-ct round brilliant-cut diamond. Our client's customer had returned the diamond on the grounds that apparent laser drilling had not been disclosed. However, examination at 63× magnification clearly revealed that the inclusion in question was actually a string of pinpoints (figure 1) connecting a small cloud and crystal to a larger cloud. The fact that this "string" did not break the surface of the stone proved that it could not be a laser drill hole. This is another instance where the client's use of a gemological microscope would have provided both more knowledge on the stone at hand as well as an opportunity to educate the customer as to the actual nature of the stone's internal characteristics.

Figure 1. Examination of this diamond at 63× magnification reveals that what appeared at low magnification to be a laser drill hole is actually a string of pinpoints connecting separate inclusions.

Figure 2. The squarish outline of the tube-like inclusions in this 4.03-ct fancy yellow diamond proved that they were etch channels. By comparison, the outlines of laser drill holes are typically round. Magnified 37×.

Another diamond, a 4.03-ct fancy yellow cushion brilliant, had many angular tube-like inclusions. Unlike the coarse etch channels shown in the Fall and Winter 1992 Lab Notes sections, the channels in this stone were very thin and resembled laser drill holes. Nevertheless, magnification revealed that these inclusions had the squarish outlines of etch channels (figure 2), not the rounded outlines of laser drill holes. The angularity also indicated that these were natural inclusions.

Occasionally, however, we do see laser drill holes that are not entirely straight, such as the one in this 4.69-ct pear-shaped brilliant cut (figure 3), which starts at the table. As seen through the pavilion (figure 4), this laser drill hole wanders off line several times before reaching the inclusions, a crystal and a feather. The cone-shaped entry point of the

Figure 3. The somewhat irregular laser drill hole in this 4.69-ct diamond travels from the table to a crystal and feather inclusion. Note the cone-shaped opening. Magnified 27×.

Figure 4. The unusual curvature of the laser drill hole shown in figure 3 is apparent when the diamond is viewed through the pavilion. Magnified 63×.

drill hole is an earmark of early laser technology, which was first noted in *Gems & Gemology* in the Fall 1970 issue (p. 224). Refinements in the laser-drilling process over the next few years led to laser drill holes without this cone-shaped point of entry.

The drill hole in figure 5, as viewed from the pavilion of this 1.15-ct round brilliant-cut diamond, is also atypical. As clearly seen in the image on the left, the main drill hole reaches a crystal-like inclusion, but also branches off to reach another inclusion, forming a "Y" shape. We spoke to a number of people who do laser drilling, but none of them could explain why these branching or curving phenomena occur.

Vincent Cracco

Figure 5. This laser drill hole (seen doubled due to prism reflection) goes straight from the surface to one included crystal, but also branches to a second, deeper inclusion. Magnified 63×.

Diamond with Unusual Color Zoning

Diamonds with a yellow body color generally have fairly even color distribution throughout. When color zoning does occur, it is usually in the form of areas that are lighter and darker yellow, with indistinct boundaries. So, the West Coast lab staff were surprised to see the unusual color zoning evident in the 1.08-ct marquise brilliant shown in figure 6. Microscopic examination revealed two very distinct, parallel, dark yellow color bands in a stone of otherwise lighter yellow color. Running the length of the stone, the bands were more reminiscent of color distribution commonly seen in yellow sapphires.

Figure 6. Parallel color banding is sharply defined in this 1.08-ct marquise brilliant-cut diamond, which measures 10.71 × 5.25 × 3.26 mm. Magnified 17×.

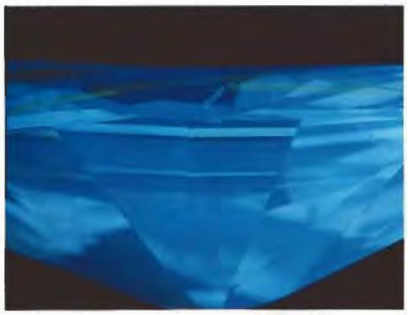

Figure 7. When the diamond in figure 6 was examined with long-wave U.V. radiation, the bands fluoresced yellow and the rest of the stone fluoresced blue. Magnified 17×.

With long-wave ultraviolet radiation and magnification, the banding was strikingly pronounced. It fluoresced a strong yellow that contrasted with the weaker blue fluorescence of the main body of the stone (figure 7). In fact, the orientation of the bands combined with the strength of their fluorescence to give the stone an overall yellow fluorescence when viewed faceup with the unaided eye.

This color distribution, obviously unrelated to the faceted shape, is an indication of natural color. Considering this and the fact that the diamond exhibited no distinct absorption lines that would be associated with laboratory irradiation, we concluded that the color was natural.

RCK and SFM

EMERALD, Trapiche from a New Locality

The locality in which a gem mineral occurs is often important to collectors and dealers alike. For some gem minerals, there is no question as to locality because they are found in only one or a few places. There are times, however, when a new locality for the same type of material shows up. The GIA East Coast lab was fortunate enough to inspect such a specimen, a trapiche emerald that reportedly came from a locality other than Colombia. The dealer who submitted the pair of polished green hexagonal tablets in figure 8 (left) to the East Coast lab informed us that these were cut from a single crystal, which came from the state of Goiás, in Brazil. One weighed 4.62 ct and the other 4.21 ct; both measured approximately 9.85 × 12.75 × 3.50 mm.

On the basis of standard gemological tests and the distinctive appearance of the slices (see H. L. McKague, "Trapiche Emeralds from Colombia," *Gems & Gemology*, Fall 1964, pp. 210–213), we identified them as trapiche emeralds. (Discovered in Colombia, trapiche emeralds were named after the Spanish word for cane-crushing gears, which the Colombian type resembles—with its central green core and six black arms extending from the prism faces of the core [figure 8, right].) However, the refractive indices and specific gravity were found to be higher than those of the Colombian material: R.I., 1.583–1.589; S.G., taken hydrostatically, approximately 2.74. Trapiche emeralds from Colombia typically have R.I.'s of 1.563–1.569 and an S.G. of 2.65–2.69 (see J. Sinkankas, *Beryl*,

Figure 8. The trapiche emeralds on the left, which are reported to be from the state of Goiás in Brazil, are the first we have seen from a locality outside of Colombia. The two slices are approximately 12.75 mm on their longest dimension. On the right is a typical Colombian trapiche crystal; it measures 16 mm × 22 mm.

Butterworths, London, 1986, pp. 121–126).

In this Brazilian material, somewhat trapezoidal opaque dark areas extend inward to a hexagonal core from each of the six first-degree prism faces. Transparent green areas separate each of the opaque dark areas. However, the spoke pattern in these slices differs from that usually seen in gem-quality trapiche emeralds from Colombia. In the latter, thin black spokes radiate from the core and separate the usually saturated emerald green color into six areas (see again, figure 8, right). The newly submitted stones almost seem to be a photographic "negative" of the Colombian material.

Nicholas DelRe

JADEITE, with Metallic Inclusions

Until the recent concern with the bleaching and impregnation of jadeite (B jade), there appears to have been little interest in identifying or cataloguing inclusions in jadeite, possibly because they are encountered so rarely, at least in fashioned material. One of the few such references was a Spring 1973 Lab Note (p. 135), which described inclusions—in translucent jadeite—that had the appearance of pyrite.

Staff members at the East Coast lab recently examined an unusually translucent 8.60-ct green jadeite cabochon (figure 9), which we determined to be untreated, that had inclusions reminiscent of those described in that earlier Lab Note. Because none of the inclusions reached the surface, the client kindly agreed to repolish the cabochon to expose several of them for further study. When viewed in reflected light, the inclusions appeared to be of two different minerals: One type seemed to be quite hard, with a brassy metallic luster; the other type had a brown appearance, undercut the surface markedly, and did not take a polish (figure 10).

Although the client did not want us to scrape the inclusions for X-ray diffraction analysis, he did agree to let us send the stone to Santa Monica for energy-dispersive X-ray fluorescence (EDXRF) analysis at GIA Research. Unfortunately, the size and position of the inclusions did not allow a definitive identification by this method. The project was further complicated by the general lack of data on trace elements in jadeite.

However, on the basis of luster, relative hardness, color, and appearance, it was concluded that the metallic inclusions are probably pyrite and the softer brown inclusions are probably pyrrhotite, which commonly occurs with pyrite. This opinion was substantiated by using polarized reflected light to observe a property that is called *bireflectance*. Specifically, the "pyrrhotite" inclusions appeared to shift in color as the cabochon (or polarizer) was rotated,

Figure 9. This highly translucent 8.60-ct jadeite cabochon has inclusions, something that is not often seen in jadeite. Magnified 10×.

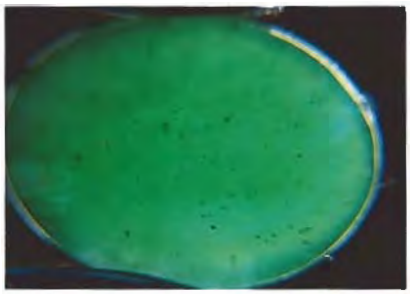

Figure 10. Some of the inclusions in the stone shown in figure 9, seen here with darkfield illumination, appear to be brown when viewed in reflected light. They may be pyrrhotite. Magnified 30×.

Figure 11. The 6.5- to 7-mm freshwater tissue-nucleated cultured pearls in this necklace are nearly round.

which indicates that the material is not isotropic; however, the color of the "pyrite" crystals did not vary with such a rotation, so they probably are isotropic. (Therefore, the soft material is not limonite, and the hard material is not marcasite.)

Although inclusions in jadeite are rare, the presence of some inclusions, such as sulfides, at the surface of a stone may indicate that the stone was not "bleached" by acid treatment, since some bleaching agents attack and may destroy certain inclusions, depending on the chemistry of the inclusion and the agent used.

GRC and Mary L. Johnson

Cultured PEARLS, Round and Near-Round Freshwater Tissue-Nucleated

With the tremendous (and still increasing) production of freshwater tissue-nucleated cultured pearls, and the greater attention to quality by cultured-pearl farmers in China, it is not surprising that some of these cultured pearls turn out nearly round or round, unlike the "rice-grain" types that dominated production up until the last few years. In fact, in late 1992 one staff member of the East Coast lab was shown a 30-inch-long twisted rope of 12 strands of near-round 4- to 5-mm freshwater tissue-nucleated cultured pearls. Another staff member reported seeing many similar strands during a late-1993 trip to the Far East; he was told they were selling quite briskly.

In December 1993, however, a client showed us the largest freshwater tissue-nucleated cultured pearls we had seen to date—6.5 to 7 mm—in an 18-strand hank. Two of these strands were later used in the necklace shown in figure 11. Note that this is a popular size for saltwater bead-nucleated "Akoya" cultured pearls from Japan.

An X-radiograph of this necklace (figure 12) reveals an interesting potential problem: Many of the pearls do not show the void that would prove they are tissue-nucleated. This evidence may have been eliminated by the drill hole. Therefore, some freshwater tissue-nucleated cultured pearls may be indistinguishable from some freshwater natural pearls by X-radiography.

We have previously noted what we feel were efforts to drill away evidence of mantle-tissue nucleation (*Gems & Gemology*, Spring 1986, pp. 51–52, and Summer 1986, p. 111). New information suggests that some "accidental" saltwater tissue-nucleated cultured pearls have been fraudulently substituted for natural pearls in old items of pearl jewelry. The perpetrators hoped that the oversized drill holes would eliminate the voids left by the tissue nuclei. *GRC*

Glass-Coated QUARTZ

Two distinctly different treatments are typically used to produce a thin layer of surface color on gems: color coating and diffusion treatment. In the first, a colored layer is applied to the surface of the stone. Color-coated stones examined by the lab over the years have included diamonds coated with pink nail polish (Spring and Summer 1983 Lab Notes, pp. 43–44 and p. 112, respectively) and pale beryls coated with a green substance to imitate emerald (Spring 1983 and 1993 Lab Notes, pp. 44–45 and 46–47, respectively).

In another, newer type of coating, elemental gold is deposited on quartz and topaz gems, producing a greenish blue color with thin-film surface iridescence. This material is marketed under the trade name "Aqua Aura" (see Gem News, Winter 1988, p. 251, and Fall 1990, pp. 234–235).

Figure 12. An X-radiograph of the tissue-nucleated cultured pearls in figure 11 shows that in many instances evidence of the nucleus has been removed by the drill hole.

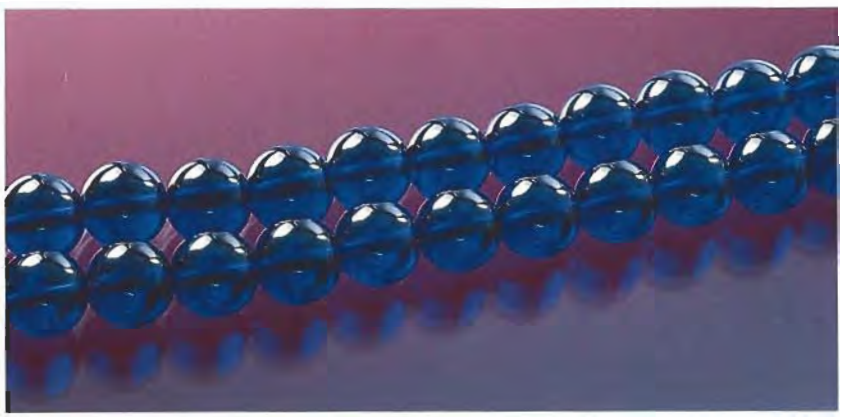

Figure 13. A glass-like coating is responsible for the apparent color of these 8- to 8.5-mm quartz beads.

In diffusion treatment, coloring agents are diffused into the surface of the stone. To date, we have only examined gem corundums that have been color enhanced by this method (see related *Gems & Gemology* articles by Kane et al., Summer 1990, pp. 115–133, and by McClure et al., Spring 1993, pp. 16–28).

Recently, the West Coast lab received for identification a strand of 51 round beads (figure 13) about 8 to 8.5 mm in diameter. The transparent beads were dark violet-blue, reminiscent of cobalt-colored synthetic spinel or the rare cobalt-colored natural spinel. The client who submitted the beads knew that they had been treated, but not the method used.

Gemological testing revealed properties consistent with those of quartz, including a "spot" R.I. of 1.54, an S.G. of 2.65, and a "bull's-eye" optical interference figure. Magnification revealed that the color layer around some drill holes was thinner and lighter in tone than elsewhere on the beads. Some beads had dimple-like depressions in the surface layer, primarily near the drill holes, which exposed the underlying bead as colorless and with a rough-ground appearance (figure 14). Microscopic examination also revealed very little color in the drill holes. A small ridge with a concave side near the drill hole on many of the beads may have resulted from their having been treated while hanging on wire.

With the client's permission, we removed one bead and sawed a slice with surfaces perpendicular to the drill hole. This revealed that, away from the drill hole, the layer of surface color was actually fairly uniform (figure 15), approximately 0.07 to 0.10 mm thick, with a somewhat lower luster than that of the underlying colorless bead. The surface layer also "undercut" during preparation of the section, indicating a lower hardness than that of the bead itself. We determined a Mohs hardness of 5-6 for the coating on the sawn bead, softer than that of quartz (Mohs hardness of 7). The hardness test also revealed that the coating was very brittle, as it produced a succession of conchoidal chips. X-ray powder diffraction analysis of a small scraping from the surface layer showed that it was amorphous. This is unlike the results we have obtained with diffusion-treated corundum, in which the surface layer is crystalline. Energy-dispersive X-ray fluorescence (EDXRF) analysis of the surface layer revealed large amounts of Si and Co, as well as smaller amounts of Pb, Na, Zn, Ti, and Fe.

From this testing, we concluded that the beads were quartz with a glass-like coating, possibly produced by an enameling process. If so, it would not be the first time enameling was used on quartz. In the rarely seen classic *en resille* enameling technique, rock crystal (or glass) was finely incised with lines that were subsequently overfilled with gold. The cells that formed were filled with enamel and then fired (see, e.g., Kenneth F. Bates's *Enameling Principles and Practice*, World Publishing Co., Cleveland and New York, pp. 138–140).

RCK and SFM

Figure 14. These "dimples" seen in reflected light are areas of incomplete coating on some of the beads shown in figure 13. Magnified 20×.

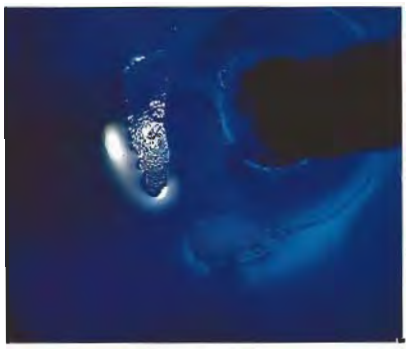

Figure 15. A slice cut from one of the beads in figure 13 confirms the thin (0.07–0.10 mm) color layer on a colorless substrate. Magnified 40×.

SYNTHETIC SAPPHIRE, with a Small Star

Almost all of the synthetic star corundums that we see exhibit not only uniform color and transparency, but also even distribution of the inclusions that cause the phenomenon. Some notable exceptions reported earlier include incomplete

stars in a synthetic star ruby (Summer 1982 Lab Notes, pp. 105–106) and a synthetic star sapphire (Winter 1991 Gem News, pp. 263–264).

Another variation on this theme was seen in an oval buff-top step-cut synthetic sapphire recently examined by the West Coast lab. The pinkish orange synthetic, measuring approximately 10.64 × 8.91 × 5.00 mm and set in a yellow metal ring, was transparent except for a small area at the top of the dome. When examined with reflected light, this area displayed distinct six-rayed asterism. Magnification revealed the cause, a small localized plane of intersecting minute needle-like inclusions (figure 16). The gemological properties were consistent with corundum, and curved yellow color banding proved it to be synthetic. As the phenomenon was distinct, albeit confined to the apex, the item was identified as a synthetic star sapphire.

RCK

Figure 16. The inclusions causing the star in this pinkish orange synthetic star sapphire are confined to the whitish area at the apex of the cabochon. Magnified 20×.

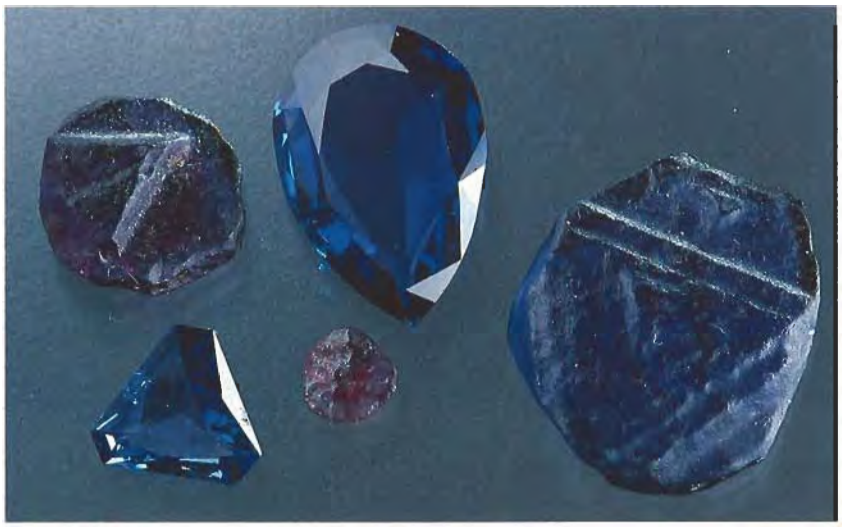

Figure 17. In keeping with the typically "stunted" shape of the Yogo sapphire crystals (the largest, at the far right, is 6.60 ct), the 13.90-mm-long pear-shaped Yogo sapphire shown here is only 2.80 mm deep.

SAPPHIRES from Yogo Gulch, Montana

A group of crystals and faceted sapphires from Yogo Gulch, Montana—seen in the East Coast lab—provide an excellent example of how the shape of the rough often determines the final cut. Sapphires from this region crystallize mainly as short prisms, characterized by repeated growth of a rhombohedral form, and are terminated by the basal pinacoid (figure 17; see S. E. Clabaugh, *Corundum Deposits of Montana*, U.S. Geological Survey Bulletin No. 983, 1952). For example, the blue 6.60-ct crystal in figure 17 measured about 15.70 × 13.00 mm, but was only 3.32 mm thick. Therefore, to retain weight, Yogo rough is typically cut into stones of shallow depth: The fine, and relatively large (for a Yogo sapphire), pear shape in figure 17 measures approximately 13.90 × 9.35 mm in outline. However, because of the shallow (2.80-mm) depth, it weighs only 3.59 ct.

In contrast, many sapphires from Sri Lanka crystallize as tapering hexagonal bipyramids (figure 18). The desire to retain weight from this type of rough typically results in native-cut stones with extremely deep pavilions.

Nicholas DelRe

TURQUOISE, Dyed and Impregnated

Seldom have staff members at the West Coast GIA Gem Trade Laboratory seen as interesting an example of dyed and impregnated turquoise as was presented by the slab (reportedly a section cut from a nodule) shown in figure 19.

Gemological testing easily identified the sample as turquoise. Microscopic examination of the very irregular, darker blue periphery revealed concentrations of a dark blue material with a subvitreous luster; the material was readily indented by the point of a metal needle and reacted like a plastic to a thermal reaction tester. No further testing was needed to identify the turquoise as dyed and impregnated.

Of particular interest was the "before-and-after" effect illustrated

Figure 18. Because Sri Lankan sapphire crystals are typically bipyramidal, as shown here, they lend themselves to cut stones with deep pavilions.

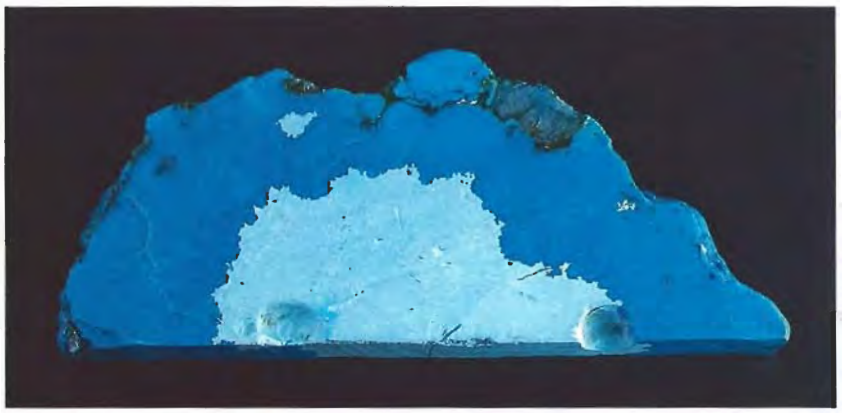

Figure 19. This 7.90 × 3.23 × 0.90 cm slab of dyed and impregnated natural turquoise clearly reveals the lighter blue color of the untreated material, in the center, where the treatment substance did not penetrate.

by the slab. The lighter portion clearly reveals the appearance of the turquoise before treatment.

RCK

Faceted VÄYRYNENITE

Among the many interesting materials we have the opportunity to examine in the laboratory are rare minerals that have been fashioned as collectors' stones. In past Gem Trade Lab Notes, we have reported on items such as augite (Spring 1989), clinohumite (Winter 1986), color-change diaspore (Spring 1987), lazulite (Spring 1993), phosgenite (Summer 1977), sapphirine (Summer 1987), stibiotantalite (Spring 1980), and triphylite (Fall 1988).

Recently, a colleague loaned the West Coast lab a 2.02-ct pinkish orange marquise step cut (figure 20) that was believed to be väyrynenite, a rare, monoclinic, beryllium-manganese phosphate that occurs in lithium pegmatites. We determined the following gemological properties: refractive indices, 1.639–1.665; birefringence, 0.026; specific gravity, 3.23; biaxial optic character; trichroism of moderate strength in pinkish orange, pink, and yellowish orange; inert to both long- and short-wave U.V. radiation; a faint pink appearance through the Chelsea color filter; and absorption features including weak general absorptions at about 400–440 nm and about 660–700 nm, with a strong band centered at about 415 nm and a weaker band from about 540–560 nm. Examination with magnification revealed many partially healed fractures composed of one- and two-phase (fluid and fluid-and-gas) inclusions. These properties are all consistent with väyrynenite, a mineral with a Mohs hardness of 5. According to J. Arem's *Color Encyclopedia of Gemstones* (2nd ed., 1987, Van Nostrand Reinhold, New York, p. 198), faceted gems of this material are extremely rare and seldom exceed 0.5 ct. Cuttable material reportedly comes only from Pakistan, although the mineral was named after Finnish geologist Heikki Allan Väyrynen, who found the first deposit in Viitaniemi, Finland. *RCK*

Figure 20. This 2.02-ct marquise step cut (11.19 × 5.20 × 4.90 mm) is a rare faceted example of the mineral väyrynenite.

PHOTO CREDITS

Vincent Cracco took the photos in figures 1–5. Shane McClure provided figures 6, 13–15, 19, and 20. Nicholas DelRe supplied the pictures used in figures 8 (left), 9, 11, and 17. The X-radiograph in figure 12 was taken by Bob Crowningshield. The photomicrographs in figures 7 and 10 are by John I. Koivula. The photo used in figure 16 was furnished by Maha DeMaggio. Michael Havstad took the photo in figure 18. Figure 8 (right) is © Harold & Erica Van Pelt.

Editor's note: The initials at the end of each item identify the contributing editor who provided that item.

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