EMERALD AND GOLD TREASURES OF THE SPANISH GALLEON NUESTRA SEÑORA DE ATOCHA

By Robert E. Kane, Robert C. Kammerling, Rhyna Moldes, John I. Koivula, Shane F. McClure, and Christopher P. Smith

During the 1970s and 1980s, treasure hunters discovered the centuries-old remains of the sunken Spanish galleons Nuestra Señora de Atocha *and* Santa Margarita. *Not only did they find massive amounts of silver and gold in coins, bars, and chains, but they also uncovered a number of rough emeralds and several pieces of emerald-set jewelry. Recently, some of the treasures recovered from the* Atocha *were examined at the Santa Monica office of the GIA Gem Trade Laboratory. Gemological testing of the emeralds revealed inclusions typical of stones mined in Colombia as well as possible evidence of extended submersion in seawater. Study of the jewelry revealed a high-karat gold content and fine workmanship that represented methods typical of the era.*

ABOUT THE AUTHORS

Mr. Kane is a supervisor of gem identification in the GIA Gem Trade Laboratory, Inc., Santa Monica, California. Mr. Kammerling is general manager of technical development, GIA, Santa Monica. Ms. Moldes is a graduate gemologist and president of International Eximgems, Miami, Florida. Mr. Koivula is chief gemologist, GIA. Mr. McClure is a senior staff gemologist, and Mr. Smith is a staff gemologist, in the GIA Gem Trade Laboratory, Inc., Santa Monica.

Acknowledgments: The authors thank Mr. Mel Fisher and Mr. R. D. LeClair for providing information and the opportunity to examine the materials for this investigation.

Gems & Gemology, *Vol. 25, No. 4, pp. 196–206*

During the Spanish conquest of the New World in the 1500s, *conquistadores* discovered vast amounts of valuable commodities such as gold, silver, copper, indigo, pearls, and emeralds. The last of these, emeralds, was one of the rarest items—with only the exhausted Egyptian deposits then known to the Western world. Gold and silver were mined in Upper Peru (now Bolivia), Mexico, and the area that was eventually known as New Granada (Colombia, parts of Venezuela, Ecuador, and Panama). In 1537, Gonzalo Jiménez de Quesada was pursuing his conquest of the interior of Colombia when his men located emerald deposits in an area then called Somondoco and later named Chivor. Subsequently, emerald deposits were also found at Muzo, with its even larger (and, many consider, finer) crystals. The Spaniards quickly enslaved the local tribes and forced them to work the mines, as they had done elsewhere (Keller, 1981). Many emeralds, both set in jewelry and as rough crystals (figure 1), were subsequently sent to Spain.

Spain set up a sophisticated system of delivery and pick-up to and from the New World and Asia using fleets of cargo vessels guarded by warships (Lyon, 1982; Mathewson, 1987). On September 4, 1622, the cargo vessels and galleons of the *Tierra Firme* fleet set sail from Havana, Cuba, carrying many noblemen and their families, as well as soldiers, slaves, and priests. Besides the personal effects of the passengers, the cargo of the heavily armed rear galleon *Nuestra Señora de Atocha* included 901 silver bars, 161 gold bars or disks, and about 255,000 silver coins (Lyon, 1976), along with copper ingots and, although not entered into its manifest, emeralds. Soon after leaving port, a

Figure 1. These rough emeralds and emerald-set and gold jewelry, found in the main body of the wrecked 17th-century Spanish warship Nuestra Señora de Atocha, *are the subject of this investigation. Photo by Shane F. McClure.*

ferocious hurricane ravaged the convoy; the *Atocha* and another galleon, the *Santa Margarita*, also heavy with cargo, were two of eight ships dashed against the reefs of the Florida Keys (figure 2). Over the next few years, Spanish salvors enlisted the help of local native pearl divers, with their rudimentary diving techniques, to search for the ships and recover their cargo (Christie's, 1988); they had some success with the *Santa Margarita*, but very little with the *Atocha* (Lyon, 1976, 1982). In all, only 380 silver ingots, 67,000 silver coins, and eight bronze cannons were recovered (Mathewson, 1986). Eventually, the remains of the ships were swept farther out to sea and forgotten.

MODERN RECOVERY OF THE TREASURES

In the early 1960s, almost 350 years after the sinking of the galleons, treasure hunter Mel Fisher and a group of collaborators arrived in Florida determined to find Spanish shipwrecks in the seas off the peninsula. After considerable success with other recoveries, the group decided in the late 1960s to search for the *Atocha* and the *Santa Margarita*. R. Duncan Mathewson, the operation's archaeologist, detailed the recovery efforts extensively in his book, *Treasure of the Atocha* (1987).

While studying the history of Spanish Florida in Spain's Archives of the Indies, Dr. Eugene Lyon came across Francisco Nuñez Melián's 17th-century account of the salvage of the *Santa Margarita* (Lyon, 1976). This document specified that the ships had gone down near the *Cayos del Marquez* (Keys of the Marquis), a group of islands situated between Key West and Dry Tortugas. Recovery efforts started in earnest.

In June 1971, divers found the anchor of the *Atocha* and a lead musketball (Lyon, 1976, 1982). Days later, professional underwater photographer Don Kincaid discovered a gold chain 8½ feet (259 cm) long. Not until 1973, however, did the Fisher group recover any significant treasure: approximately 4,000 silver coins and other objects (including swords, some gold coins, and a rare navigation instrument known as an astrolabe) found in an area called the "Bank of Spain" (Mathewson, 1986). They still did not know if they had found either the *Atocha* or the *Santa Margarita*; only when they encountered the main hulls and compared their contents with those listed in the ships' manifests would they be able to establish proof of the source.

In July 1975, Fisher's son Dirk found five cannons very near the "Bank of Spain"; later, the crew found four more cannons close to the first group. Some of these bore recognizable marks, which matched those indicated in the *Atocha's* documents. Only a few days later, though, diving came to a tragic halt after Dirk, his wife, and another member of the crew perished when their vessel sank.

The search eventually resumed and a variety of artifacts were recovered over the next five years, but not the actual hulls with the bulk of the cargo. "Mailboxes" (huge metal conduits designed by Fisher to pump clear water to the bottom of the ocean to increase visibility and remove sand from the wreck site) aided their efforts. Finally, in June 1980, the searchers located six silver ingots, copper ingots, and thousands of silver coins surrounded by ballast and shipwreck debris. From the manifest, the crew determined that they had found the hull of the *Santa Margarita*. During the next two years they recovered 43 gold chains with a total length of 180 feet and a concentration of gold bars worth an estimated $40 million (Mathewson, 1987). Yet the treasures of the *Atocha* remained elusive.

In 1985, however, two divers came across what they thought was a coral reef; it turned out to be silver bars and coins. Then they noticed the wooden beams in the area: They had finally found the main hull of the *Atocha*. The searchers eventually brought up seven chests filled with 2,000 silver pieces each and an eighth filled with gold bars (Starr et al., 1985). An added bonus, not on the manifest, were hundreds of rough emeralds—over 2,300 according to a 1986 article in the *Los Angeles Times*.

Many gold artifacts and jewels set with gems, including emeralds, also were found in the wreck (figure 3). One emerald ring, an engraved piece that still retains part of the black enameling in the shank, was sold at Christie's New York in June 1988 for $79,200. Many of the emeralds and other artifacts are on exhibit at the museum of the Mel Fisher Maritime Heritage Society in Key West, Florida.

THE EMERALDS AND GOLD TREASURES STUDIED

Several of the items recovered from the *Atocha* were recently submitted to the GIA Gem Trade Laboratory for examination. These included (again, see figure 1): seven rough emerald crystals

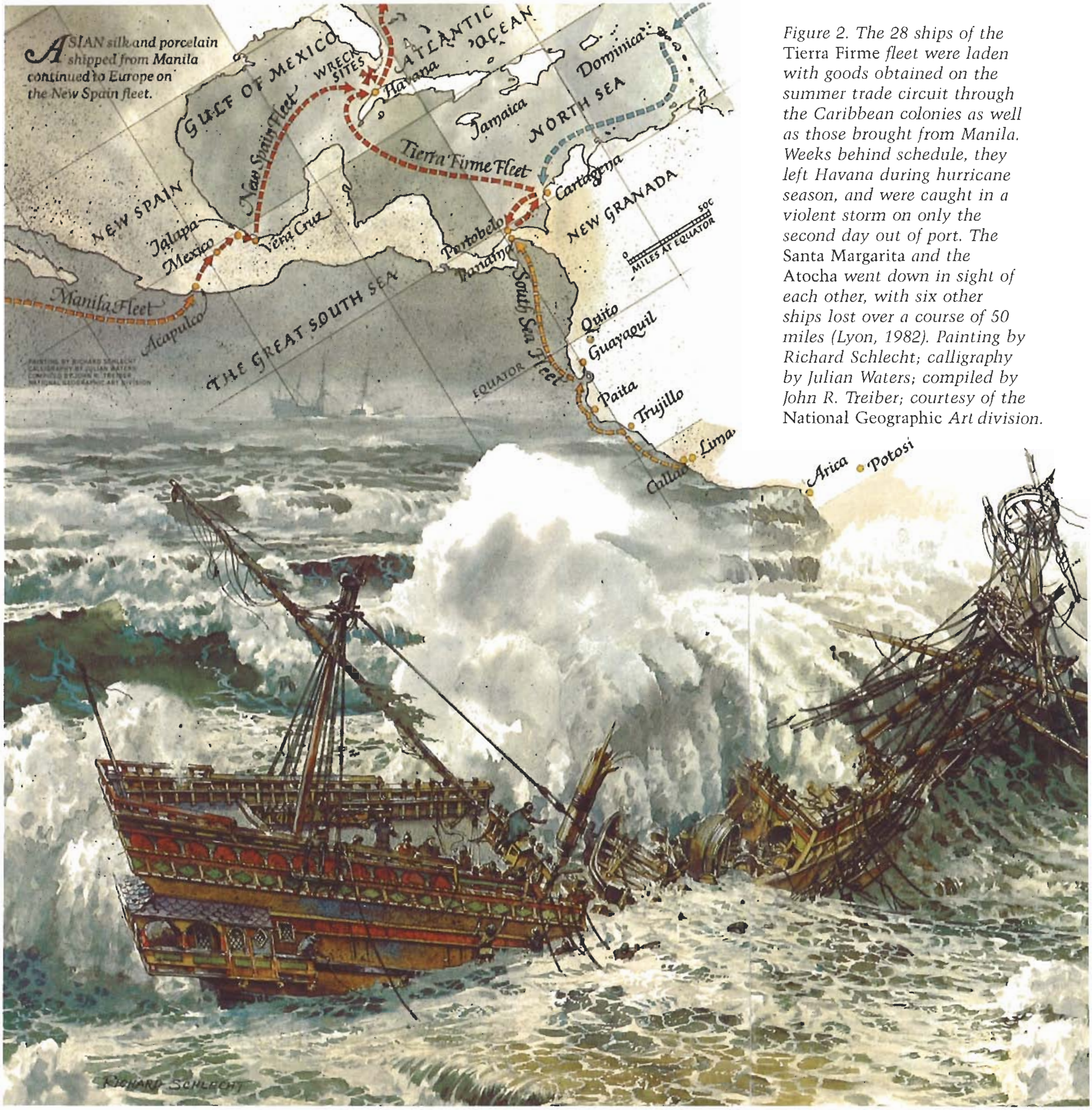

Figure 2. The 28 ships of the Tierra Firme *fleet were laden with goods obtained on the summer trade circuit through the Caribbean colonies as well as those brought from Manila. Weeks behind schedule, they left Havana during hurricane season, and were caught in a violent storm on only the second day out of port. The* Santa Margarita *and the* Atocha *went down in sight of each other, with six other ships lost over a course of 50 miles (Lyon, 1982). Painting by Richard Schlecht; calligraphy by Julian Waters; compiled by John R. Treiber; courtesy of the* National Geographic *Art division.*

ranging from 3.69 to 64.46 ct; one gold rosary and crucifix set with nine cabochon emeralds (the largest is an 8.9-mm round cabochon); two gold rings each set with a single emerald (6.7 × 7.3 mm and 8.6 × 8.9 mm, respectively); one gold brooch set with a large (9.9 × 14.9 mm) rectangular step-cut emerald; and one gold chain. Also examined was an engraved gold spoon with minor remaining inlay (figure 4).

GEMOLOGICAL DESCRIPTION OF THE EMERALDS

A gemological investigation of all the emeralds, both rough and fashioned, was carried out in order

Figure 3. The crucifix depicted on the cover of this issue and in figure 1 was recovered by divers in 1986, approximately 100 feet (35 m) from the main wreck site of the Atocha. *Photo © Don Kincaid.*

to document the properties of these historically significant stones as well as to determine if there was any evidence of their long submersion in the sea.

Visual Appearance. The seven emerald crystals ranged from transparent to translucent and from medium to dark tones of green to slightly bluish green (figure 5). We observed scattered white patches on the surfaces of most of the crystals; these were especially prominent on the 30.34-ct and 64.46-ct pieces.

The crystals were all first-order hexagonal prisms, the most common form of beryl crystallization (Sinkankas, 1981). Five were terminated at one end with pinacoidal faces; one displayed pinacoidal terminations at both ends, with only a small broken surface where it had been attached to the matrix; and one exhibited only hexagonal prism faces, with both ends broken.

Most of the emeralds set in jewelry, with the exception of two cabochons suspended from the crucifix, were bezel set in closed-back mountings, limiting visual examination. The two square stepcut stones mounted in gold rings were both moderately included, with one a medium green and the other a medium-dark green. The nine cabochons set in the crucifix were very well matched for color and transparency: medium to medium-dark green and lightly to moderately included. Six of these cabochons had small polished concave surfaces on their exposed areas.

The largest faceted stone (9.9×14.9 mm) was set in a brooch (figure 6). The stone revealed no inclusions to the unaided eye and appeared to be very dark green (almost black) with virtually no brilliance. The reasons for the exceptional darkness and lack of internal reflection were discovered during the microscopic examination (see below).

Refractive Indices and Birefringence. We obtained R.I.'s using a Duplex II refractometer in conjunction with white light for the rough crystals and the cabochons and a sodium-equivalent light source for the faceted stones. Because of irregularities on the unpolished surfaces, including surface etching, we could only obtain a very vague shadow reading of 1.58 on the seven crystals. Clearer spot readings of 1.57 or 1.58 were obtained on all nine of the cabochons set in the crucifix. The faceted emerald in the brooch and the larger ring-set emerald were determined to have refractive indices of $\epsilon = 1.570$ and $\omega = 1.578$, with a birefringence of 0.008. The faceted stone in the other ring read slightly higher, $\epsilon = 1.572$ and $\omega = 1.580$. These refractive indices are consistent with those reported in the literature for emeralds originating in Colombia (Sinkankas, 1981). While the birefringence determined for the three faceted stones is higher than that reported for Colombian emeralds, in the authors' experience this value is in fact quite common for stones from this country. Although birefringence could not be determined on the rough crystals or the cabochons, their doubly refractive nature was confirmed with a polariscope and/or dichroscope.

Figure 4. These emerald crystals from the Atocha *are sitting in a large gold spoon that was also among the items recovered from the galleon. The ornate handle still shows remnants of some type of inlay. Photo by Shane F. McClure.*

Pleochroism. Using a calcite dichroscope, we observed dichroism in strongly distinct colors of bluish green parallel to the c-axis and yellowish green perpendicular to the c-axis in all seven crystals. These results are typical of many natural emeralds (Webster, 1983).

Chelsea Filter Reaction. When viewed through a Chelsea filter, all seven crystals displayed a spectacular saturated dark red, a reaction consistent with that described in the literature for Colombian emeralds (Webster, 1983). The mounted emeralds exhibited a red reaction of varying intensity.

Figure 5. The seven emerald crystals examined (3.69–64.46 ct) ranged from transparent to translucent and from green to slightly bluish green. The chain surrounding the crystals is one of many from the Atocha *wreck site. It has been suggested that the chains were worn as jewelry to try to escape taxation; individual links could be removed and used as coinage (Lyon, 1982). Note the draw lines on the links, evidence of the relatively crude technique used. Photo by Shane F. McClure.*

Figure 6. This brooch contained the largest faceted stone examined, measuring 9.9 × 14.9 mm. The dark appearance of this otherwise fine emerald is caused by the combination of a relatively shallow pavilion, seawater trapped in the setting, and corroded remnants of the backing. Photo by Shane F. McClure.

Absorption Spectra. The visible-light absorption spectra of the seven crystals, examined with a Beck prism spectroscope, appeared to be essentially the same as those for emeralds described by Liddicoat (1989, p. 135). When looking down the optic axis direction, we observed a vague general absorption from 400 nm to approximately 480 nm, a sharp line at 477 nm, a broad band of absorption between 580 and 615 nm, and lines in the red at 637, 646, 662, 680, and 683 nm. We observed a similar spectrum perpendicular to the optic axis, but the sharp line at 477 nm was absent. The saturated color and thickness of some of the crystals caused a very strong dark, nearly black absorption in many areas of the visible-light spectrum, which tended to mask the 477-nm line even when the spectrum was viewed parallel to the c-axis.

The same basic absorption pattern, although weaker, was observed in all of the mounted emeralds. Limitations imposed by the mountings made it impossible to examine the stones both parallel and perpendicular to the c-axis. Using a polarizing filter, however, we did observe the 477-nm line associated with the ordinary ray.

Reaction to Ultraviolet Radiation. The crystals themselves appeared inert to long-wave U.V. radiation. However, there was an extremely weak to moderate chalky yellow-green fluorescence in some surface-reaching fractures and cavities. All but one of the crystals had a similar, but much weaker, reaction to short-wave U.V. The exception, the largest crystal (64.46 ct), fluoresced an extremely weak, patchy orange, possibly due to the presence of carbonaceous inclusions. Looking down the c-axis of all of the crystals while they were exposed to long-wave U.V. radiation, we also noted that the weak fluorescence seemed to be confined to less than 1 mm of the periphery of the crystals.

All of the fashioned stones were essentially inert to both long- and short-wave U.V radiation, although a few exhibited a very weak chalky yellow-green fluorescence to long-wave U.V. in small surface-reaching fractures. Furthermore, the large faceted emerald in the pendant appeared to fluoresce a weak chalky yellow-green from within, rather than from irregularities in the exposed surfaces.

The chalky yellow-green fluorescence in some of the fractures was surprising, since it is usually associated with emeralds that have had surface-breaking fractures oiled to make them less apparent. Microscopic examination showed that there was no liquid of any kind in most of the fractures. While two of the rough crystals did exhibit some form of liquid in a few fractures (figure 7), subse-

Figure 7. This fracture system in one of the emerald crystals contained a liquid that did not react like the oils commonly used to treat emeralds today. Photomicrograph by John I. Koivula; darkfield illumination, magnified 10×.

quent testing indicated that it was not an oil like those commonly used to treat emeralds. Specifically, when a thermal reaction tester (hot point), was applied the liquid flowed more rapidly within the fractures than do the typical oils. The liquid also did not "sweat out" of the fractures and bead up on the surface, as will oils used in emerald treatment; it did "sweat out" but most of it then quickly evaporated.

It is possibile that the fluorescence reaction was caused by the residue from an oil that had seeped out and/or had been flushed out by the action of water during the approximately 350 years the pieces sat on the ocean floor. Another alternative is that the crystals were stored in oil after recovery. Or the reaction might be due to something naturally present in the seawater environment. A number of additional observations supported this last theory.

According to expedition diver R. D. LeClaire, a number of the emeralds that appeared very transparent when found underwater and when first brought to the surface subsequently became much less transparent. This observation would be consistent with water-filled fractures drying out on extended exposure to air. In addition, as mentioned above, the weak chalky yellow-green fluorescence of the brooch-set emerald appeared to come from within and not from the exposed upper surfaces. Microscopic examination (covered in more detail below) revealed a liquid (seawater?) trapped beneath the emerald within the bezel setting. Examination of this stone with magnification and while exposed to long-wave U.V. radiation revealed that this trapped liquid fluoresced a chalky yellow-green; the fluorescence could actually be made to "flow" as the pendant was rocked back and forth, allowing the gas bubble to move.

The authors feel that the chalky yellow-green fluorescence exhibited in areas of some of the emeralds is probably due to some fine precipitate of seawater that has entered surface breaks.

Luminescence to Visible Light. Some gems appear red when illuminated with intense transmitted light. This reaction is typical of many chromium-colored materials, including various synthetic emeralds. It is also seen, infrequently, in some natural emeralds, such as fine-quality stones from Chivor and some medium- to light-toned emeralds from another Colombian locality, Gachalá (Kane and Liddicoat, 1985). Of the study group, only the faceted stone in the brooch exhibited a red transmission luminescence; the reaction was very strong.

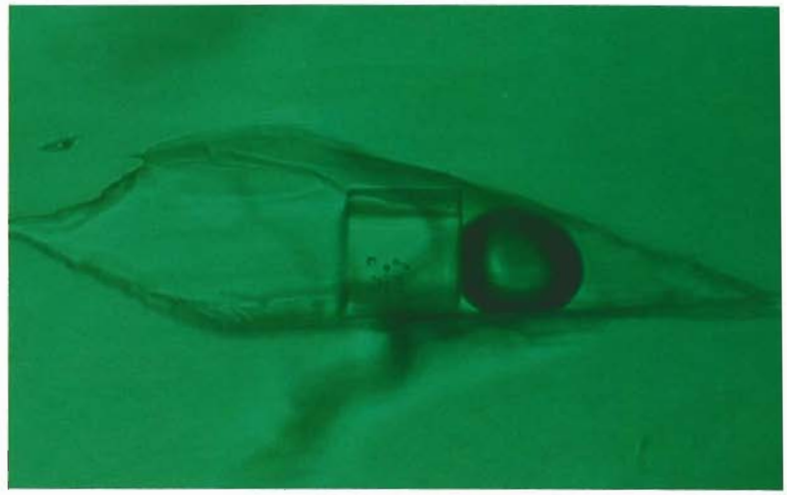

Figure 8. High magnification (200×) revealed minute fluid inclusions in the solid phase of this three-phase inclusion in one of the Atocha *emeralds. Photomicrograph by John I. Koivula; transmitted light.*

Specific Gravity. Using a Mettler AM100 electronic scale equipped with the appropriate attachments, we made at least three hydrostatic weighings for each of the crystals. Specific gravity values of 2.67 to 2.71 were determined. We attributed the relatively low values for several of the crystals to bubbles trapped in large surface-breaking cavities as well as to gaseous phases in multi-phase fluid inclusions within these stones (see the Microscopic Examination section below). Significant quantities of trapped gaseous inclusions can decrease specific gravity in emeralds just as, for example, pyrite inclusions (S.G. 4.95 to 5.10) can significantly increase it. The S.G. range determined is consistent with that reported in the literature for Colombian emeralds (Sinkankas, 1981).

Microscopic Examination. All of the emeralds exhibited classic three-phase inclusions of the type associated with Colombian localities. These inclusions ranged from less than 0.1 mm to slightly over 1 mm in the long direction. All had a jagged outline and contained a gas bubble and one or more cubic crystals (figure 8). In addition, all were oriented parallel to the prism faces, indicating that they were primary (i.e., they did not result from the

Figure 9. Dolomite crystals were exposed on the fracture surface of this 15.12-ct Atocha *emerald crystal. Photomicrograph by Robert E. Kane; oblique illumination, magnified 10×.*

Figure 10. Surface etching was noted on all of the emerald crystals examined. Photomicrograph by John I. Koivula; oblique illumination, magnified 6×.

healing of fractures). In some instances, relatively high magnification (200×) revealed primary fluid inclusions within the solid phases of the three-phase inclusions (again, see figure 8).

Several translucent crystals were exposed on a fracture surface of the 15.12-ct crystal (figure 9). These were first tested with a minute drop of dilute (10%) hydrochloric acid solution which produced an effervescence characteristic of carbonate minerals. X-ray diffraction analysis showed an exact match with dolomite.

All of the rough crystals showed surface etching (figure 10). Some, most notably the two largest, showed a considerable amount of what appeared to be very deep etching on the prism faces. Microscopy revealed that this was caused by superficial etching that had broken into near-surface fluid inclusions which apparently subsequently drained. Even on those faces that appeared relatively smooth to the unaided eye, magnification revealed very fine etch figures. Emerald, like other hydrothermally grown natural crystals, frequently shows surface etching caused by dissolution (Sinkankas, 1981).

One of the most interesting discoveries during the microscopic examination was the cause of the very dark, dull appearance of the faceted brooch-set emerald. We knew that the relatively shallow pavilion would create a "window" effect, the result of unplanned light leakage, that would seriously diminish brilliance. However, closer examination revealed that the fairly large space between the pavilion facets of the stone and the back of the mounting contained a liquid (thought to be seawater) that had probably been forced in by the pressure exerted on the piece during burial at sea over three and a half centuries. This liquid, which contained a large movable air bubble (figure 11), caused a partial immersion effect that undoubtedly contributed significantly to the stone's lack of brilliance. Finally, what appeared to be the remains of a reflective backing were trapped in the space and floated about as the liquid was agitated. The authors speculate that this backing may have been silver that corroded over time, further contributing to the dark appearance of the emerald.

SOME OBSERVATIONS ON THE GOLD WORK

Most of the jewelry we examined appeared to be cast, except for the two chains and some components of the brooch and rosary. The casting process was probably an early form of the modern-day lost-wax casting technique, which uses a wax carving encased in a thick, porous clay mixed with coarsely ground charcoal (Mitchell, 1985). Al-

Figure 11. Close examination of the brooch revealed liquid and a large gas bubble between the pavilion facets of the emerald and the back of the bezel setting. The black residue trapped between the emerald and the mounting in the pendant may have been the remains of a silver coating on either the pavilion facets of the stone or on the inner surface of the bezel itself. Slight movement of the brooch caused the bubble and the residue to move freely. Photomicrograph by Robert E. Kane; oblique illumination, magnified 10×.

though sand casting (i.e., casting from a negative impression made in sand; Hayward, 1976) was also popular in Europe at this time, the detail on the jewelry examined makes it unlikely that this coarser technique was used.

The metal was soft and appeared to be of high karat gold. Thornton Mann, of the GIA Jewelry Manufacturing Arts Department, performed an acid test on a portion of the rosary and determined it to be slightly less than 24K. All of the pieces were a deep yellow color except for one gold chain (46 in. long, 15.8 troy oz.) that was slightly greener and less saturated. XRF analysis of this piece by the GIA Research Department determined the primary elements to be gold, platinum, silver, and titanium, with trace amounts of iron and copper. As would be expected of a chain from this era, the surface of the metal was very uneven, with features characteristic of a rudimentary drawing process (see figure 5).

The emerald brooch was a particularly fine example of New World goldsmithing (figure 6). The bezel setting was burnished with such accuracy that the stone was held by pressure applied at the girdle, with very little metal actually extending onto the crown; in fact, at one corner a small portion of the upper girdle plane was exposed, with the gold bezel firmly against the girdle edge. The metal folded onto the crown was burnished to a paper thin edge for a perfectly flush seal. This was carried out with such precision that magnification revealed tiny gold remnants pressed into shallow abrasions in the emerald where the bezel and facet met, leaving the metal at a relief no higher than that of the facet. The plate on the back of the emerald was initially held in place by a series of raised pegs that were subsequently soldered for a more permanent seal. A pair of square arches had also been soldered to opposite sides of the backing, probably so that the piece could be used with a pin.

The rosary necklace presented an intriguing mystery: All of the beads were missing, with only a series of opposing bell caps remaining (figure 1). Although one theory is that the beads might have been pearls (M. Fisher, pers. comm., 1989), this is unlikely given the relatively large size of the spaces and the fact that no remnants remained. Although badly corroded, recognizable pearls were recovered from the wreckage of the *Atocha* (Mathewson, 1987). It is more likely that these were wooden beads, which were commonly used in rosaries, and which would have deteriorated rapidly in seawater (D. Kincaid, pers. comm., 1989).

The emerald-set crucifix hanging from the necklace was ornately carved. It is typical of those worn by high church officials and European nobility during this era (Muller, 1972). The several bezels were actually cast as a single piece, not as individual bezels soldered together. They were firmly attached to the main body of the crucifix by several raised metal pegs, with no solder present.

The gold spoon (11.3 cm long, 1.91 troy oz.) consisted of a large basin and an intricately carved handle (figure 4). These were held together by only two crimped pegs; again, no solder was used. The pegs appear to have worn with time, so that there is now movement between the two pieces and the joint is very fragile.

Both the back of the crucifix and the handle and back of the spoon were intricately engraved (figure 12), with deep figures and channels that were rough in texture, typical of engraving used for enameling (C. Weber, pers. comm., 1989). David Callaghan, of the Gemmological Association of Great Britain, suggested to the authors that niello, another material also popular during this period,

Figure 12. Note the intricate engraving on the back of the spoon and the crucifix. The rough nature of the engraving suggests that it was all inlaid at one time. Photo by Shane F. McClure.

may have been used instead of enamel. Niello is an opaque dark gray to black metallic mixture of sulphur, silver, copper, and lead that is ground into small grains, not powdered; enamel is a semi-transparent to opaque glass of varying composition that is ground to a fine powder (Ashbee, 1967). Both materials are applied and finished by similar techniques. The delicate artistry on the back of the cross suggests that enameling was probably used here to better display the engraver's workmanship while adding color to the intricate scenes depicted. Channels on the handle of the spoon, however, still contained severely etched, slightly granular remains of what could have been the coarser niello. The crudeness of the engraving on the back of the spoon basin suggests the use of either niello or a more opaque enamel, although the subject matter – birds – is more compatible with colors possible only with enamel.

SUMMARY

The gemological properties of the emeralds examined for this article are consistent with those reported in the literature and noted in the experience of the authors for emeralds from Colombia. Some features could be attributed to the immersion of the stones in seawater for an extended period of time.

The jewelry represents superb craftsmanship, using several techniques popular in the early 17th-century. These include early forms of lost-wax casting and chain drawing, as well as examples of stone setting and engraving that rival any seen today.

REFERENCES

Ashbee C.R., Transl. (1967) *The Treatises of Benvenuto Cellini on Goldsmithing and Sculpture.* Dover Publications, New York.

Christie's (1988) *Gold and Silver of the* Atocha *and the* Santa Margarita (catalog). Auction June 14–15, 1988, New York, NY.

Hayward J.F. (1976) *Virtuoso Goldsmiths.* Rizzoli International Publications and Sotheby Parke Bernet Publications, New Jersey and New York.

Jones J., Ed. (1985) *The Art of Precolumbian Gold: The Jan Mitchell Collection.* Little, Brown & Co., Boston.

Kane R.E., Liddicoat R.T. Jr. (1985) The Biron hydrothermal synthetic emerald. *Gems & Gemology,* Vol. 21, No. 3, pp. 156–170.

Keller P.C. (1981) Emeralds from Colombia. *Gems & Gemology,* Vol. 17, No. 2, pp. 80–92.

Liddicoat R.T. (1989) *Handbook of Gem Identification,* 12th ed., 2nd revised printing. Gemological Institute of America, Santa Monica, CA.

Lyon E. (1976) The trouble with treasure. *National Geographic,* Vol. 149, No. 6, pp. 786–809.

Lyon E. (1982) Treasure from the ghost galleon. *National Geographic,* Vol. 161, No. 2, pp. 228–243.

Mathewson R.D. III (1986) *Treasure of the Atocha.* Pisces Books, New York, NY.

Muller P.E. (1972) *Jewels in Spain, 1500–1800.* Hispanic Society of America, New York.

Sinkankas J. (1981) *Emerald and Other Beryls.* Chilton Book Co., Radnor, PA.

Starr M., Morequ R., Friday C. (1985) Treasure hunt: Wrecks to riches. *Newsweek,* August 5, pp. 18–20, 23.

Webster R. (1983) *Gems, Their Sources, Descriptions and Identification,* 4th ed. Butterworths, London.

2,300 emeralds salvaged from Spanish shipwreck (1986) *Los Angeles Times,* May 30.