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Gems & Gemology welcomes the submission of articles on all aspects of the field. Please see the Suggestions for Authors in the Summer 1986 issue of the journal, or contact the editor for a copy. Letters on articles published in *Gems & Gemology* and other relevant matters are also welcome.

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ABOUT THE COVER: The article by Sally A. Thomas in this issue examines the dramatic changes in the design of fine jewelry that occurred between the late 1930s and the mid-1960s. The heavy, curved "Retro" jewelry produced during World War II was replaced in the 1950s by a profusion of gems in light, flexible wire settings. During the late 1950s and early 1960s, many artists already skilled in painting or sculpture experimented in jewelry design. The gold, platinum, peridot, and diamond fantasy necklace, and the gold, peridot, and diamond ring (both c. 1965) shown here were designed by surrealist artist Salvador Dali and executed by goldsmith Charles Valliant. Photo courtesy of Sotheby's.

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THE GEMS & GEMOLOGY MOST VALUABLE ARTICLE AWARD

Alice S. Keller, Editor

For many in gemology, 1986 was a landmark year. Some of the most important technical developments and concerns of the year—if not the decade—are reflected in the winners of the *Gems & Gemology* most valuable article award.

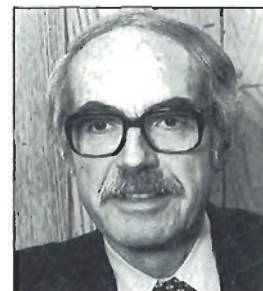
The winning article, "A Simple Procedure to Separate Natural from Synthetic Amethyst on the Basis of Twinning," by Robert Crowningshield, Cornelius Hurlbut, Jr., and C. W. Fryer, provides a practical solution to what had become a major problem in the colored-stone industry. The second-place article, "The Gemological Properties of the Sumitomo Gem-Quality Synthetic Yellow Diamonds," by James E. Shigley, Emmanuel Fritsch, Carol M. Stockton, John I. Koivula, C. W. Fryer, and Robert E. Kane, gives an in-depth examination of the first jewelry-quality synthetic diamonds to be manufactured commercially. Gemology is also, vitally, the study of the use of gems in jewelry. The award for third place goes to the beautifully illustrated "Art Nouveau: Jewels and Jewelers," by Elise B. Misiorowski and Dona M. Dirlam, which investigates one of the most fascinating and distinctive periods in jewelry history.

Cash prizes of \$500, \$300, and \$100, respectively, will be shared by the authors of the first-, second-, and third-place winners. Brief biographies of the winning authors appear below and on the following page.

We also wish to take this opportunity to thank the many people who participated in the voting this year. Your comments indicated that it was not always easy to choose. One reader simply voted for three entire issues. Others commented that "all articles are first class" (we agree). And another insisted that we acknowledge the importance of the Gem Trade Lab Notes, Gem News, Abstracts, and Book Reviews sections (we do!). Our thanks also go to the many authors, section contributors, and editorial review board members who put thousands of hours into making the 1986 issues of *Gems & Gemology* among our best ever.

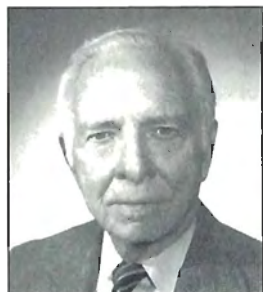
Robert Crowningshield

Currently vice-president of the GIA eastern headquarters in New York City, Bob Crowningshield has been with the GIA Gem Trade Laboratory since 1947, and is considered one of the world's leading authorities on gem identification. A native of Colorado Springs, Colorado, Mr. Crowningshield has a degree in natural science from San Diego State College and is a fellow with distinction of the Gemmological Association of Great Britain as well as a graduate gemologist.



Cornelius Hurlbut, Jr.

Dr. Hurlbut's career includes more than 50 years in the Department of Mineralogy at Harvard University (11 as chairman), where he is currently professor emeritus of mineralogy. A prolific writer, he has edited the 15th through 20th editions of *Dana's Manual of Mineralogy* and is coauthor of a college textbook on gemology. A native of Springfield, Massachusetts, Dr. Hurlbut received his doctorate from Harvard University.



C. W. Fryer

Director of gem identification for the GIA Gem Trade Laboratory, and editor of the Gem Trade Lab Notes section of *Gems & Gemology*, Chuck Fryer has more than 20 years of experience in gem identification. He is also a noted writer and lecturer on gemological instruments and identification techniques. A native of St. Louis, Missouri, Mr. Fryer is a graduate gemologist and a fellow of the Gemmological Association of Great Britain.



James E. Shigley • Emmanuel Fritsch • Carol M. Stockton • John I. Koivula • C. W. Fryer • Robert E. Kane

Dr. Shigley, who received his doctorate in geology from Stanford University, is director of GIA's Research Department. He has written several articles on gem minerals, and is currently directing research on the identification of natural, synthetic, and treated gems. A research scientist at GIA, **Dr. Fritsch** has a Ph.D. in spectroscopy from the University of Paris. He has done considerable research on the origin of color in gemstones. **Ms. Stockton** is senior research gemologist in the GIA Research Department, and has written extensively for *Gems & Gemology*. In addition to her G.G., she holds a B.A. in anthropology from the University of California, Los Angeles.

Senior gemologist in GIA's Research Department, **John Koivula** is world renowned for his expertise in inclusions and photomicrography. A graduate gemologist, Mr. Koivula also holds a fellowship diploma from the Gemmological Association of Great Britain and bachelors degrees in chemistry and mineralogy from Eastern Washington State University. **C. W. Fryer's** biography appears above. **Mr. Kane**, a graduate gemologist and native of Albuquerque, New Mexico, is staff gemologist in gem identification at the GIA Gem Trade Laboratory, Los Angeles. He is also actively involved in researching treated and synthetic gems, and has written and lectured extensively on these subjects.



l. to r.: John Koivula, Robert E. Kane, James E. Shigley, Carol M. Stockton, C. W. Fryer, Emmanuel Fritsch



Elise B. Misiorowski

Ms. Misiorowski's art history major at Knox College evolved into an avid interest in jewelry history. Currently research librarian at GIA, Ms. Misiorowski is also Book Reviews editor for *Gems & Gemology*. A native of New Canaan, Connecticut, she is a graduate gemologist and has a number of years of experience working in the GIA Gem Trade Laboratory.

Dona M. Dirlam

Now senior research librarian at GIA, Ms. Dirlam taught earth science for 10 years after she received her M.S. in geology/geophysics from the University of Wisconsin—Madison. In addition to her work expanding and updating the GIA library, she serves as editor of the Gemological Abstracts section and the Annual Index of *Gems & Gemology*. Ms. Dirlam, who is originally from Redwood Falls, Minnesota, is a graduate gemologist and holds a fellowship diploma from the Gemmological Association of Great Britain.



“MODERN” JEWELRY: RETRO TO ABSTRACT

By Sally A. Thomas

The period between the onset of World War II and the mid-1960s saw the development of several styles in fine jewelry. During the 1940s, Retro jewelry retained Art Deco's bold lines but gradually softened its colors and curved its sharp geometric shapes. These heavy settings were eventually replaced by fine, hand-made wire settings which produced flexible, three-dimensional jewelry shaped by the gemstones themselves. The designers and neo-Renaissance artists of the 1950s created colorful jewels overflowing with faceted gems as well as beads, cabochons, or rough-tumbled stones. In the late 1950s and early 1960s, gemstones became subordinate to the flow and shape of the overall design during a revival in individual craftsmanship that is still evident in contemporary jewelry.

ABOUT THE AUTHOR

Ms. Thomas is a writer and editor for the Gemological Institute of America in Santa Monica.

Acknowledgments: The author would like to thank the following people for supplying many insights and useful information for this article: A. H. Fisher, J. Jonas, N. Letson, R. T. Liddicoat, B. Merritt, F. Rich, and J. Samuel. D. Beasley of The Worshipful Company of Goldsmiths, C. Elkins of Sotheby's-Beverly Hills, M. Kellaher of Verdura, L. Krashes of Harry Winston, Inc., J. Landers of Tiffany & Co., W. Rösli of Gübelin, Harold & Erica Van Pelt—Photographers, and B. Wasserman of Sotheby's-New York were very helpful in securing photos. Special thanks go to Dona Dirlam and Elise Misiorowski for their comments and encouragement. Ruth Patchick did a wonderful job typing the manuscript.

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The roughly 30 years between the onset of World War II and the early 1960s were dynamic ones in jewelry design. Art Deco, which was the predominant style of jewelry in the 1920s and early 1930s, was a backlash against the disillusionment following the first world war. Deco jewelry was weighty, bold, and exotically geometric, a bonding of art and industry (Ebert, 1983). By the late 1930s, however, Deco had begun to alter into a softer, more voluptuous style that has recently been loosely classified as Retro (figure 1). Created primarily in France, Italy, and the United States during the lean war years, Retro jewelry used what precious metals (for the most part gold) and gemstones were available during and immediately after the war.

As was the case following the first world war, people in the late 1940s and early 1950s were hungry for luxury and opulence, which prompted a revolution in the design of fine jewelry. Light, hand-made wire settings enabled jewelers to create flexible, three-dimensional pieces that shimmered with cascades of fine diamonds, rubies, sapphires, and emeralds.

During the mid-1950s, artists already skilled in painting and sculpture began to take an active role in jewelry design. Many new or improved methods to work gold had evolved during the war; at the same time, new quantities of gems such as citrine, tourmaline, amethyst, and aquamarine became available on the market. These neo-Renaissance artists—applying their design talents in many different areas, like their counterparts centuries earlier in Europe—used these materials to create colorful, exotic pieces that appealed to a burgeoning upper middle class seeking both quality and stylish creativity in their jewelry.

The demand for creativity in design also propelled individualized craftsmanship in the late 1950s and early 1960s. Eventually, fewer gemstones were used, as the emphasis in design shifted from the materials to the design itself.

This article, then, traces the evolution of jewelry design from Retro, the most recently defined period, to the beginning of contemporary jewelry design in the early 1960s.

JEWELRY OF THE 1940S: THE INFLUENCE OF WAR

World War II, with the destruction and privation that it brought to much of Europe and Asia, greatly affected the design and production of jewelry. In Europe especially, metal, jewels, and craftsmen were consumed by the war. Many jewelry firms were forced underground, disbanded, or even destroyed. And many pieces made during this time were broken up after the war to finance reconstruction efforts. In addition, during the 1960s some jewelers had their 1940s gold jewelry florentined (a texturing process whereby parallel lines are closely engraved in one direction and then cross-hatched at 90° with parallel lines more lightly engraved) to make it more salable (J. Samuel, pers. comm., 1987). This is why, until recently, many jewelry historians have overlooked the decade surrounding World War II, believing it was little more than a buffer between the bold geometric jewelry of Art Deco and the luxurious flexible pieces of the 1950s.

Only within the past several years has interest in this "lost" period been piqued. During the past decade, jewelry from the 1940s began to appear in prestigious auction houses. François Curiel, head of the jewelry department at Christie's New York office, is credited as having been the first, in the early 1970s, to categorize jewelry from this period under the term *Retro*. He chose this word because it was, like much of the jewelry it described, reminiscent of Art Deco, and it would be easily recognized by the public (N. Letson, pers. comm., 1987). The identification of a recognizable style initiated research and reevaluation of the jewelry produced during the years surrounding the second world war.

Retro Jewelry: The Materials and the Style. Retro jewelry evolved directly out of Art Deco, which had waned by the early to mid-1930s (again, see figure 1). Pieces became much heavier and more curved, as jewelers consolidated gold and gemstones into easily transported items of jewelry (Gabardi, 1982). Whereas Deco jewelry was usually flat and one dimensional, early Retro jewelry

had a chunky, sculptural quality, accompanied by raised rectangles, domes, and baroque scrolls set with bands of gemstones.

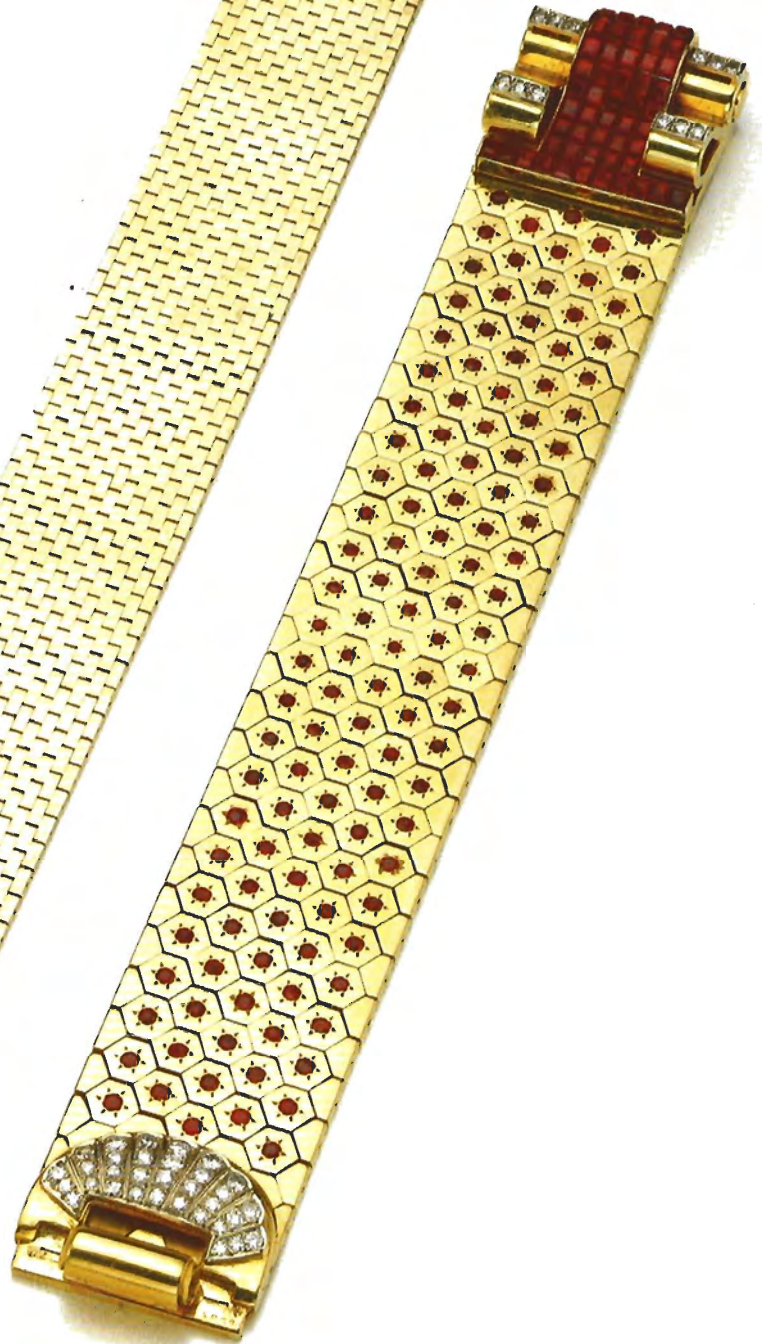
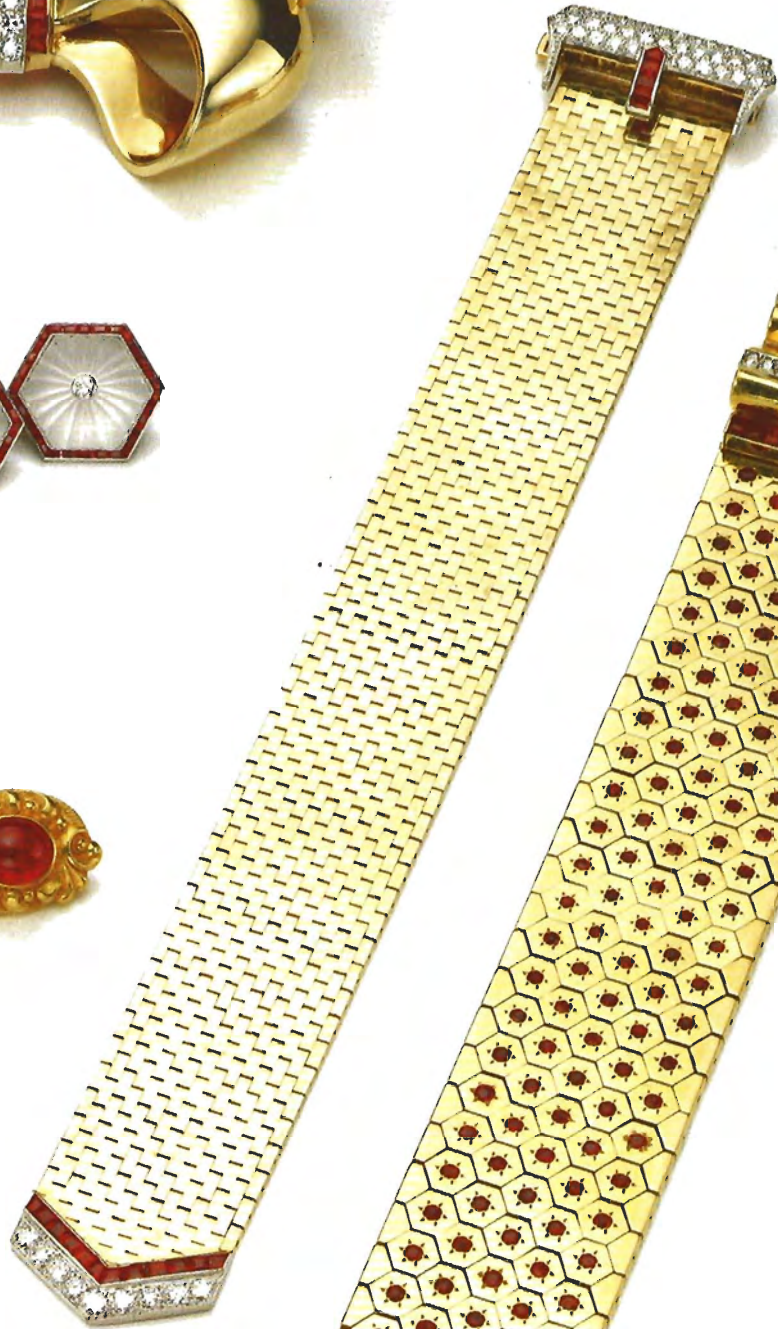
Because the war cut off most of the usual gemstone supplies, Retro jewelry was fashioned almost exclusively from gems and metals in stock when the war broke out. Diamonds were abundant, usually in small and medium sizes and cut in calibre, round, or baguette shapes. Like Deco, some Retro jewelry also used vibrant colored stones such as rubies (and synthetic rubies), sapphires, and emeralds. However, as it grew away from Deco, Retro jewelry started to use different color combinations. For example, in 1939 Louis Cartier produced jewelry that combined orange and brown gems (Sindt, 1987), initiating the use of less vividly colored stones such as topaz, citrine, green beryl, and aquamarine (figure 2). In Retro jewelry, citrines and aquamarines were often paired with rubies.

The war also had a dramatic impact on the type of metal used for jewelry. Platinum, the most popular metal of the 1920s and early 1930s, was commandeered for war-time manufacturing. Thus, most Retro jewelry was set with gold. It was often used as smooth or fluted sections, pierced strips, or wires interwoven in lattice and grid meshes (Gabardi, 1982). After the war, warm, soft shades of pink, green, white, and yellow gold were created with copper and silver alloys. Many pieces combined several different shades of gold together (N. Letson, pers. comm., 1987).

Although early Retro jewelry retained much of Deco's geometric lines, pieces produced near the end of the 1940s took on a distinctly floral style. Sprays or bunches of diamonds burst forth, loosely bound with flowing scrolls, plaques, twists, and spirals of diamond baguettes. Many of the finer diamonds in these pieces had been part of the Spanish crown jewels, which were broken up and the stones placed on the market in the early 1940s.

Figure 1. These jewels represent three distinct periods in jewelry design. The cabochon ruby cufflinks (manufactured around the turn of the century) are late Victorian, and the ruby, rock crystal and diamond cufflinks (1930) are typical Art Deco. Note how the gold, ruby, and diamond bow and bracelets (all are c. 1940), which are characteristic of the early Retro style, combine the softness and the geometry of the other two styles. Photo courtesy of Sotheby's.





A number of these diamonds were purchased by American dealers, who often had the old-mine stones recut into modern styles by European cutters who had fled the war (A. H. Fisher, pers. comm., 1987).

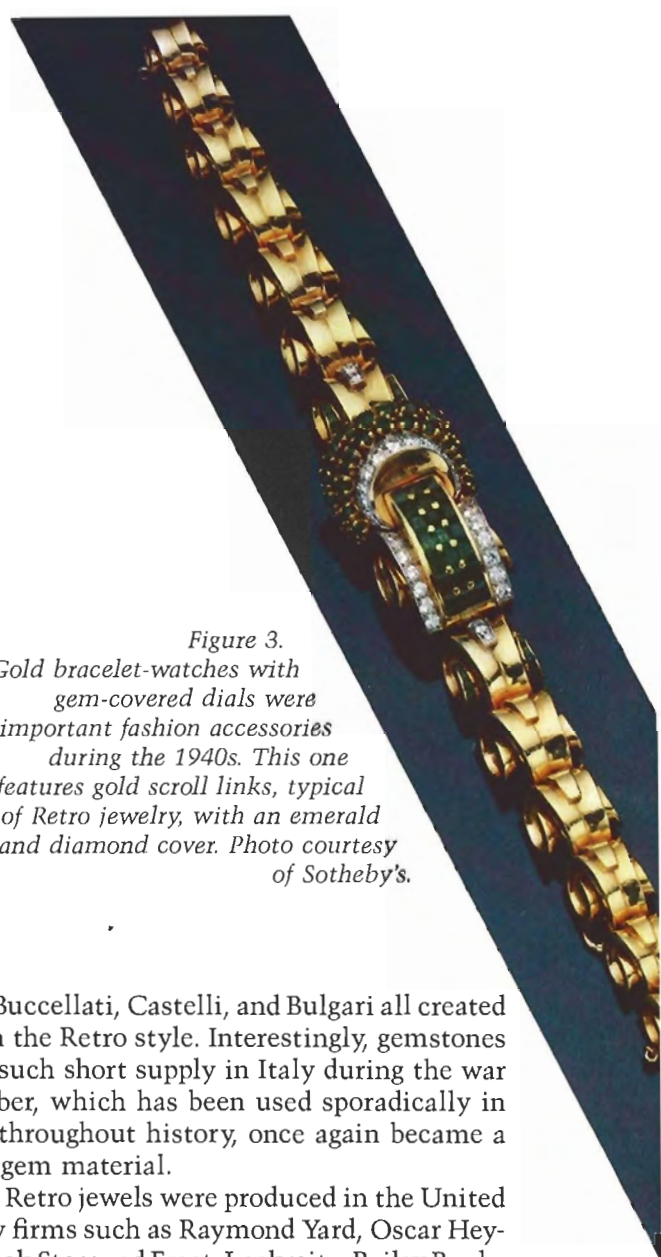
Retro jewelry originated in France, spread throughout Europe, and emigrated to the United States with the outbreak of the war. For example, the French firm of Van Cleef & Arpels produced a collection of jewelry for exhibit at the 1939 World's Fair in New York, but when the war broke out, the pieces remained in New York and served to influence U.S. designers. Van Cleef and Arpels jewels were particularly known for their *bouquets de fleurs* style. Ribbon-like bracelets consisted of hexagonal links that were centered on flowery clusters of fine gemstones and fastened with heavy clasps containing gems set *en suite* with the band (Gabardi, 1982).

Much of the war-time jewelry produced by Cartier was in the "animalier" style. Many kinds of animals, such as birds, dogs, cats, and horses, were created by individual Cartier craftsmen. These miniature golden figures were studded with a variety of fine-colored gems and often brightly enameled—a gay, rebellious style against the advancing war. Cartier mastermind Jeanne Toussaint designed two symbolic pieces, *L'oiseau en cage* and *L'oiseau libre* (the bird in the cage and the free bird), in mute defiance of the German occupation. Other French firms such as Boucheron, Chaumet, Lacluche Frères, Fouquet, and Mauboussin, as well as the closely linked Belgian firms of Wolfers, Leysen Frères, Altenloh, and Sturbelle, all produced fine Retro jewelry during and after the war.

Italian jewelry of this period tended to adopt the French forms, motifs, and materials. Firms

Figure 2. This assortment of jewels illustrates many of the characteristics that are distinctive of the Retro style. The ruby and diamond bangle bracelet (c. 1940) shows the curved lines of Retro but with the sharply contrasting white and red that are often associated with Art Deco. The citrine and diamond brooch by Cartier (c. 1940) and the green beryl, sapphire, and diamond ring (1940) demonstrate the trend toward tawny-colored gems during this period. Gold "snake" chains, like those in the gold and emerald Van Cleef & Arpels wristwatch (1940) shown here, were also popular in the 1940s, as were animal figures such as the ruby, emerald, and diamond owl brooch. Photo courtesy of Sotheby's.

Figure 3. Gold bracelet-watches with gem-covered dials were important fashion accessories during the 1940s. This one features gold scroll links, typical of Retro jewelry, with an emerald and diamond cover. Photo courtesy of Sotheby's.



such as Buccellati, Castelli, and Bulgari all created pieces in the Retro style. Interestingly, gemstones were in such short supply in Italy during the war that amber, which has been used sporadically in jewelry throughout history, once again became a popular gem material.

Fine Retro jewels were produced in the United States by firms such as Raymond Yard, Oscar Heyman, Black Starr and Frost, Lackreitz, Bailey Banks & Biddle, Seaman Shepps, Shreve & Co., William Russer, and John Rubel. Traubert and Hoeffler created a jewelry line called *Reflection* for Mauboussin in New York. In addition, Forstner Chains of Rhode Island became known for their snake-like gold chains, which were often seen in conjunction with American jewelry of the 1940s (F. Rich, pers. comm., 1987; again, see figure 2).

Retro Fashion. The dramatic change that occurred in women's fashion during the 1940s greatly affected Retro jewelry. The sleek, elegant fashions of the Deco period were suddenly replaced by severely tailored jackets, with lapels and padded shoulders, that were worn with narrow skirts.

The single most important item of jewelry during this time was without a doubt the clip. Popular in the 1930s, clips of the Retro period served to soften and feminize the starker clothing

of the 1940s. Two clips worn together often served as a brooch or a pendant to a neckline. Separately, they adorned jacket lapels or served as hair ornaments.

Bracelets were commonly made of heavy gold bands, often thickly set with precious stones. It was during this period that "tank-tread" style bracelets appeared, bracelets formed of chains of angular links simulating the tracks of armored cars (Gabardi, 1982). Swiss jewelers of this period produced *montres* bracelets, wrist watches that were actually heavy gold bracelets with small dials that were commonly concealed under jeweled covers (see figure 3).

Brooches were enormously popular, especially as executed in heavy, flowing gold bows (figure 1) or sprays of flowers. Necklaces and rings also followed the basic Retro style.

Retro jewelry was born and nurtured out of World War II. As French jeweler Jean Mauboussin observed: "The jewellery of the Forties was the jewellery of an age of crisis, so it was only logical that it should come to an end with the crisis itself" (Gabardi, 1982). However, although the war ended in 1945, it would take several years for manufacturing jewelers, particularly those in Europe, to recover from its effects. Thus, Retro jewelry appeared in the early postwar years as well, until it was gradually replaced by the multitude of styles that came to the forefront during the late 1940s and early 1950s.

POSTWAR TRENDS: CLASSIC TO AVANT GARDE

Since jewelry historians have only just begun to recognize and define the jewelry of the 1940s, it is not surprising that the jewelry of the ensuing decade has not yet been given a specific name. Not only do we lack the benefit of historical perspective, but this period is also difficult to pinpoint because of the surge of diversity in jewelry design that began in the late 1940s and has, in fact, continued to the present. We can, however, identify certain important trends during this period—in the gemstones, types of settings, and designs—that give it a distinctive character.

Gemstones at the Forefront. As the world left the war behind, wealth was redistributed to a rapidly growing upper middle class, which was hungry for luxury and eager to display its prosperity. Consequently, the most striking characteristic of the

jewelry of the late 1940s and the 1950s was an almost ostentatious use of gemstones.

The fascination with gemstones was propelled by the numerous discoveries of new gem sources that occurred both during and right after the war. In their search for large quantities of minerals and metals to support the machinery of war, many countries looked to South America for electronic-grade mica, feldspar, quartz, and lithium minerals. During the prospecting for these minerals, several hundred gemstone mines were discovered in Brazil alone (Proctor, 1984). These prodigious discoveries launched the subsequent interest in and popularity of Brazilian gems such as citrine, topaz, kunzite, and chrysoberyl. Aquamarine and amethyst were also extremely popular and were often set together, accented with diamonds (N. Letson, pers. comm., 1987). Tourmaline, particularly rubellite, experienced an increase in popularity (R. Liddicoat, pers. comm., 1987). In fact, literally tons of gem-quality tourmaline crystals were discovered by American miners intent on recovering mica from deposits in the Governador Valadares district of Minas Gerais, Brazil (Proctor, 1985).

Although faceted stones were extremely popular at this time, beads, cabochons, and rough-tumbled gems also experienced a revival. They were often mounted in independent prong settings to create a smooth continuous band, or jumbled together in a riot of color. Rubies, sapphires, and emeralds, as well as coral and turquoise, were favorite stones of firms such as Boucheron, Bulgari, and Van Cleef & Arpels. According to Baerwald and Mahoney (1949), during this time peridot was "rapidly becoming one of the most popular gemstones for modern pieces." And, indeed, peridot was commonly seen in jewelry of the 1950s.

Also following the war, diamonds were brought to the attention of consumers at all income levels by De Beers, who in 1948 coined the now-classic phrase "a diamond is forever" (Nadelhoffer, 1984). In 1954, De Beers instituted the annual Diamonds International Awards to encourage the use of diamonds in both daytime and evening jewelry and to advance diamond jewelry design (Scarlsbrick, 1981).

Flexible Settings. The growing demand for conspicuous luxury was eloquently expressed in the new flexible jewelry pioneered by Harry Winston of New York. The heavy settings characteristic of Retro jewelry had some sense of dimension, but a



Figure 4. Light, hand-made wire settings enabled Harry Winston to create supple jewelry—here, 142 ct of diamonds set in platinum—that was shaped entirely by the gemstones themselves. Courtesy of Harry Winston, Inc.

ponderous amount of metal still dominated the gemstones. Winston spent a lifetime accumulating fine diamonds, as well as rubies, sapphires, emeralds, and pearls. To him, fine gemstones were the essence of jewelry, meant to be displayed in elegant but undeniably unobtrusive settings (Krashes, 1984).

Innovative fabrication methods were needed to accomplish the lightness and dimension Winston desired. His inspiration for this new method occurred one Christmas as World War II drew to a close. Arriving home one evening, Winston noticed how

the leaves of the holly wreath on his front door gave the wreath shape and dimension. It suddenly struck him that perhaps gemstones could be made to shape jewelry, and at once he set craftsmen to the task. What resulted was a revolutionary way of setting and designing jewelry: fine, hand-made, flexible wire settings of platinum or gold (figure 4). Independent prong setting allowed Winston's famous diamonds and colored stones to shape jewelry that was light, dimensional, and so flexible that bracelets could be "crumpled like a sweater and not one stone will touch another" (Krashes, 1984).



Figure 5. During the 1950s, gemstones could not be too large or too lavish. Created in 1951 by Harry Winston for Mrs. I. W. Killam of Canada, these five pear-shaped diamonds (ranging from 14 to 20 ct) drop gracefully from a river of round and baguette diamonds (62 ct total). Illustration by A. V. Shinde; courtesy of Harry Winston, Inc.

Winston's earrings were shimmering cascades of diamonds falling from larger and often detachable bases suitable for daytime wear. Perhaps the most sumptuous pieces are his necklaces: brilliant, supple rivers of large diamonds (figure 5) and fine colored stones that lie softly against the contours of the neck and throat. This style proved enormously popular with wealthy, conservative cli-

ents, and remains a hallmark of Winston jewelry. This method of setting jewelry was adopted by other large firms such as Tiffany and Van Cleef & Arpels and established an important trend in jewelry design.

Legendary Designers. The nouveau riche of the 1950s wanted color, creativity, and individuality in their jewelry — pieces to express the vitality of the times. Two jewelry designers of this period created pieces that capture the essence of 1950s style: Jean Schlumberger (1908–) and Fulco, Duke of Verdura (1898–1978).

Jean Schlumberger (“berger” pronounced as in Fabergé) is famous for both his jeweled objects and his jewelry (Hoving, 1982). Born in France, he

Figure 6. Fanciful and prickly, this “Sea Bird” was designed in the 1950s for Tiffany & Co. by Jean Schlumberger. The body is made from diamonds pavé set in platinum, with gold scales and crests, a ruby eye, a black enamel beak, and a blue enamel collar. Photo courtesy of Tiffany & Co.





Figure 7. Schlumberger also designed this sinuous "Leaves" necklace, created from diamonds pavé set in 18K gold. Photo courtesy of Tiffany & Co.

emigrated to the United States during World War II and set up a small shop on Fifth Avenue. In 1955, his business was absorbed into Tiffany and he entered his prime as a jewelry designer. He created lavish pieces to suit the individual tastes of his wealthy American customers. As he commented in a recent interview, "To create these splendid baubles, I become almost a psychoanalyst. When a new client comes in, I must determine her taste, her way of life, her likes and dislikes, her superstitions, her physical characteristics, and the sense she has of her appearance. You see, I must know the physical environment in which my jewel will live" (Hoving, 1982).

Schlumberger produced numerous imaginative pieces: angels, sea horses, birds, flowers, and star fish (figures 6 and 7). Many were set in prickly

spines of gold amid a profusion of faceted jewels. He is also credited with reviving enameling in jewelry (figure 8). Schlumberger's famous Pegasus pin combines emeralds and amethysts with gold and sparks of diamonds, endowing the legendary winged horse with flight and fire. He also created a whimsical setting for the 100-ct Dancing Girl sapphire by centering this magnificent stone in a spikey gold sunflower "growing" out of an ordinary clay pot taken from his client's greenhouse. After this piece, Schlumberger went on to design a series of jeweled boxes and other objects valued by Tiffany between \$200,000 and \$500,000 (Hoving, 1982). Although he closed his studio in the late 1970s, his designs are still being interpreted and executed by Angelo Polisenio, Schlumberger's chief jeweler at Tiffany.



Figure 8. Known as "The Classics," Jean Schlumberger's vivid enameled bracelets and earrings studded with 18K gold were almost a necessity for fashionable, upper-class women in the 1950s. Photo courtesy of Tiffany & Co.

Fulco Santostefano della Cerda, Duke of Verdura, was another innovative jewelry designer of the 1950s and early 1960s. Born into a noble Sicilian family in 1898, Verdura's talent for drawing was evident at an early age. In 1927, he became a textile designer for Chanel in Paris. His creations were so original that within a short time he became Chanel's head jewelry designer. In 1937 and 1938, he designed jewelry for Paul Flato in New York and then in California, and in 1939 he set up his own business at Cartier's original headquarters on Fifth Avenue. Despite the war, his jewels quickly became popular, and were purchased by such personalities as Cole Porter, Baron Nicolas de Gunzburg, and opera star Lily Pons.

Verdura's pieces, many of which originally sold for less than \$1,000, show a more subtle, rounded elegance that was also characteristic of the 1950s. Verdura believed that jewelry should enhance, not overwhelm, the wearer. Favorite motifs included ropes and knots of gold and diamonds, caning, coins, and tassels similar to those in the papal coat of arms (figure 9). He also liked to design pieces based on nature: feathers, wings, ferns, and leaves. Verdura's exquisitely executed jeweled sea shells

were fashioned from colorful scallop shells skillfully set with thin gold rims and small diamonds and cabochons of coral or turquoise (figure 10). A versatile designer, he could create a delicate "fairy queen's tiara" of branched pink coral set with tiny diamonds, and at the same time produce an abstract set of large baroque pearl links and studs inset with round brilliant diamonds.

In 1970, Verdura retired to London and sold his business to his associate Joseph C. Alfano. In 1985, Alfano turned the business over to Ward Landrigan, who continues to execute Verdura's original designs. Verdura's jewelry influenced both his contemporaries, such as David Webb (figure 11), and later designers such as Margaret Styx, Angela Cummings, and Paloma Picasso (Letson, 1983).

NEO-RENAISSANCE IN JEWELRY

An important development in jewelry design occurred in the late 1950s and early 1960s with the emergence of neo-Renaissance artists. Like Cellini, Botticelli, and de Luca of the Italian Renaissance, these artists were already skilled in painting and/or sculpture when they began to experiment with jewelry design. Few of these modern artists



Figure 9. Tassels were popular with the Duke of Verdura, and were often seen in his designs. Here they appear in gold and diamonds, setting off a necklace of tumbled peridot, a gemstone that was particularly popular during the 1950s. The matching pearl with diamond earrings were also designed by Verdura. Photo courtesy of E. J. Landrigan Inc./VERDURA.



Figure 10. Verdura's sensitivity to natural beauty is evident in this scallop shell set with turquoise and diamonds. Photo courtesy of E. J. Landrigan Inc./VERDURA.

had the technical skills needed to actually manufacture their creations, yet they were responsible for introducing concurrent art movements such as cubism and surrealism into modern jewelry design, generating a trend that has heavily influenced contemporary jewelry.

There is a small group of artists who designed only a handful of pieces: Calder, Giacometti, Cocteau, Ernst, Arp, Man Ray, Tanguy, de Chirico, and Dubuffet (Black, 1974). However, two neo-Renaissance artists did produce impressive collections of jewels, and contributed greatly to the advancement of jewelry design: Georges Braque (1882–1963) and Salvador Dali (1904–).

Georges Braque was a French painter and designer who, together with the famous painter and sculptor Pablo Picasso, pioneered cubism in the early 1920s (Hughes, 1963). In contrast to the single artistic viewpoint characteristic of Renaissance art, cubism involved multiple angles of vision and the simultaneous presentation of discontinuous planes.

The culmination of Braque's work in jewelry design occurred in 1963 when, at age 81, he exhibited 133 jewels executed by Baron Henri-Michel Heger de Lowenfeld at the Musée des Arts Décoratifs in Paris. Most of these jewels portrayed themes taken from classic mythology and inter-

preted with Braque's cubist vision (figure 12). Many of the forms are similar: textured gold over thin slabs of stone such as jasper, rhodochrosite, lapis lazuli, grossularite, and turquoise. Some pieces also used masses of pavé diamonds to complement areas of textured gold.

Salvador Dali, the celebrated surrealist Spanish painter, wholly believed in the Renaissance concepts of an artist's versatility and integrity of design. As he commented in *Dali, A Study of His Art-In-Jewelry* (Dali, 1959):

Paladin of a new Renaissance, I too refuse to be confined. My art encompasses physics, mathematics, architecture, nuclear science—the psycho-nuclear, the mystico-nuclear—and jewelry—not paint alone.

My jewels are a protest against emphasis upon the cost of the materials of jewelry. My object is to show the jeweler's art in true perspective—where the design and craftsmanship are to be valued above the material worth of the gems, as in Renaissance times.

Although he was influenced by Picasso in the late 1920s, Dali was much more closely associated with the surrealist art movement, a revolution against traditional representational art. The surrealists portrayed fantasy and images from the subconscious mind, founded for the most part on Freud's methods of psychological investigation. Thus, much of Dali's jewelry has a dream-like, if not nightmarish quality. Many of his pieces are anthropomorphic: An anemone swirls its petals of human arms formed from pavé diamonds and gold in an unseen wind; a honeycomb heart of gold with rubies and diamonds drips a golden drop of honey (figure 13); an oak leaf is startlingly transmuted into a gnarled hand with ruby cabochon fingertips; two rows of lustrous white pearls beckon from a pair of sensual, yet vaguely sinister, ruby lips.

Dali's religious convictions are embodied in his crosses. Many show a cubist influence and convey an explosive divine power with sharp needles of diamonds radiating from shattered or disjointed golden crucifixes. One of his medallions presents the world as a misshapen sphere, ruby blood oozing from deep cracks, pierced together with an arrow that Dali says represents the healing power of Christ (Dali, 1959).

INDIVIDUALISM PREVAILS: THE EARLY 1960S

The jewelry designed by artists such as Dali and Braque helped to close the gap between the main-



Figure 11. Jewelry designer David Webb was influenced by Verdura's designs and, like Verdura, many of his pieces used beads or rough-tumbled gemstones (often in conjunction with faceted material). This necklace of baroque rubies and pavé diamonds set in gold, with a 27.5-ct ruby pendant, also shows the geometric lines that were distinctive of Art Deco. The ring, another David Webb piece, contains a 32.5-ct ruby. Photo courtesy of Sotheby's.

stream art world and the applied art of jewelry design. As mentioned previously, most of these artists merely designed the pieces, leaving their interpretation and execution to highly skilled metalsmiths. However, the 1950s and early 1960s witnessed a revival of individual craftsmanship,

and the reemergence of artisans who possessed the talent to design, manufacture, and market their jewelry.

In the United States, one woman is credited with almost singlehandedly reviving the crafts: Mrs. Eileen Vanderbilt Webb (Black, 1974). Webb



Figure 12. By French artist Georges Braque, this brooch of turquoise, textured gold, and pavé-set diamonds portrays the bird Memnon flying away from the walls of Babylon. Photo courtesy of The Worshipful Company of Goldsmiths, London.

strove to establish a school in the U.S. that, initially, would train World War II veterans in the American (primarily Appalachian) crafts, including jewelry fabrication (B. Merritt, pers. comm.,

Figure 13. The famous surrealist painter Salvador Dali also designed a collection of jewels, including this "Honeycomb Heart" with rubies and diamonds set in gold. Photo courtesy of Sotheby's.



1987). In 1952 she founded the School for American Craftsmen in Alfred, New York (now part of the Rochester Institute of Technology), and in 1955 she founded the Museum of Contemporary Crafts in New York City. Shortly thereafter, Webb implemented America House in New York, a retail gallery and shop open to any qualified craftsmen. Backed by these institutions, the American craft movement grew quickly and eventually influenced many talented artisans and jewelers such as Irena Brynner, Ronald Pierson, Art Smith, and Stanley Lexon.

The surge of craftsmen into jewelry was also evident in Europe, particularly in Great Britain. Graham Hughes, former artistic director of The Worshipful Company of Goldsmiths, has been particularly instrumental in promoting the crafts movement. In 1962, in association with the Victoria and Albert Museum, he helped assemble 1,067 jewels from 28 countries. The exhibits were selected on the basis of originality of design and artistic merit rather than monetary value. Thus, "the most precious diamond jewels in existence shared the showcases with intrinsically worthless pieces of extraordinary beauty" (Hughes, 1963).

The basic trend of this period, then, was one of freedom and diversity unbound by any single rigid standard of taste or fashion. The concept that jewelry need not be dominated by expensive, large stones to have value and merit encouraged individual craftsmen (and women) of the early 1960s to pour their energy into individualistic, nonrepresentational pieces (figure 14). In general, gemstones became subordinate to the flow and texture of the overall design. Many pieces, particularly those from Switzerland (figure 15) and Scandinavia, revolved entirely around the cool, smooth, abstract lightness of gold or silver.

During this time, many artists turned to creating *objets trouvés*, the "found objects" that owe their shape to chance or the work of nature (Hinks, 1983). British artist John Donald was one of the first to attempt to mount high-quality gem crystals into rings, pendants, or pins. Through arduous experimentation, he discovered methods that enabled him to set the specimens without damaging or even destroying their sometimes fragile beauty (Hinks, 1983). Artisans such as Georg Jensen, David Thomas, Desmond Clen Murphy, and Gilbert Albert also produced some stunning natural crystal pieces. Donald also experimented with dropping molten gold into cold water, allowing the physical reaction to naturally shape

the piece. Andrew Grima, who is most famous for his innovative watches, was also very skilled in producing *objets trouvés*, such as a delicate rosette-like brooch of diamonds set in gold cast from pencil shavings. Others successfully incorporated nongem materials, such as arrowheads, meteorites, and even small chunks of coal into beautiful, expressionistic jewelry.

SUMMARY

The 30 years from the onset of World War II to the mid-1960s witnessed dramatic changes in jewelry design. The heavy, curved jewelry of the 1940s gradually evolved into the sumptuous, gemstone-oriented jewels of the 1950s, and then expanded and grew to incorporate a multitude of textures, forms, and materials. In essence, modern jewelry has moved from periods (such as Art Nouveau, Art Deco, or even Retro) where one style predominated and was relatively easy to identify, to a multitude of styles unhampered by any one standard. The "do your own thing" credo of the 1960s artisans encouraged a new generation to embrace the values of originality and craftsmanship, and to continue to experiment with shape, form, and texture. This creative freedom has produced fine contemporary jewelry designers such as Paloma Picasso, Elsa Peretti, and Angela Cummings. In

Figure 14. Jewelry of the mid-1960s became increasingly abstract and individual, as demonstrated by this bangle-bracelet made from malachite, tiger's-eye, diamond, and rhodonite. Courtesy of Gübelin.



Figure 15. Individualism in the 1960s emphasized originality in texture and design rather than gems. Courtesy of Gübelin.

turn, their individualistic jewelry has encouraged consumers to dare to express their own tastes, whether it be meteorites in niobium or diamonds in gold.

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INFRARED SPECTROSCOPY IN GEM IDENTIFICATION

By Emmanuel Fritsch and Carol M. Stockton

Infrared spectroscopy is a powerful tool for gem identification and research. Absorptions of a gem material in the infrared region of the electromagnetic spectrum are due to vibrations in the crystal structure; they can be used to help separate one gem material from another or to detect certain types of treatments. The authors describe the new Nicolet 60SX Fourier transform infrared spectrometer recently acquired by GIA's Research Department, and outline the detection of polymer-impregnation of opal as an example of the use of infrared spectroscopy in gemology.

Infrared spectroscopy in itself is not new, having become generally available to scientists about 50 years ago. However, technological advances in instrumentation in the past 10 years have made infrared spectra much more readily and rapidly accessible. In recent years, this spectroscopy has been used in several instances by a number of gemologists (e.g., Arnould and Poirot, 1975; Zecchini, 1979); and since its arrival at the GIA Research Department in January 1986, the Nicolet 60SX Fourier transform infrared (FTIR) spectrometer (see box) has consistently proved its value in gemological applications. As a result, gemologists can expect to encounter numerous reports in the future that involve the use of infrared spectroscopy. This article is intended to introduce gemologists to the concepts, instrumentation, and terminology of infrared spectroscopy, as well as to illustrate the usefulness of this technique through several examples, in particular the distinction of natural from polymer-impregnated opals (figure 1).

INFRARED ENERGY

The infrared region of the electromagnetic spectrum is the energy range just beyond the red end of the visible spectrum. In fact, the term *infrared* is derived from being lower in energy ("infra-") than the red end. The unit by which infrared energy is usually measured is the wavenumber (number of waves per centimeter), which is expressed in reciprocal centimeters (cm^{-1}). The infrared is thus referred to as the energy range between $13,333 \text{ cm}^{-1}$ (the edge of the red) and 33 cm^{-1} (a limit determined by use and technology). Alternatively, infrared radiation can be expressed in wavelength units, traditionally the micrometer ($1 \mu\text{m} = 1,000 \text{ nm} = 10,000 \text{ \AA}$), or in another energy unit, electron volts (eV). This broad region is divided on the basis of experimental techniques and applications into three parts: near infrared, mid-infrared, and far infrared (figure 2). For most gemological purposes, infrared energy is

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Figure 1. One of these two opals (7.00 and 1.14 ct) has been treated with polymer to improve its play of color, while the other is completely natural. No traditional gemological tests can distinguish between the two and, until now, laboratory testing took hours. With the infrared techniques described in this article, however, identification can be done in a matter of minutes (see figures 6 and 8). Photo © Tino Hammid.

expressed in cm^{-1} ; energies above 400 cm^{-1} —that is, the mid-infrared and the near infrared—are of greatest interest gemologically.

APPLICATIONS OF INFRARED SPECTROSCOPY

Absorption features in the visible range are largely due to electron transitions, including those that generate color, such as occur with chromium atoms in the corundum lattice and cause the color of rubies. In the infrared, however, spectral features generally arise from vibrations (as well as, in the far infrared, from rotations) of molecular and structural components of the crystal. For example, carbon in diamond and water when present in a gemstone have characteristic signals in the infrared.

Crystal structures consist of atoms held together by chemical bonds. A possible analogy to describe these bonds is to think of them as springs connecting heavy weights such that the weights representing atoms have the ability to vibrate. Every group of atoms has a number of intrinsic vibration frequencies that correspond to rocking, stretching, or bending of the bonds between the atoms of the group (see figure 3). In order to actually vibrate, the structure must extract energy from some source, in this case a beam of incident infrared radiation, giving rise to an absorption band. This band is usually very sharp for organic

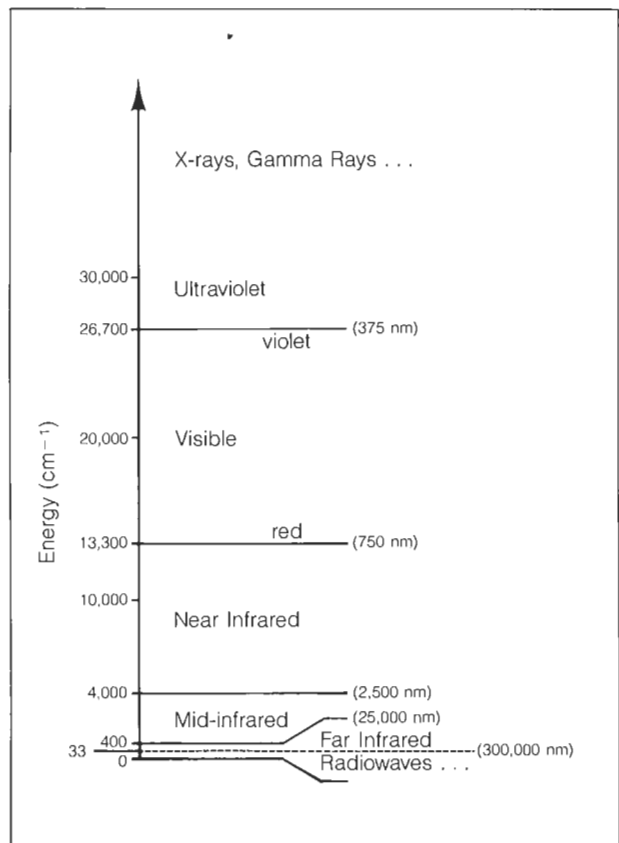


Figure 2. The position of the infrared region and its three subdivisions in the electromagnetic spectrum.

THE NICOLET 60SX FOURIER TRANSFORM INFRARED SPECTROMETER



Figure 1A. The Nicolet 60SX FTIR spectrometer. Photo courtesy of Nicolet Instrument Corp.

This spectrometer (figure 1A) is a state-of-the-art instrument capable of measuring spectra between 400 and 25,000 cm^{-1} —that is, through the entire mid- and near infrared, as well as visible, ranges.

How an Infrared Spectrometer Works. In a typical dispersive instrument, the beam is split into two parts: One goes through the sample, while the other passes through a reference. Each beam is dispersed through a prism or a grating, and the absorption at one particular wavelength is analyzed by partially ob-

structing the reference beam, until the same amount of energy goes through both beams. An FTIR spectrometer contains two parts that do not exist in classical dispersive instruments: a Michelson interferometer, which combines all the incoming infrared radiation into one "interferogram," and a mathematical program that operates on the principle of the Fourier transform, which converts an interferogram back into a spectrum. In the FTIR concept, the light is split into two halves by a semitransparent mirror (called a beamsplitter). These two beams are then

reflected back toward one another by two additional mirrors, one fixed, the other moving, so that the two beams "interfere" when they come back together at the beamsplitter, giving rise to an interferogram.

Figure 1B shows the optical path of the infrared radiation in a classical dispersive spectrometer, compared with the way the same radiation is handled through an FTIR instrument. In the Fourier transform instrument, when the moving mirror is at exactly the same distance from the beamsplitter as the fixed mirror (or the same distance plus an integer times half the wavelength), the interference is constructive (i.e., the two intensities are added together). Otherwise, the interference is destructive. With such a configuration, the further the moving mirror travels, the better two very close frequencies will be separated. In this manner, a very good resolution is obtained without cutting down the amount of energy, a problem inherent to any dispersive instrument. The interferogram then goes through the sample, and parts of the wavelengths are absorbed. The transmitted wavelengths—still in the form of an interferogram—reach the detector. The data are digitized and processed using a Fourier transform program, which (through a sequence of many steps) basically transforms the final interferogram into a transmission spectrum and eventually into an absorption spectrum.

The FTIR spectrometer has a number of important advantages over the older dispersive instrument. Because the entire spectrum is recorded at the same time in the form of an interferogram, there is no need to mechanically scan one wavelength after the other. Thus, where 20 minutes were needed in the past to obtain a spectrum using a dispersive instrument, only a fraction of a second is required on an FTIR spectrometer. This allows the operator to run 100 or even 1,000 spectra of the same sample in a very short time and then average the results in order to reduce the random "noise" and bring out weak bands that often contain essential information. There is also reduced heating of the sample, in contrast with dispersive instruments, and the consequent spectral perturbations are largely avoided.

In addition, the FTIR concept uses a laser both to check the moving mirror displacements and as an internal reference for wavelength, another feature that is not found on the dispersive spectrometer.

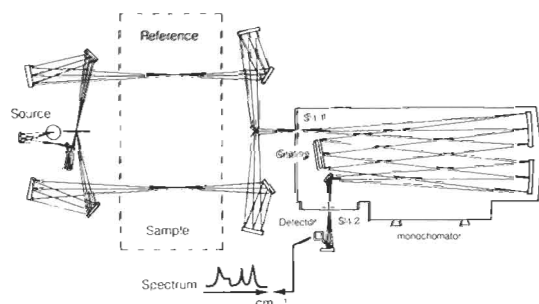
A further advantage is that the Nicolet 60SX spectrometer is monitored by a powerful computer that not only does the mathematics of the Fourier transform, but also provides considerable flexibility to plot, display, store, and manipulate spectra. Basically, then, an FTIR spectrometer is both faster and more accurate than a dispersive instrument.

How Spectra Are Obtained from Gemstones. A transparent gemstone is usually cut in such a way that light returns to the eye, creating the brilliance and fire of the gem. The problem in spectroscopy is exactly the reverse: How do we get light to pass through the stone and emerge on the other side? Several sample holder "attachments" are available on an FTIR spectrometer to achieve this purpose.

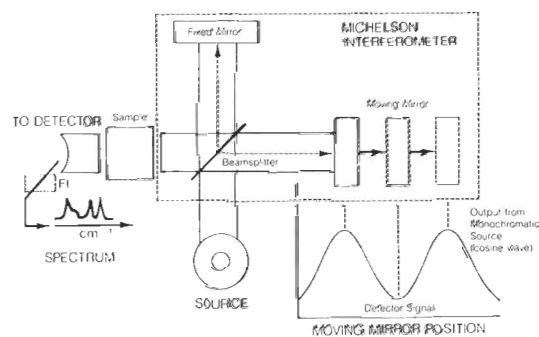
The most useful adapter is probably the micro-beam chamber, where a curved mirror focuses the beam down to an area the size of a pinhead, or smaller. This intense, focused beam can then be passed with relative ease through a very tiny culet or the girdle of a stone to obtain a spectrum.

For nontransparent materials, such as jade and turquoise, the diffuse reflectance attachment provides satisfactory spectra, with the beam of energy barely penetrating the surface of the sample, "bouncing" off, and then being collected by a curved mirror before passing to the detector.

Figure 1B. Comparison of the principle of a dispersive infrared spectrometer with that of an FTIR instrument. The monochromator in the former is replaced by an interferometer and Fourier transform program in the latter (after Nicolet User's Manual, 1986).



Typical Dispersive Spectrometer Design



FTIR System Concept

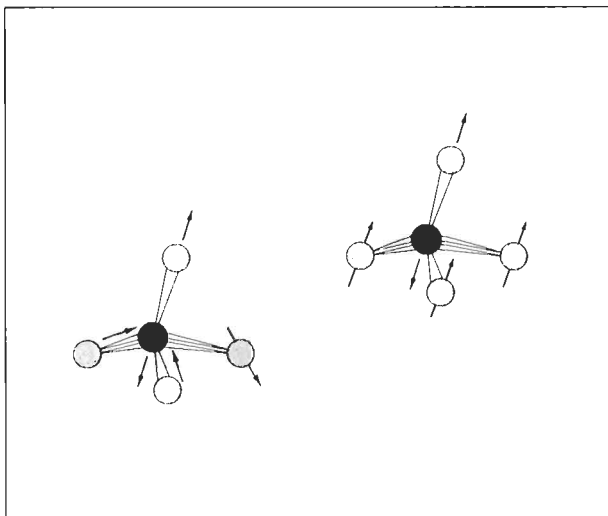


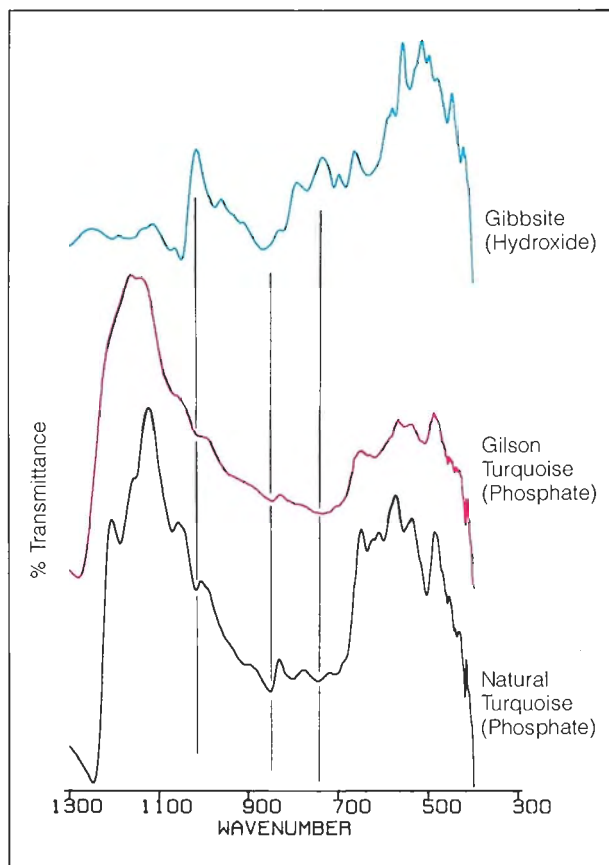
Figure 3. The vibrations of atoms in, for instance, a tetrahedral unit—such as in the SiO_4 tetrahedron of silicates and quartz illustrated here—are responsible for the absorption of infrared radiation (after Conley, 1972).

molecules (such as polyester), and infrared spectroscopy has, indeed, been most extensively developed for organic chemistry.

Gemstone Identification through Characteristic Infrared Spectra. Inorganic materials, including gemstones, also have characteristic vibrational energies in the infrared that can be used for identification. However, their spectral features are usually broader than for organic molecules. An analogy can be made with X-ray diffraction, where a pattern for a given mineral is the “fingerprint” of its atomic structure. For infrared spectroscopy, absorptions associated with the vibrations of the crystal structure (“lattice vibrations”) are characteristic of the given combination of atoms constituting the gemstone. A good example is provided by turquoise: Natural turquoise—a phosphate, $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 5\text{H}_2\text{O}$ —can be distinguished easily from one of its common substitutes, gibbsite—a hydroxide, $\text{Al}(\text{OH})_3$ —by features in the mid-infrared. Because the two materials are so different chemically, their patterns are also very different (see figure 4). Even Gilson turquoise, which is a synthetic, exhibits a significantly smoother pattern when compared with natural turquoise, because of a different state of aggregation (Arnould and Poirot, 1975; Rossman, 1981).

Detection of “Water” and Its Significance in Gemology. “Water,” either molecular (H_2O) or as hydroxyl groups (OH) is combined in various forms in many gemstones or is present as an impurity. These various forms of water have characteristic patterns in the mid-infrared and can be good indicators of structure, origin, or treatment. Preliminary results show that natural amethyst can be distinguished from its synthetic analog on the basis of slightly different types of water absorptions. Water is typically the first component to leave a mineral on heating; therefore, there is some hope that infrared spectroscopy may also be useful in identifying the absence of heat treatment in some water-containing gemstones (Aines and Rossman, 1985).

Figure 4. Gem identification with infrared spectra: Natural turquoise has a very different spectrum compared to that of gibbsite, an increasingly common substitute. Gilson man-made turquoise exhibits flattened features. For the purpose of this illustration, transmittance values are arbitrary.



Detection of Gemstone Impregnation. The extensive documentation by organic chemists of the characteristic infrared absorption spectra of organic compounds is very helpful in recognizing impregnation in gemstones. One or more sharp bands will show up in the spectrum of an impregnated stone that are not present in the spectra of similar untreated stones. A detailed example of how this is applied to impregnated opal appears below. Not only does infrared spectroscopy enable one to detect impregnation, but the additional bands can also reveal which species of polymer or other material has been used to process the stone.

Other Applications. Infrared spectroscopy reveals characteristic patterns for different types of diamonds (Ia, Ib, IIa, IIb), inasmuch as both nitrogen and boron impurities trapped in the diamond lattice have absorption features in the mid-infrared. One of the most significant gemological uses recently revealed for the near infrared is detection of the H1b and H1c bands (4941 and 5165 cm^{-1} , respectively), which identify that a diamond has been irradiated and heat treated to produce or enhance yellow to brown coloration (Woods, 1984; Woods and Collins, 1986).

THE DETECTION OF POLYMER-IMPREGNATION OF OPAL BY MEANS OF FTIR SPECTROSCOPY

The ability of infrared spectroscopy to provide information about various organics, plastics, dyes, and hydroxides makes this technique particularly useful in the study of opal, especially the detection of treatment. Until now, the only positive method of identifying polymer-impregnation of opals (including impregnation with plastics and, more recently, with silicon-based polymers) has been examination with an electron microscope (Manson, 1978), a time-consuming and expensive procedure.

The infrared spectra of opals in the 4000–9000 cm^{-1} range have been well characterized (e.g., Langer and Flörke, 1974). While the spectra of natural opals vary somewhat, all exhibit a broad transmission region between 5300 and 6800 cm^{-1} and another between 4000 and 5000 cm^{-1} . The strongest absorption features lie between 5000–5300 cm^{-1} and 6700–7200 cm^{-1} , and have been attributed to combination vibrations of molecular water (H_2O). Weaker absorptions also usually occur at about 4400 and 4500 cm^{-1} , both caused by

vibrations of SiOH groups, as well as at 5500 cm^{-1} (figure 5).

We examined 15 natural, untreated opals by FTIR spectroscopy and found that all displayed infrared spectra consistent with the above general pattern. These samples (figure 6) include Australian white, gray, and black opal; Brazilian white and hydrophane opal; and (from various localities) blue, brown, orange, and transparent colorless opal with play of color, red-orange and yellow non-phenomenal transparent opal, and green chrysopal ("prase opal"). Variations among their spectral features (figure 7) are related to differences in microstructure, hydroxyl content, and organic impurities.

We also examined 23 polymer-impregnated opals by FTIR spectroscopy (figure 8). They include opals treated as long as 10 years ago as well as stones treated within the last two years; some of these can be detected by electron microscopy and some cannot. White, black, brown, blue, and orange background colors are represented.

Without exception, the impregnated opals exhibit absorption features in the infrared that have

Figure 5. The near-infrared spectrum of a natural, untreated white opal from Australia. Absorption features characteristic of opal are labeled.

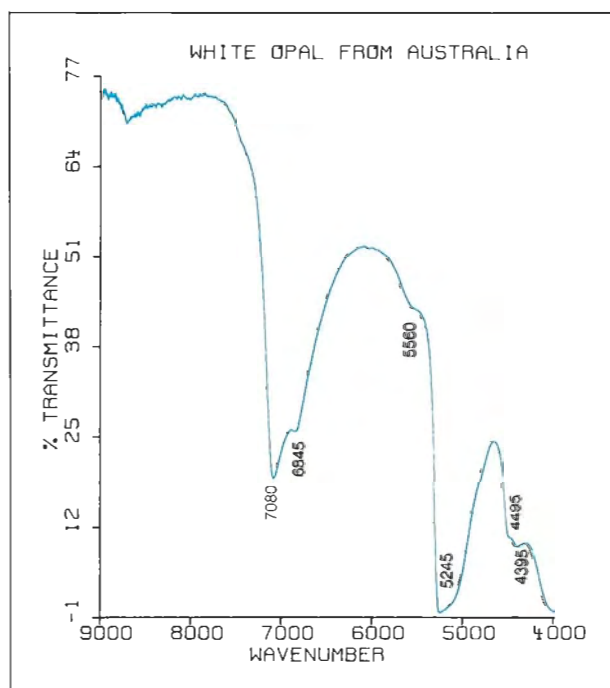
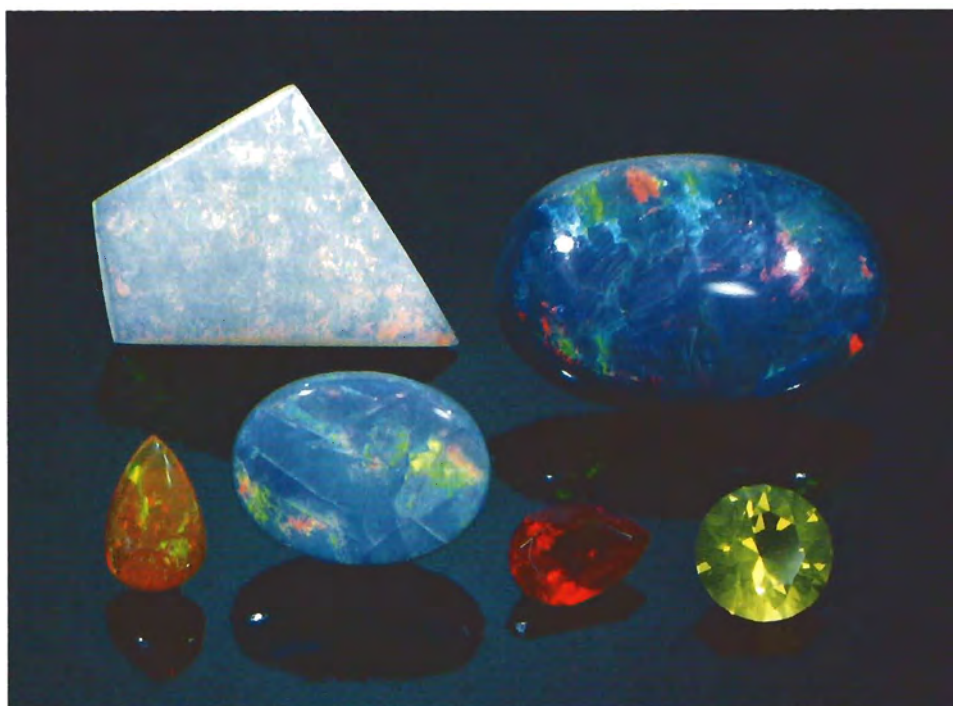


Figure 6. Several of the natural, untreated opals (0.88–14.79 ct) examined for this study, including material from Australia, Brazil, Mexico, and Idaho. Photo © Tino Hammid.

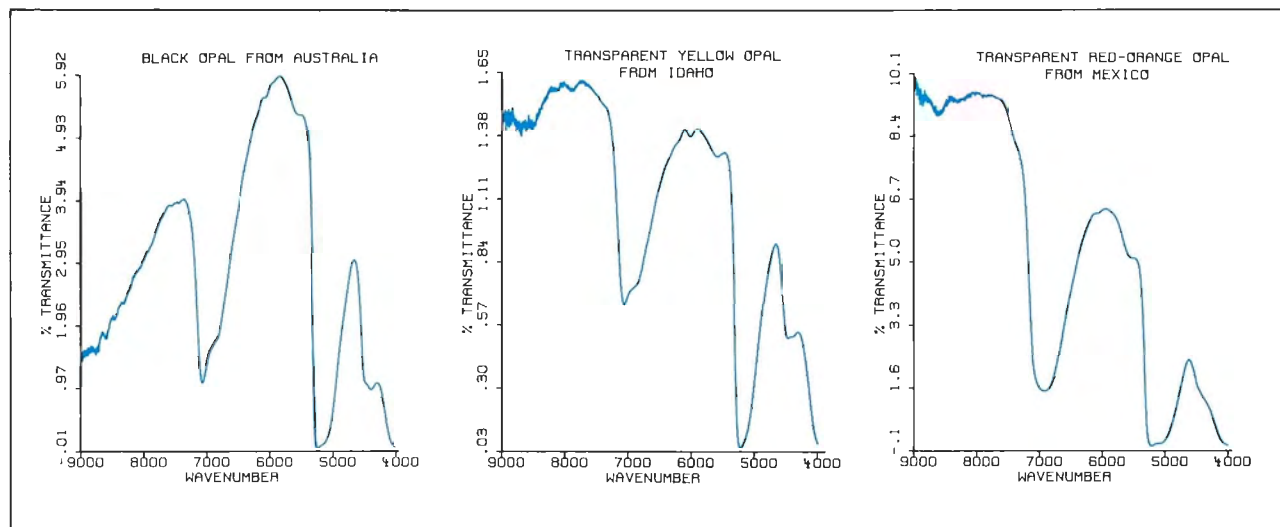


never been reported for *any* natural, untreated opals. Two types of spectra can generally be distinguished for these treated opals. The first has strong overlapping features at about 5725 and 5810 cm^{-1} , with weaker bands at about 4265, 4350, 4670, and 4775 cm^{-1} (figure 9). The second has strong overlapping bands at 5780, 5890, and 5925 cm^{-1} ; distinct features at 4735 and 6155 cm^{-1} ; and lesser ones at 4270, 4350, and 4405 cm^{-1} (figure 10).

Because of the overlap of features in the 4300–4500 cm^{-1} range found in both treated and untreated specimens, however, we do not recommend the use of bands in this region to determine treatment.

The exact cause of each feature has not yet been identified; nor has correlation been made with the types of materials being used for impregnation. However, consistent differences in the spectra of impregnated as compared to untreated

Figure 7. Near-infrared spectra of the Australian black, Idaho yellow, and Mexican red-orange opals pictured in figure 6. In spite of the variability exhibited among these spectra, their basic similarity to the spectrum in figure 5 is evident.



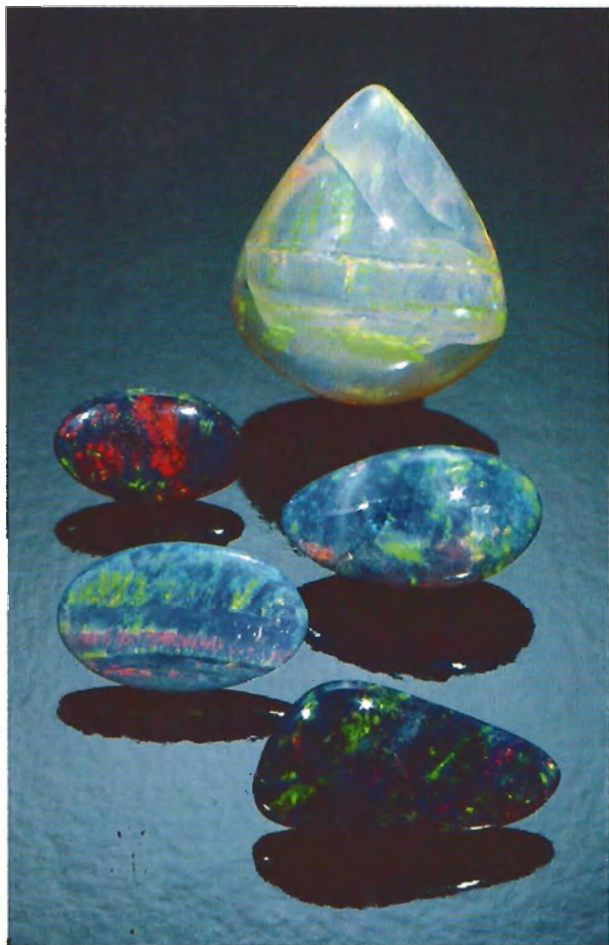


Figure 8. A representative sample (1.00–20.37 ct) of the polymer-impregnated opals examined for this study. Some of these can also be detected by electron microscopy, while others cannot.

Photo © Tino Hammid.

opals are sufficient to deduce that certain features are related to the impregnation materials. Thus, a new method for the identification of polymer-impregnated opal, faster and more foolproof than the old electron microscope test, has been identified. It should be noted, as a caution, that identification of treated opals by infrared spectroscopy applies only to opals treated with polymer-type materials. Sugar- and smoke-treated opals exhibit no significant differences from untreated opals in the 4000–9000 cm^{-1} region. Identification of these older types of treatment rests in the use of the gemological microscope (e.g., Gübelin, 1964).

CONCLUSION

Infrared spectroscopy has now joined the ranks of laboratory techniques that can be applied to solv-

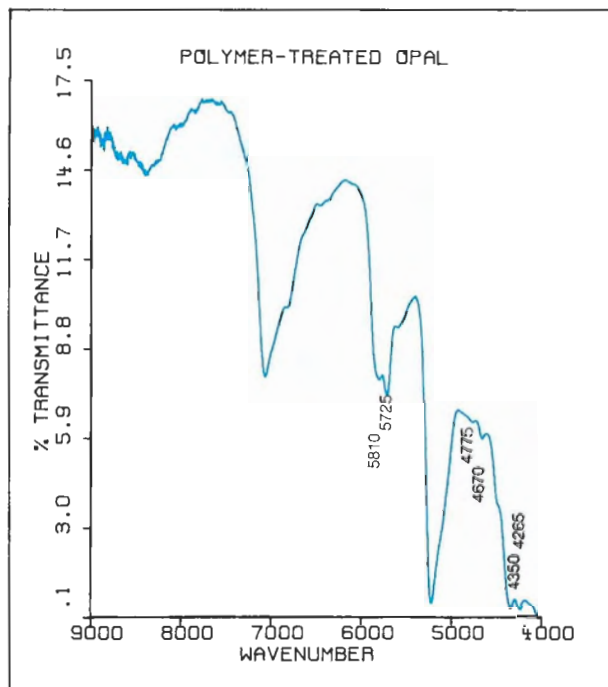
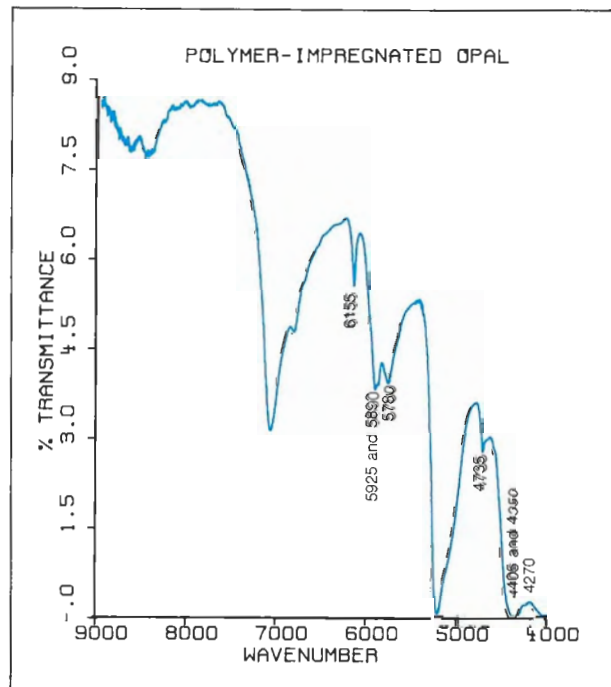


Figure 9. The near-infrared spectrum of the opal at top left in figure 8 is representative of the first type described for polymer-treated opals in the text. Absorption features diagnostic of the treatment are labeled.

Figure 10. The near-infrared spectrum of the opal at middle right in figure 8 is representative of the second type described in the text. Absorption features diagnostic of the treatment are labeled.



ing gemological problems that have thus far eluded solution by traditional gem-testing techniques. Reports on the use of infrared spectroscopy by other scientists to identify irradiation and annealing of diamonds (Woods, 1984; Woods and Collins, 1986) as well as treatment and synthesis of other gem materials (Langer and Abu-Eid, 1977; Zecchini, 1979; Dontenville et al., 1986) indicate that infrared analysis is gaining popularity for gemological applications.

Other projects using infrared spectroscopy that are now under way in the GIA Research Department include:

- Colored diamonds, especially the presence of treatment-related absorptions in the near infrared
- Natural/synthetic separations: amethyst and corundum
- Impregnation: identification of the presence of organic polymers in gemstones other than opal, such as turquoise

- Gem identification through fundamental lattice vibrations: turquoise vs. gibbsite, jadeite vs. nephrite, etc.

To increase our knowledge of gemstones, and to simplify identification procedures by comparison with standard references, the GIA Research Department will also create a library of gemstone infrared spectra. Each spectrum will be correlated with the stone's geographic origin or method of synthesis, its chemistry, the orientation of the crystal, and standard gemological properties.

In the near future, the above applications will be developed and infrared spectroscopy will be extensively used to help detect other forms of treatment, especially heat treatment, inasmuch as water is usually one of the first components to be modified (Aines and Rossman, 1985). All these ongoing studies suggest that infrared spectroscopy is one of the most promising analytical techniques available today for resolving otherwise elusive gemological problems.

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A STUDY OF THE GENERAL ELECTRIC SYNTHETIC JADEITE

By Kurt Nassau and James E. Shigley

The gemological properties of synthetic green and lavender jadeite, which has been manufactured by the General Electric Company on an experimental basis, are summarized. The synthetic jadeites examined appear as flattened or rounded disks that have indices of refraction of about 1.66 and specific gravities of 3.28–3.34. They are also similar in many other respects to natural jadeites, except for a slightly greater hardness (7½–8) and differences in luster, translucency, and appearance. The synthetic jadeites are the result of an experimental study, and at present there are no plans for commercial production.

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Acknowledgments: The authors thank Drs. R. C. DeVries and J. F. Fleischer, of the General Electric Company, for providing the synthetic jadeite examined. D. Hargett, R. E. Kane, J. I. Koivula, and C. W. Fryer made some of the gemological observations and provided helpful suggestions on the manuscript.

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In examining the prospects for the future of synthetic gemstones, Nassau (1980) noted that "Another field providing scope for further work is that of the polycrystalline materials. . . . With their toughness derived from tiny interlocking crystals . . . the jades should provide interesting preparation problems to the materials scientist." We now know that at that time R. C. DeVries and J. F. Fleischer, of the General Electric (G.E.) Research Center in Schenectady, New York, had already completed the bulk of their research on the synthesis of jadeite by a high-pressure technique, although this work was not published until 1984 (DeVries and Fleischer, 1984 a and b).

In the course of their experiments, DeVries and Fleischer produced white, various shades of green to black, and lavender jadeite, in cylindrical pieces up to 12 mm in diameter and 3 mm thick (figure 1). Although this product can be considered gem material, it does not match the highly translucent, almost transparent, quality of what is known in the trade as "Imperial" jadeite. Both total synthesis, as well as reconstruction of crushed natural jadeite with additional colorants added, were used to produce uniform as well as mottled and layered structures. It appears that at present the General Electric Company has no intent to continue this research or to market a synthetic jadeite. A brief preliminary description of this material was provided by Pough (1985).

The following report describes the synthesis experiments and, on the basis of the authors' examination of a set of samples obtained courtesy of Dr. DeVries, presents a comprehensive gemological description of this synthetic jadeite.

THE JADEITE "PROBLEM"

Jadeite is one of the pyroxene "single-chain" silicates, with ideal composition $\text{NaAlSi}_2\text{O}_6$ (Deer et al., 1978). Both jadeite and the amphibole mineral nephrite are called *jade*.



Figure 1. These nine synthetic jadeites manufactured by the General Electric Company were examined by the authors. The sample numbers of the jadeites, starting at the top row and proceeding left to right, are as follows: 7, 6; 9, 3, 1; 4, 8, 5; 2. The pieces range from 0.68 ct to 2.46 ct in weight. Photo © Tino Hammid.

The two kinds of jade consist of aggregates of tiny interlocking crystals. In the case of nephrite, these microscopic crystals are long and fibrous, whereas in jadeite they are more prismatic or platy (Zoltai, 1981). In both cases, the crystals themselves are not particularly hard ($5\frac{1}{2}$ to 7 on the Mohs scale), but in their compacted, interlocked arrangement they are collectively extremely tough. This intricate network of tiny crystals is responsible for the great toughness and excellent polishing quality of both types of jade (see Bradt et al., 1973). Like nephrite, jadeite is found in a range of colors, and has been used extensively for carvings and other ornamental purposes (for further details, see Hobbs, 1982; Webster, 1983).

Early attempts to synthesize jadeite in the laboratory have been summarized by Yoder (1950). According to Roy and Tuttle (1956), L. Coes (Norton Company) may have been the first to achieve success, in 1953.

Jadeite cannot be synthesized at atmospheric pressure, since it decomposes into a mixture of the minerals nepheline and albite when heated (see Bell and Roseboom, 1969). Pressure is required to maintain the stability of jadeite at elevated temperatures. As shown in figure 2, based on several studies as summarized in Deer et al. (1978), a pressure of about 28 kilobars at about 1330°C (and higher pressures at higher temperatures) is required so that jadeite melts without prior decomposition. Equally important, such conditions are also required for a melt of jadeite composition to form crystalline jadeite without the presence of any other phases.

To prepare a mixture of the correct composition for high-temperature studies of jadeite, it has been customary to mix the ingredients (e.g., $Al_2O_3 + Na_2CO_3 + 4SiO_2$) and melt the mixture at a high temperature in air. Typically, this is done at 1550°C in a platinum crucible. The CO_2 is released and the result on cooling is a glass of jadeite composition. The crystallization of such a glass at high temperature and pressure then readily produces synthetic crystalline jadeite, although this had previously been done only with very tiny

Figure 2. Temperature-pressure relations of jadeite, showing the stability fields of jadeite and other phase assemblages in this compositional range (after Bell and Roseboom, 1969).

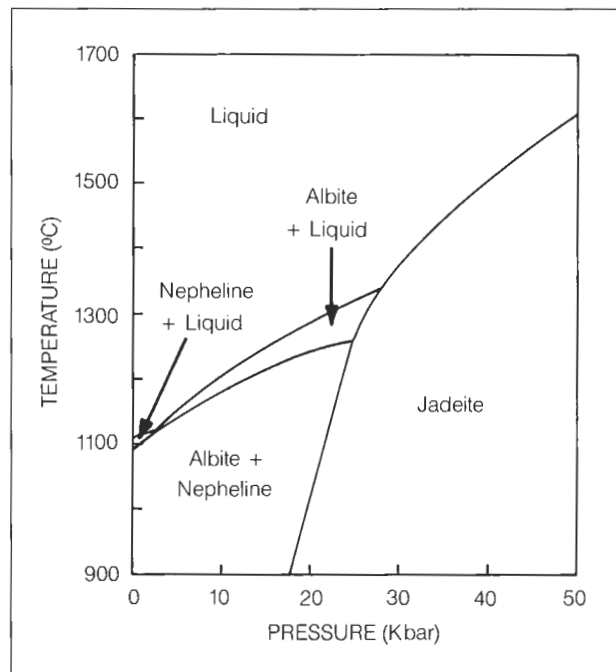




Figure 3. In this photograph of the high-pressure apparatus used to synthesize jadeite, R.C. DeVries is loading a sample into the apparatus while J.F. Fleischer looks on. Photo courtesy of the General Electric Company.

specimens, for example, by Williams and Kennedy (1970).

THE GENERAL ELECTRIC EXPERIMENT

In the latter of the two descriptive accounts published by DeVries and Fleischer (1984 a and b) on their synthetic-jadeite experiments, they provide tabulated data giving the 61 compositions used and some details of the 189 high-pressure synthesis experiments.* These data indicate that the work was begun in 1974, not long after G.E. accomplished the production of gem-quality synthetic diamonds (see, e.g., Nassau, 1980), and that it was basically completed in 1979. The final 14 high-pressure experiments, involving five compositions, were performed between 1979 and 1982.

According to DeVries and Fleischer (1984 a and b), three major types of starting material were used in the G.E. experiment. Most of the starting materials were glass, prepared as described above, but subjected to several crushing and remelting steps to achieve a high level of homogeneity; these were found to be the best type of starting material and were the ones used to produce the samples examined here. The G.E. researchers also performed some experiments using crushed white or gray natural jadeite, sometimes with colorants added. This method has the advantage that there is

no significant volume change on crystallization as there is with glass, but the overall results were not as good. Finally, some compositions were prepared by a sol-gel method (Sakka, 1982) to improve homogeneity, but there were no particular benefits in the final product. Exact compositional data on the starting materials used to produce the group of synthetic jadeites examined herein are not available.

In the absence of color-active impurities, the synthetic jadeite produced was white. Colorants used included chromium as Cr_2O_3 , which gave the typical light to dark green jadeite colors when present in the 0.5 to 2.0 wt.% range, but produced black at higher concentrations. Manganese, best added in the form of Mn_2O_3 as 1.5 to 3 mol.%, gave medium to dark purple (lavender) colors. Titanium added as TiO_2 at similar concentrations provided a measure of whiteness (rather than gray) and translucency. Additional impurities tried included erbium, europium, iron, nickel, samarium, uranium, and vanadium, as oxides, as well as some combinations, such as iron with chromium and iron with vanadium. However, the results usually were either not reproducible or provided no improvement over the use of chromium or manganese alone.

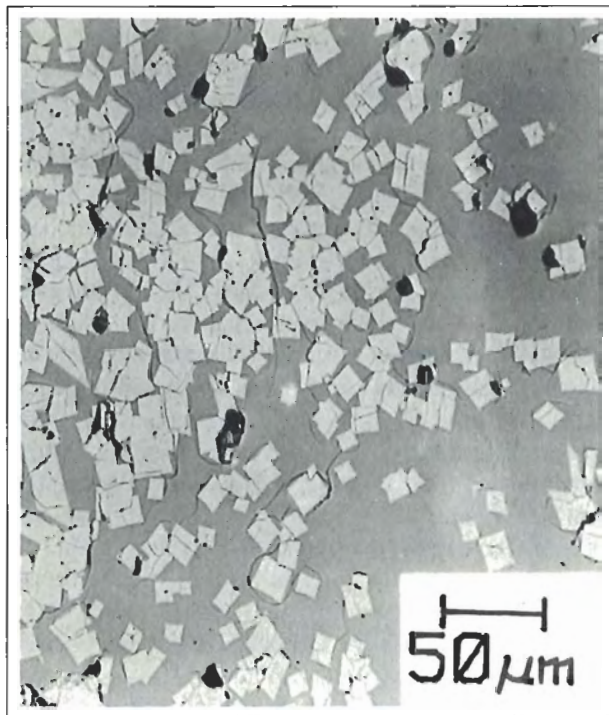
The high-pressure experiments were carried out in a belt apparatus (for details, see Nassau, 1980) within a graphite heater (figure 3). Processing was performed for one-half to 24 hours at 30 to 50 kilobars pressure and 1200° to 1400°C; values

* Please note that there are a number of typographical errors in this report, some of which are not obvious.

near the higher end of all of these ranges gave the better results. Finally, the temperature was reduced before the pressure was released in the manner normally used to preserve the high-pressure equilibrium phases. Crystallization occurred at the high pressure and temperature, possibly with some strain recrystallization as described above. Figure 4 shows jadeite crystals grown in a glass taken from an experimental run that was quenched by cooling prior to complete crystallization.

The experimental product, consisting of flat or rounded circular disks up to 12 mm across and 3 mm thick (figure 5), was principally jadeite as determined on the basis of X-ray and optical characterization by the G.E. researchers. The sizes and shapes obtained were limited by the apparatus used. Given the known high-pressure technology, there is little doubt that uniform pieces up to the size of a 10-mm cube and even larger could be

Figure 4. This photomicrograph shows euhedral synthetic jadeite crystals that have grown in a glass. The glass sample was removed from an experimental run that had been quenched to room temperature prior to complete crystallization of the glass. Photo courtesy of the General Electric Company.



produced if large tetrahedral or cubic presses were used (Nassau, 1980). One problem also probably avoided by the use of these alternative configuration presses would be the laminar structure often observed, which is caused by the uniaxial pressure present in a belt-type apparatus.

A variety of other problems were noted by the G.E. researchers, including the frequent occurrence of a residual glassy phase. Again, there is little doubt that with a suitable development effort, should one wish to market synthetic jadeite, such problems could be solved. General knowledge of high-pressure technology suggests that a price on the order of \$100 per disk would be feasible, with a significant reduction for larger-scale production.

GEMOLOGICAL PROPERTIES

We examined nine specimens of synthetic jadeite (figure 1), seven of which range from medium light green to dark grayish green, with the remaining two medium and dark purple. Three are rounded "cabochons" and six are flat disks; all are approximately 5–10 mm in diameter. The cabochons range up to 3 mm thick, and the flat disks are approximately 1 mm thick.

The color of natural jadeites can vary greatly in terms of hue, saturation, tone, and uniformity of appearance. The synthetic jadeites correspond closely to natural jadeites in many of these respects, and thus color provides little assistance as a distinguishing feature. However, the synthetic lavender jadeites and some of the synthetic green jadeites do have a more intense color than is commonly seen in natural jadeites. In addition, the color of the synthetic lavender jadeites is quite mottled, and appears to be concentrated in distinct areas. One of the synthetic jadeite disks also exhibits aventurescence, which is caused by the reflection of light from numerous tiny grains (figure 6).

All of the synthetic jadeites are semitranslucent to almost opaque, with a deep green or purple color being visible when the green and purple samples, respectively, are placed over a strong light source. Polished samples of the synthetic jadeite exhibit a vitreous luster and an appearance exactly like that of natural jadeites. We were not permitted to prepare optical thin sections of the synthetic jadeite for examination with the microscope, so features such as the nature of the granular texture, aventurescence, and the sometimes irregular color



Figure 5. The crushed glass on the left was used as starting material in some of the synthesis experiments, and is shown here with one of the synthetic jadeite disks that resulted. Photo courtesy of the General Electric Company.

distribution could not be investigated further; nor could we cut the samples for use in preparing spectrophotometric absorption curves. However, the infrared reflectance spectra of the synthetic jadeites (DeVries and Fleischer, unpublished data) agree with those of natural jadeites.

The nine specimens were examined using standard gemological methods and instruments. The measured gemological properties for all of the synthetic jadeites are tabulated in table 1 along with values for natural jadeites. The values for most of the physical properties are very similar to those reported for natural jadeites. However, the synthetic jadeites were all found to have a somewhat greater hardness ($7\frac{1}{2}$ –8, as measured using hardness points) than natural jadeites (7). The cause of this difference is not known, but it may be due to the size, degree of compaction, or orientation of the jadeite grains themselves, or it may be a result of the method of synthesis employed in these experiments that gave rise to the pronounced lamellar structure. For the synthetic jadeites, we attribute the somewhat lower density values measured by the hydrostatic method, as compared to those obtained by the heavy liquid method (both measured in repeated trials), to the fact that the flat shape, light weight, and small size of the disks leads to greater buoyancy, to the trapping of air bubbles along surface cracks and irregularities, and to the lesser wetting characteristics of water as compared to those of the immersion oil (meth-

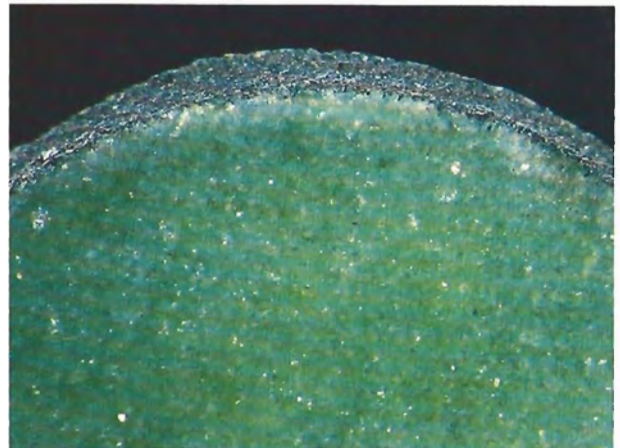


Figure 6. The upper surface of this synthetic jadeite disk (no. 6) shows granular texture, mottled color distribution, and an aventurine-like appearance caused by light reflecting from numerous tiny grains. In contrast to the other samples, this disk has a black rim; it has probably not yet been cleaned. Reflected light, magnified $20\times$. Photomicrograph by John Koivula.

ylene iodide diluted as needed with benzyl benzoate) used as the heavy liquid.

Natural green jadeites exhibit a range of behavior when exposed to ultraviolet radiation. Our own observations indicate that they can either be inert or fluoresce in various colors (366 nm long-wave—yellow, yellowish green, or yellowish white; 254 nm short-wave—yellow, orangy yellow, orange). The intensity of this fluorescence varies greatly from extremely weak to moderate, and it can have a “chalky” or an uneven, mottled appearance. The synthetic green jadeites vary from inert to weak in their fluorescence (see table 1), and the fluorescence is often visible either at the edges or at the center of a disk, perhaps related to the textural difference described below. This range of behavior falls within the fluorescence range observed in natural green jadeites, and thus is not a distinguishing feature.

Natural lavender jadeites also vary in their reaction to ultraviolet radiation. If the color of the jadeite is mottled, so is the fluorescence. The fluorescence ranges from very weak to strong in intensity, and may occur in many colors (366 nm long-wave—grayish white, yellowish white, violetish white, reddish orange, orange; 254 nm short-wave—yellowish white, greenish white, reddish orange, orange). Again, the color is often “chalky.”

In contrast, the two synthetic lavender jadeites displayed only weak fluorescence, but they exhibited small distinct spots of brighter orange fluorescence. Because only a few synthetic jadeites were available for study, it is difficult to assess the significance of these observations. In general, though, it does not appear that natural jadeites can be distinguished from the synthetic stones on the basis of their fluorescence behavior.

Observations with the Microscope. Each of the synthetic jadeite samples was examined with the microscope in transmitted and in reflected light. The three "cabochons" (nos. 4, 5, and 8) appear to have been partly polished, but the flat disks have surfaces that vary from rough to rather smooth. All of the samples display a granular texture, especially along their outer edges and along broken areas (figure 7). Even on flat or semi-polished areas, this granular texture was apparent from slight differences in surface luster, in the appearance of

vague grain outlines, and in minor variations in surface relief suggesting hardness differences. Some of the synthetic jadeites exhibit a "dimpled" surface caused by a slight undercutting during polishing. Broken edges display no evidence of cleavage but represent irregular fracture surfaces. The rims of many of the disk-shaped specimens are lighter and more grayish in color, which is caused either by a compositional inhomogeneity or, more likely, by textural differences, since the rim areas are highly fractured (figure 8).

One of the more interesting observations concerns the pronounced lamellar structure present in most of the disks. When viewed along their edges, the disks exhibit numerous, parallel fractures that give the material a distinct layered appearance (figure 9). Around the edge of a disk or cabochon, there frequently is some breakage of the outermost layers (figure 10). It is likely that this layered (or delaminated) structure of the synthetic jadeite is related to the method of synthesis under uniaxial

TABLE 1. Gemological properties of natural and nine General Electric synthetic jadeites.

Property	Natural jadeite		Synthetic jadeite				
	Deer et al. (1978) ^a	Webster (1983) ^a	1	2	3	4	5
Shape	—	—	Disk	Disk	Disk	Cabochon	Cabochon
Diameter (mm)	—	—	9.5	9.4	10.6	10.3	5.7
Thickness (mm)	—	—	2.4	1.2	0.9	2.5	3.0
Weight (ct)	—	—	2.21	1.17	1.31	2.46	0.68
Color	— ^c	— ^c	Dk. grayish ^d green	Dk. green	Med. green	Med. dk. green	Med. green
Color description ^b	—	—	—	vsbG 6/2	G 5/2	vsbG 5/2	G 5/2
ColorMaster reading	—	—	—	C 2/29/7	C 7/73/16	C 6/74/21	C 7/73/16
Hardness (Mohs scale)	6	7	8	7½	8	7½–8	7½–8
Refractive index							
α	1.640–1.681						
β	1.645–1.684	1.66	1.653	1.652	1.654	1.655	1.655
γ	1.652–1.692						
Specific gravity							
Heavy liquid (3.32)	—	3.30–3.36	3.34	3.34	3.31	3.34	3.28
Hydrostatic	3.24–3.43	—	3.31	3.27	3.25	3.28	3.28
Fluorescence							
Long-wave UV	— ^c	— ^c	Inert	Inert	Ex. wk. greenish at edges	Ex. wk. greenish at edges	Ex. wk. greenish at edges
Short-wave UV	— ^c	— ^c	Inert	Inert	Ex. wk. chalky orange	Ex. wk. chalky orange	Ex. wk. chalky orange
X-ray	—	Yellowish white	None	None	None	None	None

^a Compilation of data.

^b Color description terminology taken from the GIA Colored Stone Grading System; colors for sample nos. 1 and 7 do not fall within the system.

^c See discussion in the text.

^d Abbreviations: dk. = dark, med. = medium, lt. = light, ex. = extremely, wk. = weak, v. = very, mod. = moderate, st. = strong.

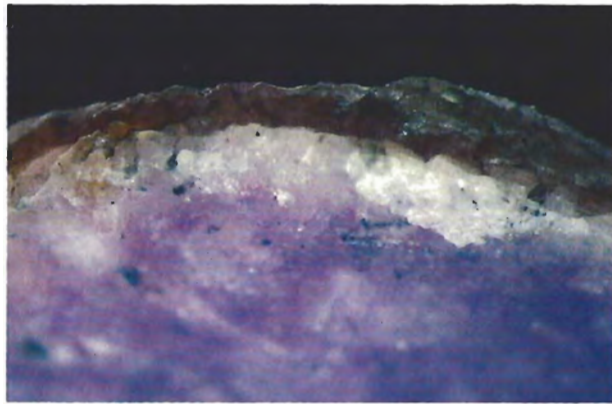


Figure 7. The edge of one of the synthetic jadeite disks (no. 9) shows granular texture along with the irregular surface and fracture. Also note the blotchy color that is typical of these synthetic jadeite samples and the presence of small black grains of unknown identity. Reflected light, magnified 25 \times . Photomicrograph by John Koivula.

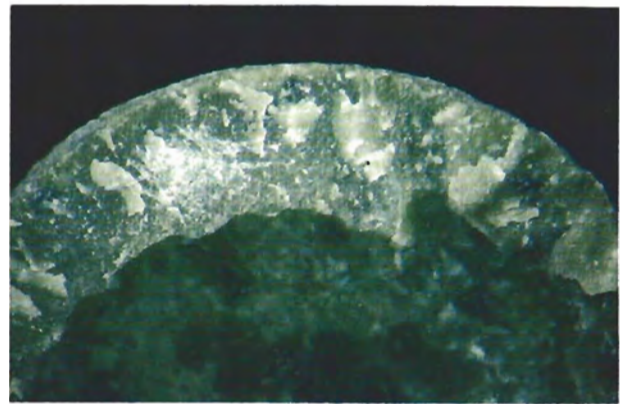


Figure 8. The rim area of this jadeite disk (no. 2) illustrates the fractured lighter-colored edge evident on most of the synthetic jadeites examined. Reflected light, magnified 15 \times . Photomicrograph by John Koivula.

Synthetic jadeite			
6	7	8	9
Disk	Disk	Cabochon	Disk
11.1	10.8	7.3	9.3
1.7	1.5	1.6	1.1
2.11	2.08	0.70	1.14
Med. lt. green	Dk. grayish green	Med. purple	Med. dk. purple
G 5/2	—	bP 5/1	V 5/2
C 7/73/16	—	C 14/45/52	C 14/44/74
8	7 $\frac{1}{2}$ -8	7 $\frac{1}{2}$ -8	7 $\frac{1}{2}$ -8
1.65	1.655	1.65	1.655
3.33	3.34	3.28	3.32
3.27	3.29	3.22	3.24
V. wk. yellowish green	Inert	Wk. reddish orange	Reddish orange with orange spots
Ex. wk. chalky orange	Inert	V. wk. reddish orange	Wk. reddish orange
None	None	St. yellow	Mod. yellow

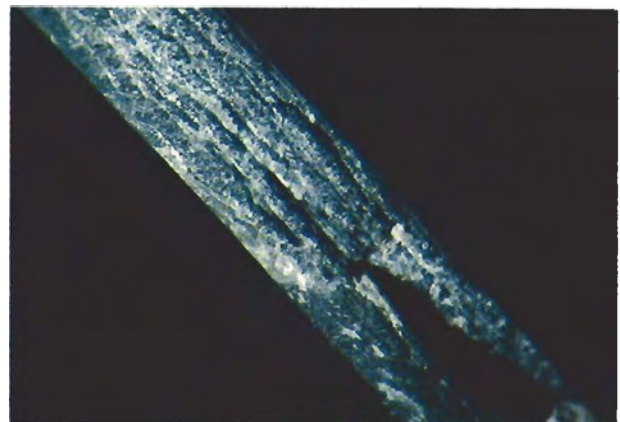


Figure 9. This view of the edge of one of the synthetic jadeite disks (no. 7) shows numerous fractures that run parallel to the upper and lower surfaces of the disk. Reflected light, magnified 25 \times . Photomicrograph by John Koivula.

pressure and, as discussed earlier, could probably be avoided.

Chemistry. Chemical compositions of the synthetic jadeites were obtained by electron microprobe analysis. Table 2 summarizes the chemical compositions of two representative specimens. These analyses are consistent with reported data on the chemistry of natural jadeite with the exception of the greater amounts of manganese in the synthetic lavender samples and the absence of



Figure 10. This view of the upper surface of one of the synthetic jadeite cabochons (no. 4) shows the broken edges of several of the thin layers that make up the material. Reflected light, magnified 20×. Photomicrograph by John Koivula.

magnesium and calcium in both the synthetic green and lavender samples. Minor differences in concentrations of the color-causing transition elements (Fe, Cr, Mn) give rise to the variations in color among the samples. Further chemical analysis by X-ray fluorescence (XRF) confirmed the presence of the major elements shown in table 2 and also indicated the presence of trace amounts of zirconium, nickel, zinc, tin, and strontium in almost all of the synthetic jadeites. The reason for the presence of these trace elements is uncertain, but their presence does provide a good indication of synthetic origin and thus distinguishes these specific samples from natural jadeites.

Spectroscopy. Viewed with a hand spectroscope and transmitted illumination, the synthetic green samples exhibit general absorption from 400 to 500 nm, a narrow region of transmission from about 500 to 600 nm, and then absorption from 600 to 700 nm. The degree of absorption in these two regions increases as the synthetic jadeites become more blackish green in color. In some instances, the green samples exhibit three absorption bands, at about 630, 655, and 690 nm, which vary in intensity from one sample to the next. These three bands are also present in natural deep green jadeites. However, the sharp band at 437 nm typically observed in the spectrum of any translucent color of natural jadeite (except for some darker green natural jadeites, in which the 437 nm band is masked by general absorption in this region of the

spectrum) was not seen in the spectrum of any of the synthetic jadeites. While the darker green natural jadeites are colored by chromium, the principal coloring agent of most natural green jadeites is iron (Rossman, 1974). In natural jadeite, iron gives rise to the 437 nm band and to weaker bands at 573 and 610 nm, while chromium is responsible for the 630, 655, and 690 nm bands. Because of its high content, chromium appears to be responsible for the green color in the synthetic jadeites. An exception is sample no. 6, which does not show the 437 nm iron line despite a high iron content. No features in the spectra of the synthetic jadeites could be attributed to iron.

There is little written in the gemological literature on the spectra of lavender jadeites. The absorption spectrum of a natural lavender jadeite shown in Rossman (1974) has a sharp band at 437 nm that is due to iron, and a very broad, prominent band at 573 nm which is responsible for the lavender color. Rossman attributed this latter band to a mechanism involving $Fe^{2+}-Fe^{3+}$ intervalence charge transfer. In the hand spectra of both the synthetic lavender jadeites, in contrast, there is a broad absorption band from approximately 530 to 630 nm but no other features. The low iron content but high manganese content of these two samples suggests that manganese is the likely cause of this broad band in synthetic lavender jadeite.

TABLE 2. Chemical data on natural and G.E. synthetic jadeites.

Oxide	Natural green ^a	G.E. synthetic green (no. 3) ^b	Natural lavender ^a	G.E. synthetic lavender (no. 8) ^b
SiO ₂	59.65	60.2	60.40	59.3
TiO ₂	0.02	ND ^c	0.07	ND
Al ₂ O ₃	24.07	25.3	24.22	23.5
FeO	0.63	— ^d	0.43	—
MnO	0.02	ND	ND	2.0
MgO	0.71	ND	0.66	ND
CaO	1.08	ND	1.02	ND
Na ₂ O	14.01	14.9	13.83	15.2
K ₂ O	NR ^c	ND	NR	ND
Cr ₂ O ₃	0.01	0.5	ND	ND
Total	100.20	100.9	100.63	100.0

^a Data taken from Rossman (1974) for jadeite samples from Burma. Average of two electron microprobe analyses. Fe₂O₃ value recast as FeO.

^b Average of three electron microprobe analyses of two representative samples of the G.E. synthetic jadeite. Total iron as FeO. Analyst C. M. Stockton.

^c NR = not reported, ND = not detected.

^d Presence detected by energy-dispersive X-ray fluorescence. Analyst C. M. Stockton.

X-Ray Diffraction Analyses. Unit-cell parameters for one representative specimen (no. 4) were determined by least-squares refinement of d-spacing values measured from an X-ray powder diffraction film. Refinement of 23 measured values yielded the following parameters: $a = 9.434(6)$, $b = 8.565(5)$, $c = 5.227(3)\text{\AA}$, $\beta = 107.67(6)\text{\AA}$. These values are very close to the unit-cell parameters of natural jadeite (see Prewitt and Burnham, 1966).

CONCLUSIONS

Given the published details of these experiments, anyone with access to high-pressure equipment could probably produce synthetic jadeite. Several characteristics should permit the distinction of a product made by this process from natural jadeite. These include differences in texture and appearance as well as the greater hardness of the synthetic stones. The more intense and often mottled color of the synthetic jadeites may also be helpful. There are no significant differences in indices of refraction, absorption spectra, fluorescence, or specific gravity. Note also that the observed cracking and delamination caused by the uniaxial pressure in the belt-type synthesis apparatus can probably be avoided by the use of a tetrahedral or cubic high-pressure apparatus; thus, the absence of these features is not necessarily diagnostic.

The successful synthesis of jadeite raises the question of whether the other "jade" mineral, nephrite—a "double-chain" silicate with the ideal composition $\text{Ca}_2(\text{Mg}, \text{Fe}^{2+})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$ —could be similarly synthesized. Amphiboles have been grown in the laboratory under pressure (Gilbert et al., 1982), the aim, however, being to produce single crystals as opposed to a polycrystalline jade structure. We suspect that such a synthesis would be feasible, but it would be complicated by the need to have only ferrous iron and the difficulty of achieving a set hydroxyl content. In view of the lower value usually attributed to nephrite as compared to jadeite, a commercial synthesis would be even less likely.

It should be emphasized that the synthetic jadeite described in this report is an experimental product and is not likely to be encountered on a commercial basis. We do not know whether similar materials of improved appearance will be synthesized in the future, but it seems unlikely given the cost of the synthesis process versus the ready availability of natural jadeite for gemological purposes. Any such commercial product prepared and grown under different conditions could, of

course, have somewhat different characteristics. The General Electric experiments do, however, demonstrate that the understanding and technology exist to synthesize polycrystalline gem materials such as jadeite in the laboratory. Although G.E. has not applied for a patent on the synthetic jadeite, an essentially identical process has been patented in Japan by the Suwa Seikosha Co., Ltd. (1985).

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NOTES · AND · NEW TECHNIQUES

A NEW GEM MATERIAL FROM GREENLAND: IRIDESCENT ORTHOAMPHIBOLE

By Peter W. Uitterdijk Appel and Aage Jensen

Orthoamphiboles with pronounced iridescence are found in eight localities in the vicinity of Nuuk, the capital of Greenland. The iridescence, difficult to see on rough samples, becomes clearly visible when the material is cut. This iridescent orthoamphibole is mined by a company wholly owned by Nuuk commune, and is sold under the trade name Nuummite. This orthoamphibole has a composition similar to that of iridescent orthoamphiboles described earlier from Greenland as well as from New Hampshire and Massachusetts, but is believed to be the first such orthoamphibole to be regarded as a gemstone.

In the early 1980s, the Geological Survey of Greenland had several geologists working the Nuuk area of West Greenland. The first-named author joined the field work in 1982, and devoted his attention to mineral deposits. During the work, some peculiar rusty horizons composed essentially of orthoamphiboles with small amounts of copper and iron sulfides and molybdenite were discovered. Subsequent microscopic investigations of thin sections revealed that the orthoamphiboles in some of the samples exhibited a weak iridescence. When pieces of this material were cut and polished as cabochons, they revealed a spectacular iridescence in different colors. It was thus realized that this type of iridescent orthoamphibole had a potential as a gemstone (figure 1; Appel, 1983).*

*Orthoamphibole is a group name for amphiboles that crystallize in the orthorhombic system. Gem-quality amphiboles are relatively uncommon. The best known are actinolite (nephrite) and tremolite.

After the initial discovery, the authors conducted an investigation of the gemstone. It was decided, however, that the results should not be published internationally before a commercial production had started. Inasmuch as the material was recently introduced on the jewelry market in Greenland under the trade name Nuummite, we are now able to provide the gemological community with the following information on the location and occurrence of the material, its appearance, chemistry, and gemological properties, and the lapidary and commercial aspects.

LOCATION AND OCCURRENCE

To date, the iridescent orthoamphiboles have been found in eight localities within 50 km (approximately 30 mi.) of Nuuk, the capital of Greenland.

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Figure 1. The 2.8 cm × 3.7 cm cabochon of iridescent orthoamphibole that is shown here mounted in silver exhibits golden and greenish iridescence colors.

Nuummite Nuuk A/S, the company responsible for mining and distributing the gem material, does not wish to make the precise localities and mining operations public at this time.

The iridescent orthoamphiboles are found in a sequence of Precambrian rocks called the Malene supracrustals (figure 2), which are enclosed in extensive gneisses. Isotopic work shows that these rocks are more than three billion years old. The supracrustals comprise a varied sequence of rocks which have undergone strong deformation and metamorphism at temperatures of at least 550°C.

In spite of the metamorphism and deformation, it is possible locally to recognize original sedimentary and volcanic structures, such as sedimentary layering and pillow lava flows. These structures, as well as the chemistry of the rocks, indicate that the depositional environment of the Malene sediments was very similar to present conditions on the ocean floor. Most of the rocks in the Malene supracrustals have modern counterparts. However, some thin layers occur that have a



Figure 2. This map of the Nuuk area, West Greenland, shows the rock units (in gray) in which iridescent orthoamphiboles may be expected to occur.

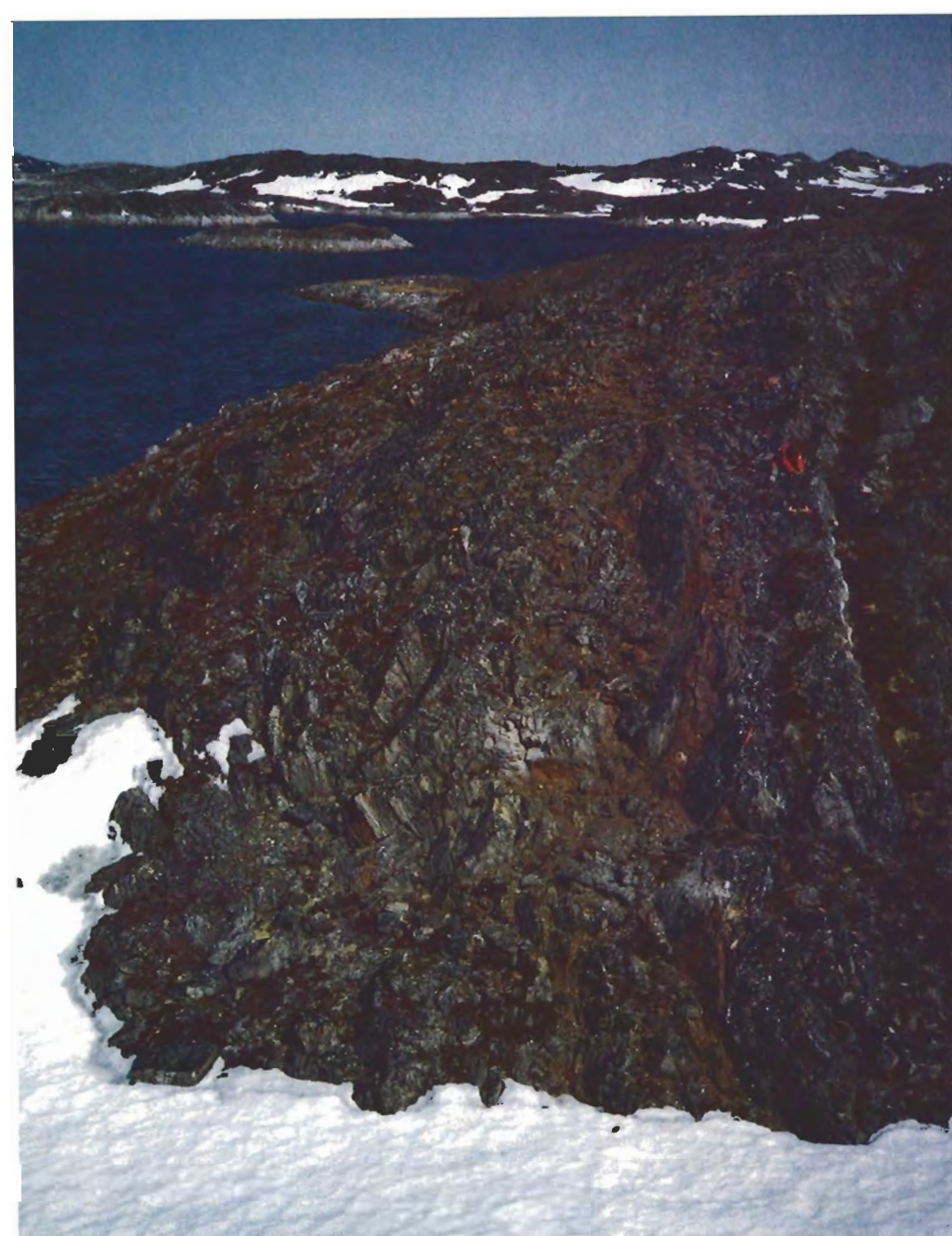


Figure 3. The first locality where iridescent orthoamphiboles were found. The occurrences form lenses up to one meter wide in the slightly rusty band.

rather peculiar chemistry: approximately 50% SiO_2 , 10% Al_2O_3 , and roughly equal amounts of FeO and MgO (about 18%). Modern counterparts with this chemistry are rare.

These peculiar layers are up to a few meters wide, and can be traced for several hundred meters along the strike. They consist almost exclusively of orthoamphiboles (anthophyllite-gedrite), with small amounts of pyrrhotite, chalcopyrite, magnetite, molybdenite, and gahnite. The amphiboles range in grain size from less than a millimeter to more than 10 cm. The rock is generally dull gray to black in appearance, and is locally slightly rusty because of weathering of the sulfides.

This rock type hosts the iridescent orthoamphiboles. In the field, however, it is very diffi-

cult to determine which samples contain the iridescent material. A couple of horizons were trenched by blasting and subjected to detailed sampling, but the quality of the material could only be determined in the field by cutting each sample with a portable diamond saw. The gem-quality material tends to occur as thin bands and lenses up to one meter wide, pinching and swelling along the strike. There is also an apparent tendency for the best-quality material to be situated in areas of high strain such as fold closures.

At present we do not know exactly how much gem-quality material is in the area. Two showings with iridescent orthoamphiboles have been found on the islands south of Nuuk. From one showing (figure 3) about 1200 kg of raw material has been



Figure 5. This cabochon of iridescent orthoamphibole (4.1 cm × 2.6 cm) is the largest so far produced. It displays the whole range of iridescence colors, from violet at one end to green at the other.



Figure 4. As is common with the material, this raw sample of the orthoamphibole displays only weak iridescence.

mined. Part of this material has been used for marketing studies and the rest will be used in the future production of jewelry. Horizons consisting almost of pure anthophyllite-gedrite are extensive, and there is thus a good possibility that more deposits will be found.

DESCRIPTION

Raw samples of this orthoamphibole rarely display iridescence (figure 4); this phenomenon is apparent only when the stone is cut. Cut and polished cabochons show a sparkling iridescence that ranges from green and metallic blue through yellow to golden, reddish, and (rarely) violet colors (figures 5–7). Single cabochons may show the



Figure 6. This cabochon of iridescent orthoamphibole (3.0 cm in diameter) has slightly reddish to greenish golden iridescent colors.

whole range of colors from one end of the cabochon to the other (figure 5). Most commonly, however, cut and polished stones exhibit one or two iridescence colors only (figures 1 and 6). In cabochons with two colors, the colors are usually from the same end of the spectrum, for example, green–

metallic blue or yellow-golden. Only a few stones show contrasting iridescence colors, for example, blue-golden or green-reddish.

The matrix of the iridescent grains ranges from light gray to almost black, in rare instances with a brownish tinge. The individual iridescent grains range in size from a few millimeters up to a couple of centimeters. Most grains show one iridescence color only, but a few large grains have been seen with a core of purple iridescence rimmed by reddish iridescent orthoamphibole.

There is some correlation between the size of the orthoamphibole grains and the iridescence color. Small grains display iridescence of different colors, whereas large grains (between half a centimeter to a couple of centimeters) most commonly show golden to reddish iridescence (figure 7). Still larger grains (up to 15 cm) exhibit no iridescence.

The number of iridescent grains varies from one or two per square centimeter to dozens per square centimeter. This feature implies a lower limit to the size of cabochons. Cabochons less than 0.5 cm long usually have too few iridescent grains to produce attractive jewelry. The largest cabochon produced to date is 4.1 cm × 2.6 cm (again, see figure 5).

CHEMISTRY

Previous Studies. Iridescent orthoamphibole was first mentioned by Bøggild (1905, 1924), who described a specimen collected in the Nuuk area, West Greenland, by K. L. Giesecke in 1810. Bøggild established that the iridescence occurred parallel to the pinacoid {010}. Robinson et al. (1969) showed that some orthoamphiboles from Massachusetts and New Hampshire were composed of lamellae parallel to {010} that were just resolvable at high-power magnification.

The orthoamphiboles are considered to be a solid-solution series between the end members anthophyllite $(\text{Mg,Fe})_7\text{Si}_8\text{O}_{22}(\text{OH})_2$ and gedrite $\text{Na}_{0.5}(\text{Mg,Fe})_{5.5}\text{Al}_{1.5}(\text{Si,Al})_8\text{O}_{22}(\text{OH})_2$ (Robinson et al., 1971). These authors also showed that blue, green, and yellow iridescence occurs where lamellae are so thin (less than 0.2 μm) that their presence can only be seen by X-ray data; samples with lamellae thick enough to be seen under the microscope generally have no iridescence. In addition, they showed that gedrite lamellae are coarser (0.8 μm) than anthophyllite lamellae (0.2 μm), and that the chemical composition of their iridescent samples is similar to that of the sample that was



Figure 7. The large orthoamphibole grains in this 2.3 cm × 4.0 cm cabochon exhibit a striking golden iridescence.

described by Bøggild (1905): $\text{Na}_{0.43}(\text{Mg,Fe})_{6.1}\text{Al}_{0.8}(\text{Al}_{1.0}\text{Si}_{7.0})\text{O}_{22}(\text{OH})_2$ with a trace of Ca (0.13) and a ratio of Fe/Mg of 0.45. Christie and Olsen (1974) report blue iridescence in an orthoamphibole with the composition $\text{Na}_{0.33}(\text{Mg,Fe})_{6.4}\text{Al}_{0.6}(\text{Al}_{1.2}\text{Si}_{6.8})\text{O}_{22}(\text{OH})_2$ with a trace of Ca (0.10) and a ratio of Fe/Mg of 0.69.

The cell dimensions of anthophyllite and gedrite are very similar: \underline{a} and \underline{c} values are practically identical and the difference in the \underline{b} value is in the order of 1%. Ross et al. (1969) report for anthophyllite, $\underline{a} = 18.54\text{--}18.58 \text{ \AA}$, $\underline{b} = 17.98\text{--}18.11 \text{ \AA}$, $\underline{c} = 5.27\text{--}5.30 \text{ \AA}$; and for gedrite, $\underline{a} = 18.54\text{--}18.60 \text{ \AA}$, $\underline{b} = 17.76\text{--}17.88 \text{ \AA}$, $\underline{c} = 5.27\text{--}5.30 \text{ \AA}$.

Present Investigations. The X-ray powder diffraction pattern of the material from Nuuk showed the

presence of an orthoamphibole with a few weak lines of an unidentified mineral phase. Most of the powder lines could be satisfactorily indexed with the orthorhombic unit cell $a = 18.57 \text{ \AA}$, $b = 17.77 \text{ \AA}$, $c = 5.28 \text{ \AA}$ (all $\pm 0.02 \text{ \AA}$), found by the least-squares refinement of 30 unequivocally indexed powder lines. This unit cell indicates that the material is close to gedrite.

Electron microprobe analyses* of the orthoamphibole from Greenland gave a variation from $\text{Na}_{0.17}(\text{Mg,Fe})_{6.3}\text{Al}_{0.7}(\text{Al}_{0.9}\text{Si}_{7.1})\text{O}_{22}(\text{OH})_2$ to $\text{Na}_{0.29}(\text{Mg,Fe})_{6.3}\text{Al}_{0.7}(\text{Al}_{1.0}\text{Si}_{7.0})\text{O}_{22}(\text{OH})_2$ with a trace of Ca (0.07) and an Fe/Mg ratio varying from 0.59 to 0.62. According to Leake (1978), the orthoamphibole with $\text{Na}_{0.17}$ is an anthophyllite, whereas the one with $\text{Na}_{0.29}$ is just on the gedrite side of the border between anthophyllite and gedrite.

The variation found, however, cannot be expected to represent the composition of anthophyllite and gedrite lamellae, respectively, as these lamellae, in the iridescent areas, are less than 0.2 \mu m , and the analyzing spot of the electron microprobe is slightly less than 2 \mu m .

Thus in an attempt to obtain analyses closer to the composition of the respective anthophyllite and gedrite lamellae, the electron microprobe analyses were extended to include noniridescent areas of the orthoamphibole, inasmuch as the lamellae are known to be broader in noniridescent areas than in iridescent areas. The electron microprobe analyses of noniridescent areas did not result in anthophyllites with a lower Na content than was already obtained from iridescent areas, but to the gedrite side the composition was extended to $\text{Na}_{0.38}(\text{Mg,Fe})_{6.0}\text{Al}_{1.0}(\text{Al}_{1.4}\text{Si}_{6.6})\text{O}_{22}(\text{OH})_2$ with a trace of Ca (0.04) and an Fe/Mg ratio of 0.58. That the composition could be extended only to the gedrite side is in agreement with the earlier findings that gedrite lamellae are always coarser than anthophyllite lamellae (Robinson et al., 1971; Christie and Olsen, 1974; Spear, 1980).

It is therefore concluded that the orthoamphibole from Greenland consists of alternating anthophyllite-gedrite lamellae and has a composition similar to other iridescent orthoamphiboles described by Bøggild (1905), Robinson et al. (1971), and Christie and Olsen (1974).

*Electron microprobe analyses were carried out with a JEOL Superprobe JXA 733 using the PACX-program (WDS) as well as the LINK EDS program 4/FLS+, with 15 kV accelerating voltage and 20 respectively 1.0 nA.

GEMOLOGICAL PROPERTIES

Refractometer measurements show that the indices of refraction of the orthoamphibole from Greenland average $\alpha = 1.64$ and $\gamma = 1.66$, with a birefringence of 0.02. Material from the locality where the material was initially found (figure 3) has $\alpha = 1.641$ and $\gamma = 1.663$, with a birefringence of 0.022, whereas material from the second locality has $\alpha = 1.635$ and $\gamma = 1.657$, also with a birefringence of 0.022.

The density of the orthoamphibole from the first locality is generally 3.24 g/cm^3 but can vary between 3.20 g/cm^3 and 3.37 g/cm^3 , while the density of the material from the second locality is a rather constant $3.18\text{--}3.19 \text{ g/cm}^3$.

When exposed to ultraviolet radiation, short-wave as well as long-wave, the orthoamphibole fluoresces dark violet.

Cabochons of the orthoamphibole have been placed in a window and exposed to sunshine for more than a year without showing any change in appearance.

It has not been possible to obtain results with the spectroscope when working on cabochons, but spectroscopic investigation in transmitted light on approximately 1-mm thin slices has revealed a general absorption from the blue end to about 485 nm, and two rather broad absorption lines at 505 and 545 nm.

CUTTING AND POLISHING

Orthoamphiboles have a hardness of 6. The iridescent orthoamphiboles from Nuuk are coarse to medium grained. The crystals have locally a slight tendency to parallel alignment, as a result of which the rock has to be cut in certain specific directions in order to obtain a stone with maximum iridescence.

Polishing of the orthoamphiboles entails no special difficulties, inasmuch as the rock is generally massive with no pervasive cracks occurring in fresh material. However, material near the surface tends to have small cracks. In spite of the rather low hardness of the stone, we found that it cannot be polished satisfactorily with either tin oxide or cerium oxide, and final polishing is best done with diamonds 3 \mu m in size.

COMMERCIAL ASPECTS

The commercial possibilities for the stone have been discussed since 1982, when the gem potential of the iridescent orthoamphiboles was determined.

First, the town council of Nuuk gave the stone the trade name Nuummite, which means "derived from Nuuk" in Greenlandic. Next, the company Nuummite Nuuk A/S, wholly owned by Nuuk commune, was established. The government granted the company an exploration concession for Nuummite in the Nuuk area, as well as permission to manufacture and sell Nuummite jewelry. The company, based in Nuuk, now employs one full-time goldsmith and three to four lapidaries to cut and polish the gem material. A continuous production has not yet been established. The stone was launched on the Greenlandic market before

Christmas 1986, and the jewelry will subsequently be marketed in Denmark. The company plans to introduce Nuummite internationally at a later date.

Nuummite Nuuk A/S has so far marketed jewelry with Nuummite mounted in both gold and silver, and has sold unmounted cut and polished cabochons. The most important items are pendants, but some rings have also been produced.

Editor's Note: The material submitted by the authors to GIA has a spangled pattern associated with aventurescence. Each "spangle" or bright reflection is reminiscent of labradorescence.

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Gem Trade Laboratory, Los Angeles

A NOTE FROM THE EDITOR

The strength of the Gem Trade Lab Notes column lies in the willingness of so many members of the gemological community to bring unusual items to the attention of the GIA Gem Trade Laboratory and allow us to publish our findings. The following individuals and firms were particularly helpful during the past year: Marvin Bankoff, Alan Bronstein, Tom Chatham, W. L. Cotton, Colin Curtis, Jim D'Andrea, Pravin Davé, Robert Dunnigan, Sy Ellerhorn, Pete Flusser, Gem Mart, Kaiser Habib, Roger Krakowski, Bill Larson, John R. Latendresse, Reginald Miller, Fred Montezinos, Mary Murphy, Kurt Nassau, Carol O'Baugh, Judith A. Osmer, Rima Investors Corp., Gerald Rogers, Howard Rubin, Maurice Shire, and E. F. Watermelon Co.

Glass Imitation BERYL

In this era of space-age technology, which has produced sophisticated synthetics that often require equally sophisticated skills to detect, some jewelers and gemologists often fail to consider one of the oldest gem substitutes known to man: glass. Although some glass imitations look unnatural and so can be identified with little more than a "sight i.d.," others are deceptively realistic and require standard gemological testing.

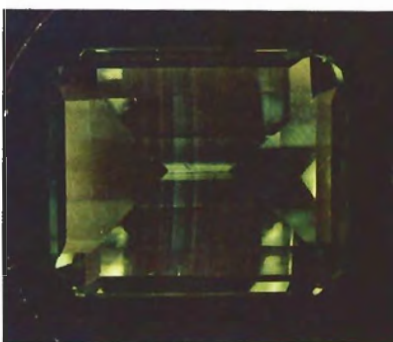
The Los Angeles laboratory recently encountered one of these realistic glass imitations. The 43.24-ct light green emerald cut shown in



Figure 1. This 43.24-ct (23 mm long) green beryl imitation proved to be glass.

figure 1 was submitted for identification. A single reading of 1.529 was obtained on the refractometer. Examination with a polariscope produced a singly refractive reaction, but with strong anomalous double refraction that was generally oriented in a straight, parallel pattern

Figure 2. The glass shown in figure 1 reveals a straight, parallel strain pattern when observed between crossed polaroids.



(figure 2). This strain pattern corresponded directly to the straight, parallel features that were easily visible when the piece was examined with a microscope in dark-field illumination. No other inclusions were observed. The piece fluoresced very weak dull yellow to long-wave ultraviolet radiation and very weak chalky greenish yellow to short-wave U.V. radiation. No bands or lines were visible when it was examined with a hand spectroscope. On the basis of these findings, we identified the material as glass.

To the unaided eye, this piece of glass very closely resembles a light green beryl, or an aquamarine that has not yet been heat treated. Since the piece is quite large, it could easily be hefted to estimate the specific gravity, which seemed to be close to the beryl it resembles. Testing with heavy liquids revealed that the specific gravity, approximately 2.50, is indeed relatively close to that of beryl. Even an experienced gem dealer could mistakenly purchase such a piece as beryl if he did not test it.

We are often told of such things happening, for example, light blue glass being represented as aquamarine, or purple glass being offered as amethyst. In fact, some time ago a Brazilian dealer of fine amethyst purchased a parcel of 5,000 ct, only to discover that a large percentage of the pieces were glass. RK

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

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Figure 3. Bright green crystals of unknown identity are easily seen in this diamond. Magnified 10 \times .

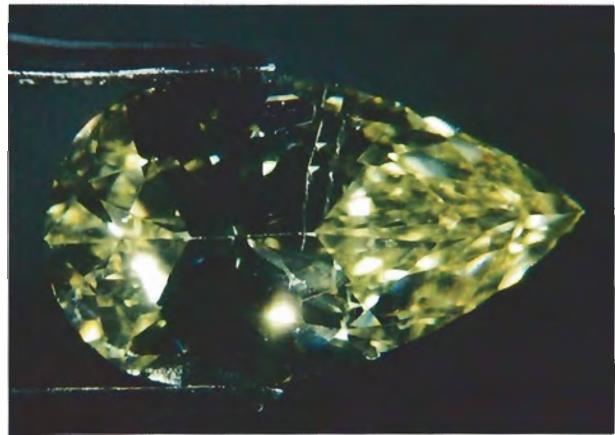


Figure 4. Note the very unusual rectangular knot in the pavilion of this 1.96-ct yellow diamond. Magnified 10 \times .

DIAMOND with Interesting Inclusions

Two diamonds with interesting inclusions were recently seen in the New York laboratory. The first stone, shown in figure 3, contains several bright green, transparent, nearly euhedral included crystals. Because the crystals are completely enclosed in the diamond, we could not perform the tests needed for definitive identification. However, these inclusions are almost certainly chromium-bearing minerals in the pyroxene group, probably diopside or enstatite.

The second noteworthy inclusion is a knot in the 1.96-ct yellow pear-shaped diamond shown in figure 4. This knot is in the unusual form of an irregular rectangular prism that extends from the pavilion near the keel (approximately one-third of the distance to the girdle), across the keel plane, to the edge of the table. It is most unusual for a thin columnar knot such as this to extend through the stone in this manner.

Clayton Welch

Synthetic DIAMOND

On February 18 of this year, two small diamonds were submitted to the New York lab for origin-of-color reports. The 0.46-ct stone was identi-

fied as a fancy brown natural-color diamond. However, the yellow 0.23-ct square emerald-cut stone fluoresced medium chalky yellow-green to short-wave ultraviolet radiation, but was inert to long-wave U.V. No absorption lines or pattern were observed with the spectroscope. An hourglass graining pattern was easily seen through the pavilion. These characteristics are typical of those observed in the new Japanese synthetic diamonds described in the Winter 1986 issue of *Gems & Gemology*. The stone reacted positively to the thermal inertia tester, as would be expected of a diamond. Congratulations to Kathleen Knox, who identified the stone, since this is the first time we have encountered a true gem-quality synthetic diamond in the trade and not just in the research laboratory.

CF

DIASPORE, A Rare Gem Material

In the Fall 1983 issue of *Gems & Gemology* (pp. 172–173) we reported on a rare faceted gem material, diaspore. This 1.24-ct square step-cut stone showed a moderate color change from light greenish yellow in daylight to light pinkish yellow in incandescent light. In 1985, the Los

Angeles lab had the opportunity to examine two other faceted diaspires (157.66 ct and 26.97 ct) as well as two large crystals. These four specimens reportedly came from a locality in Turkey (see *Gems & Gemology*, Spring 1985, p. 59).

Recently, the Los Angeles laboratory identified a 3.68-ct octagonal mixed-cut diaspire that exhibited a distinct color change from yellowish green in daylight to yellow-brown in incandescent light. Although only rarely encountered by the gemologist, diaspire is relatively easy to identify. The 3.68-ct stone shown in figure 5 revealed typical properties: refractive indices of $\alpha = 1.702$, $\beta = 1.722$, and $\gamma = 1.750$, with a corre-

Figure 5. This rare 3.68-ct faceted diaspire exhibits a distinct color change from yellowish green in daylight to yellow-brown in incandescent light.



sponding birefringence of 0.048; biaxial positive; specific gravity (with heavy liquids) of approximately 3.40; and weak pleochroic colors of yellowish green, orange-brown, and near-colorless. Examination with a spectroscopy unit revealed a very weak absorption band from about 4500 to 4600 Å; an extremely weak, vague line centered at 4710 Å; some absorption in the far red portion of the spectrum; and moderate absorption in the violet area, which gradually tapered off at around 4250 Å. Examination with the microscope revealed several thin white needles and a few small crystals.

RK



Figure 7. This faceted table-cut lodestone measures approximately $9.97 \times 7.95 \times 2.00$ mm.

GOETHITE?

On several occasions, South American diamond dealers have submitted opaque black, apparently water-worn, pebbles to the New York laboratory for identification (see, for example, figure 6). They claim that the pebbles are found in the same riverbeds as the diamonds.

Examination with overhead illumination revealed that the true color of the 6.72-ct pebble (reportedly from Venezuela) shown in figure 6 is a very dark variegated brown with a few black veins. Standard gemological tests gave the following information:

Figure 6. This tumbled stone, found in the diamond-bearing riverbeds of South America, appears to be a rock that is altering to goethite. Magnified 10×.



a refractive index over the limits of the refractometer, a specific gravity of approximately 3.50, and a hardness of about $6\frac{1}{2}$ –7 on the Mohs scale. The stone gave a brown streak and did not react to either hydrochloric or sulfuric acid. At this point, we decided to use X-ray diffraction. The diffraction pattern matched that of the mineral goethite, which is an iron hydroxide. However, the properties of goethite (S.G. of 4.28, hardness of 5 – $5\frac{1}{2}$) do not match those of the material in question. We can only speculate that this is perhaps some mineral or rock that is in the process of altering to goethite.

Dave Hargett

MAGNETITE, Lodestone

The New York lab was asked to determine whether the 2.55-ct faceted stone shown in figure 7 is hematite. We routinely test suspected hematite for magnetism with a small horseshoe magnet. In this case, we found that placing the stone on a piece of paper and moving the magnet around under the paper caused the stone to move and to flip over, proving its strong magnetic polarity. This fact, together with the results of other standard tests, indicates that this material is probably the polarized form of magnetite known as

lodestone. Although hematite can sometimes be weakly magnetic, it certainly is not as strongly polarized as lodestone. Magnetite is a ferrous and ferric iron oxide in the spinel group that can change to hematite when heated in an oxidizing atmosphere. It can also alter in a normal atmosphere over a period of time, but what effect, if any, this would have on surface appearance, especially luster, is not known.

Clayton Welch

NEPHRITE Imitation

The New York lab recently received for testing a strand of dark green 10-mm beads that were being represented as imitation nephrite (figure 8). Although dark green nephrite is relatively inexpensive and readily available, there is apparently enough of a demand for this even less expensive imitation to create a market.

A refractive index of 1.55, Mohs hardness of 7, specific gravity of approximately 2.65, and a crystalline aggregate structure (as seen with magnification) proved the beads to be quartzite. A broad absorption band at 6500 Å was visible in the hand spectroscopy, and a positive color filter reaction proved the presence of dye. Green color concentrations in the interstices were also seen when the stone was examined with magnification (figure 9).

Dave Hargett

PEARLS

An Unusual Clam "Pearl"

A jeweler from northern California sent a round, very dark, approximately 11-mm purple bead to the Los Angeles laboratory for identification. Since this bead had been found in a clam, which is a bivalve mollusk, he questioned whether it could not be called a black pearl. As shown in figure 10, the dark purple bead obviously lacks the characteristic orient required for it to qualify as a pearl. A sheen-like effect was visible



Figure 8. The 10-mm imitation nephrite beads in this strand proved to be dyed quartzite.

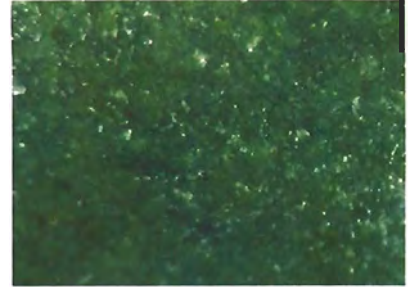


Figure 9. The concentration of dye can be seen in the interstices of the quartzite grains in the beads shown in figure 8.

to the unaided eye, but it was confined to certain areas. Between those distinct areas, a flow, or flame-like, pattern was visible with magnification (figure 11). The whole bead resembled a type of *Hexagonaria* coral. The high birefringence and the relative softness of the material indicated that the bead was a carbonate. When exposed to long-wave ultraviolet radiation, the bead showed a very faint orangy red fluorescence similar to that of some natural-color black pearls. The X-radiograph revealed a quite homogeneous structure with one faint circular growth line just beneath the surface. This proved the bead to be a calcareous concretion, but with a unique appearance not previously encountered in our laboratories. KH

Pearls and Their Apparent Colors

An article in the September 1986 issue of *Scientific American* stated that human color vision is not simply a reaction to specific wavelengths

of light, but rather that it responds to changes in color across boundaries. Put simply, this means that an object's apparent color can change depending on its surroundings, or color environment. This phenomenon is the basis for many popular optical illusions, but more importantly to

Figure 10. This 11-mm calcareous concretion was thought to be a black pearl.



the jeweler, it explains in part why pearls look different on different skin tones, why stones look better on certain color papers, and why jewelry looks best on certain color pads.

A short time ago, while preparing a pearl choker for X-radiography in New York, we inadvertently demonstrated this phenomenon in a very dramatic manner. Part of the choker lay on some papers and part lay on the brown desk top. Our attention was attracted because the pearls on the papers appeared to be cream colored, while those on the brown desk looked white (figure 12). Because pearls are so strongly affected by background color, they are usually displayed on a light beige surface to show their best color, and are graded on a light gray surface to show their true color. Clayton Welch

Figure 11. The unusual surface of the concretion shown in figure 10 is evident in this 6× magnified view.





Figure 12. Note how different in color these pearls appear on the different-colored backgrounds.

QUARTZ

Fossiliferous Chalcedony

The fossiliferous chalcedony cabochon shown in figure 13 was donated to the New York laboratory. Figure 14 shows the numerous smaller fossils concentrated in each of the larger fossils in this stone. At first glance, this material appears to be one of the various decorative marbles that are used as building facings or table tops. Marble is a metamorphosed limestone and, as a carbonate, should effervesce when a small drop of acid is applied to it. However, this stone did not react to acid. Routine gemological tests

Figure 13. This small chalcedony cabochon showing fossil shells is a *Turritella* agate.



proved this material to be a type of chalcedony that is commonly known as *Turritella* agate. Undoubtedly the limestone was replaced with quartz over time by the action of siliceous ground water. When magnified, this particular piece showed the presence of gold in the form of numerous sectile yellow metallic inclusions. Such gold is often found in secondary quartz deposits, but it is not normally associated with limestone.

Clayton Welch

Phenomenal Quartz

Figure 15 shows a trio of quartz cabochons, ranging from 17.84 to 45.45 ct, that all display phenomena.

Figure 14. At 10× magnification, the cabochon in figure 13 shows numerous small shells inside the larger shells.



The star quartz on the right was featured in both the Summer 1977 and Summer 1984 Lab Notes sections, and is actually a multi-star stone. The other two stones were submitted together to the New York laboratory for identification.

Stones like the transparent dark brown cat's-eye shown on the left in figure 15 are rarely seen in the lab. As with all brown quartz, the possibility exists that the color has been enhanced by irradiation, which cannot be detected by standard gemological tests. The star in the middle stone is particularly interesting because two of its arms are significantly stronger than the other four. In many lighting conditions, this stone actually appears to be a cat's-eye (figure 16). Such a stone should probably be identified simply as phenomenal quartz, since it can appear either as a cat's-eye or a star, depending on the viewing conditions.

Clayton Welch

RUBY

Natural Ruby Doublet

When a jeweler damaged a customer's ruby recently, he agreed to replace the stone. However, when the replacement stone was submitted for appraisal, the appraiser suspected that the stone might be a doublet.

Examination in the New York lab proved that although the stone is a doublet, it is no ordinary doublet: it consists of a natural ruby crown and a natural ruby pavilion. In *Gems, Their Sources, Descriptions and Identification*, Webster referred to these stones as "true doublets." Shipley called them "genuine doublets." Although they are very rarely seen in the labs, one Far Eastern gem dealer informed us that these stones have been seen in Thailand. Fine rubies over one carat are rare. If the potential fraud went undetected, a true doublet weighing one carat could be sold for much more than the value of two half-carat stones. A bezel setting could make the separation plane very difficult to detect.



Figure 15. These cat's-eye and star quartz cabochons range from 17.84 to 45.45 ct.



Figure 16. The star quartz shown in the middle of figure 15 appears to be a cat's-eye when viewed under different lighting conditions.

When we received this 1.18-ct stone for testing, it was unmounted. Overhead vertical illumination easily revealed the separation plane just below the girdle (figure 17). Immersion in methylene iodide showed that the twinning plane present in each piece did not meet. Natural inclusions and standard gemological tests proved that both crown and pavilion are natural ruby. *Dave Hargett*

With Unusual Cavities

In recent months, the New York laboratory has noted an increasing number of heat-treated rubies with oval to circular surface cavities (figure 18), especially on the pavilion. They

appear to be areas of spalling, probably caused by the heating. The interior surface of the cavities is not fire skinned (partly melted), which suggests that the spalling took place at the end of the heating process. Also, the cavities are smooth at the bottom, with no evidence of a crystal or negative crystal as a contributing factor. Seven of 14 natural rubies in a lot submitted recently had these spall cavities. Although these were the first we noticed, last year we saw

several glass-filled cavities that could have been filled spall cavities.

RC

Heated SAPPHIRE

In the ongoing controversy regarding disclosure, perhaps one of the greatest concerns is heat-treated corun-

Figure 17. A separation plane can be seen just below the girdle of this doublet, which consists of a natural ruby crown and a natural ruby pavilion. Magnified 20 \times .

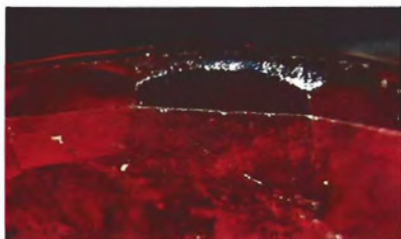
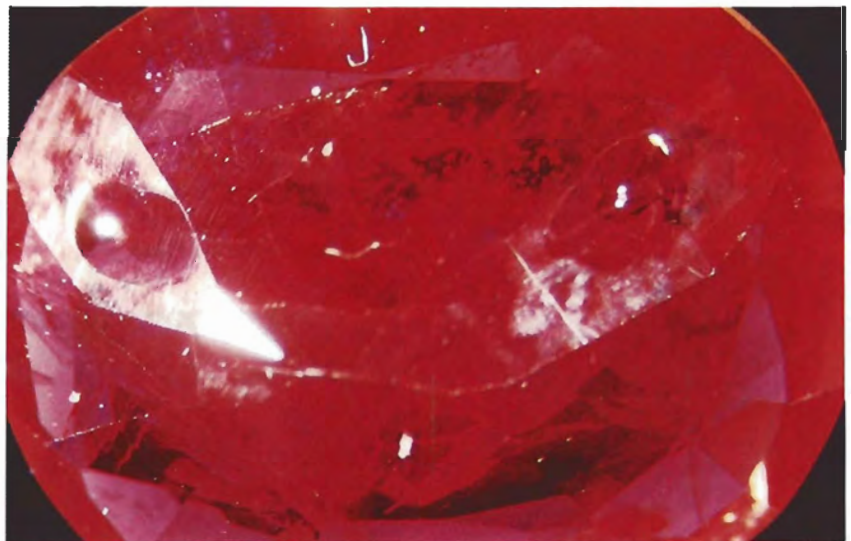


Figure 18. These oval cavities were caused by spalling in a heat-treated ruby. Magnified 10 \times .



dum. Many dealers are becoming adept at recognizing characteristics associated with heat treatment. One of them sent the stone shown in figure 19 to the New York lab for examination. Although a reworked girdle is a common feature of heat-treated corundum, the zone of brown color evident in this stone is rarely seen. The lack of a spectrum indicates that this stone is not Australian. It was probably originally a "geuda," the whitish, translucent Sri Lankan corundum that is most frequently used in heating; we have seen such a brown color zone a few times before in geuda material that has been heated.



Figure 19. Brown color zoning is a rare occurrence in heat-treated sapphire. Magnified 10X.

One heat treatment that usually cannot be detected is the lightening of dark blue Australian sapphire. The stones are not heated to the extent that they need repolishing, so surface evidence of treatment is

lacking. Unlike the heated "geuda" sapphires, which show no iron lines in the spectroscope, the heated Australian stones display distinct to strong iron lines both before and after treatment. The trade should be aware that a great deal of heated Australian material is sold mixed in with Thai stones. RC

FIGURE CREDITS

Figures 1, 2, 5, and 10 were furnished by Shane McClure. Clayton Welch took the pictures used for figures 3, 4, 7, 12-16, and 18. Dave Hargett supplied figures 6, 8, 9, 17, and 19. John Koivula provided the photomicrograph in figure 11.

The Gemological Institute of America extends its sincerest appreciation to all of the people and firms who contributed to the activities of the Institute through donations of gemstones and other gemological materials. We are pleased to acknowledge many of you below:

- | | | |
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Gems & Gemology

C · H · A · L · L · E · N · G · E

You, the readers of *Gems & Gemology*, are undoubtedly among the most knowledgeable jeweler-gemologists and gem enthusiasts in the world. But just how much do you *really* know? To give you an opportunity to test yourself on what you've actually learned from G&G in the past year, the GIA Education Department has compiled the first annual *Gems & Gemology* Challenge.

The following multiple-choice questions are based on articles published in the four 1986 issues of *Gems & Gemology*. Feel free to refer to those issues to find the *single best answer*, and then mark the appropriate letters on the card provided in this issue (photocopies or other facsimiles of this card will not be accepted). Return the card with your answers (be sure to include your name and address) by Monday, June 15: Don't forget to put sufficient postage on the card (14¢ in the U.S.). All entries will be acknowledged. Those with a passing grade (75% or higher) will receive an attractive letter, suitable for framing, that acknowledges your successful completion of the exam and your interest in continuing your gemological education. Those readers who receive a perfect score (100%) will also be publicly applauded in the upcoming Summer issue of *Gems & Gemology*.

So . . . get out those last four issues, sharpen your pencils, and **take the challenge!**

Note: Questions are taken only from the four 1986 issues. Choose the single best answer for each question.

- In China, the gem mineral from the Altay pegmatites that has the best commercial potential is
 - beryl.
 - corundum.
 - spodumene.
 - tourmaline.
- The many colors used in Art Nouveau jewelry were often executed by the extensive use of
 - enamel.
 - jadeite.
 - tourmaline.
 - mother of pearl.
- Future emerald prospectors in the Muzo district of Colombia will probably look for
 - shale beds.
 - water seepage.
 - fault patterns.
 - thermal plates.
- Historically, the principal gemstone used by Chinese gem carvers is
 - quartz.
 - jadeite.
 - corundum.
 - nephrite.
- Sillimanite is also known as
 - ilmenite.
 - silicate.
 - fibrolite.
 - mennoite.
- Natural, untwinned amethyst is
 - rare.
 - common.
 - very rare.
 - nonexistent.
- The two major areas currently producing gem-quality sapphire in China are
 - Hunan and Hubei.
 - Mingxi and Canton.
 - Mengyin and Shandong.
 - Hainan Island and Fujian.
- Glass made entirely from the volcanic ash of Mount Saint Helens will probably be
 - blue.
 - green.
 - black.
 - colorless.

9. Which one of the following jewelers contributed the most to Art Nouveau jewelry in terms of innovative design and use of materials?
- Henri Vever
 - René Lalique
 - Emile Dubeque
 - Luis Masriera
10. In early literature, the "Portuguese" diamond was referred to as the
- "Star of Brazil."
 - "Portuguese Star."
 - "Star of Portugal."
 - "Regent of Portugal."
11. To date, the largest rough diamond recovered at the Changma Diamond District of China weighed
- 59.05 ct.
 - 89.07 ct.
 - 119.01 ct.
 - 249.25 ct.
12. Which one of the following choices best describes the annual production of gem-quality diamonds in China?
- 30,000 to 40,000 ct
 - 45,000 to 75,000 ct
 - 300,000 to 500,000 ct
 - 450,000 to 750,000 ct
13. In China today, significant quantities of turquoise are coming from
- Henan Province.
 - Hubei Province.
 - Shanxi Province.
 - Yunnan Province.
14. All of the inclusions observed to date in Chinese peridot have also been seen in peridot from
- Burma.
 - Arizona.
 - Zabargad.
 - Sri Lanka.
15. Inclusions in emeralds from the Coscuez mine, Colombia
- clearly identify the mine.
 - commonly include apatite and barite.
 - are similar to those in other Colombian emeralds.
 - include more three-phase inclusions than other Colombian emeralds.
16. Which one of the following instruments is the most useful in separating natural from synthetic amethyst?
- dichroscope
 - polariscope
 - spectroscope
 - refractometer
17. The only known in-situ occurrence of pink topaz is the locality
- in Rajasthan, India.
 - near Katlang, Pakistan.
 - near Ouro Preto, Brazil.
 - in the Ural Mountains, USSR.
18. The Sumitomo synthetic yellow diamonds examined by GIA Research were all
- Type Ia.
 - Type Ib.
 - Type IIa.
 - Type IIb.
19. The first useful textbook of gem identification was written by
- J. R. Blum.
 - R. J. Haüy.
 - John Ellicott.
 - Richard Davis.
20. Most of the scheelite from Colombage-Ara, Sri Lanka is
- gray.
 - pink.
 - yellow.
 - colorless.
21. Currently, the largest yellow synthetic diamond crystals produced by Sumitomo weigh approximately
- 1.00 ct.
 - 2.00 ct.
 - 3.00 ct.
 - 4.00 ct.
22. The inlay technique that involves fitting together small pieces of gem material to produce an intricate design is known as
- intaglio.
 - intarsia.
 - cloisonné.
 - plique-à-jour.
23. Which one of the following characteristics is an identifying feature of Sumitomo synthetic yellow diamonds?
- Inert to long-wave ultraviolet radiation only
 - Inert to short-wave ultraviolet radiation only
 - Blue fluorescence to short-wave ultraviolet radiation
 - Yellow fluorescence to long-wave ultraviolet radiation
24. In Sri Lanka, the Elahera gem field is
- of little importance.
 - falling off in production.
 - the most productive gem mining area.
 - the second most important gem mining area.
25. The only conclusive proof that corundum gemstones have **NOT** been heat treated is the presence of
- color zoning.
 - angular inclusions.
 - CO₂ fluid inclusions.
 - H₂O fluid inclusions.

GEM NEWS

John I. Koivula, *Editor*

DIAMONDS

Cubic zirconia coated by synthetic diamond? Over the past few years, Gem News has reported periodically on the new technology of coating with synthetic diamond. Thus far, this technology has been researched and developed for application in various industries, but not as a method of gemstone synthesis or enhancement.

Now that may have changed. Bernice Backler, of Barnscott Gemological & Metallurgical Laboratory in Pinetown, South Africa, reports that a client brought in

a "diamond" ring for laboratory certification. It had been purchased in Bangkok, Thailand, for \$1,000, with a "guarantee that the stones were white De Beers diamonds cut in Belgium," according to Ms. Backler.

The ring was stamped 18K and was bezel set with seven reportedly 0.20-ct stones and pavé set with 12 reportedly 0.05-ct stones, for a presumed total weight of 2.00 ct of "diamond." The two things that first made the laboratory personnel suspicious were the unusually low price paid for the ring and the fact that they "could see through the stones." The setting was also found to be gold-plated base metal.

Although a thermal probe indicated that the stones were diamonds, further testing showed that they were in fact "cubic zirconias coated with a fairly heavy coating." When examined with the microscope, the coating was determined to match that "described by O'Donoghue" for synthetic diamond (*Identifying Man-made Gems*, p. 89). It was "very granular, in some cases almost mountainous," with "many high heaps and ridges near the girdle and running right up to the crown and star facets. . . . The whole appearance was one of an amateurishly performed job." We are most grateful to Bernice Backler for reporting this item to Gem News.

Editor's Note: To date, neither the GIA Research Department nor the GIA Gem Trade Laboratory has encountered a cubic zirconia layered with any coating that would fool a thermal diamond probe. However, we are aware that a number of companies have applied polycrystalline diamond coatings to a variety of materials, although cubic zirconia was never specifically cited.

TUCSON '87

From February 7 through 15, the desert city of Tucson, Arizona, was once again transformed into a gem and mineral fancier's paradise. Each year this event seems to get larger and that trend was not broken this year, with dealers working out of more than a dozen hotels as well as the convention center.

Without question, Tucson has become the largest

Figure 1. For the first time in many years, fine iris agate such as this 70.2 × 35.0 × 2.0-mm piece was available at the 1987 Tucson Gem and Mineral Show. Photo © Tino Hammid.



gem and mineral show in the world. And again this year, dealers from virtually every gem-producing country were present in abundance. As a result, many interesting and unusual items were there waiting to be discovered. The following report of new and different items seen at Tucson this year was compiled by the Gem News editor with the help of Emmanuel Fritsch, Pat Gray, James Shigley, and Carol Stockton.

Amber. Dominican amber was available in large amounts, although pieces with interesting inclusions were, as usual, difficult to find. Good pieces of the so-called blue (strongly fluorescent) amber were fairly common this year. A few of the amber dealers also reported a small but steady market for transparent Polish amber and for the cloudy, translucent to opaque, Russian material.

Aquamarine. Zambia is said to be the source for a new find of aquamarine. The gems are a darker shade of what has become known in the trade as "aquamarine" blue, and are very similar in color to some of the fine aquamarines that have come out of Nigeria over the past few years. The color in these Zambian stones, as with their Nigerian counterparts, is said to be natural and not the result of heat treatment.

Chalcedony. For the first time in many years, a few very fine iris agates were being offered for sale. Acting as a diffraction grating, the ultra-fine fortification banding in these agates splits any source of transmitted white light into a rainbow of bright spectral colors (figure 1). It is hoped that more of this phenomenal material will be available in the future.

Chrysoberyl. A number of very fine alexandrite chrysoberyls from Sri Lanka, Brazil, and even the Soviet Union were available in sizes up to 8 ct. All of the Soviet gems were said to be from old stock, and their appearance on the market does not reflect any renewed mining activity.

Diamond. The Tucson Gem and Mineral Show is generally not thought of as a diamond show but each year more and more diamond dealers are involved. Melee-sized diamonds seem to be very popular, usually purchased as accent stones for the major colored gems that are so abundant at the Tucson show. This year, however, several major white diamonds were on display, as well as a number of fancy pink, blue, green, and yellow stones. Some of these faceted diamonds were as large as 20 ct.

Euclase. Colorless Brazilian euclases can be irradiated with gamma rays to produce a pale green color. After hearing a rumor to the effect that colorless euclase was being enhanced in this manner, Pierre Bariand, curator of the Sorbonne Collection, personally conducted a

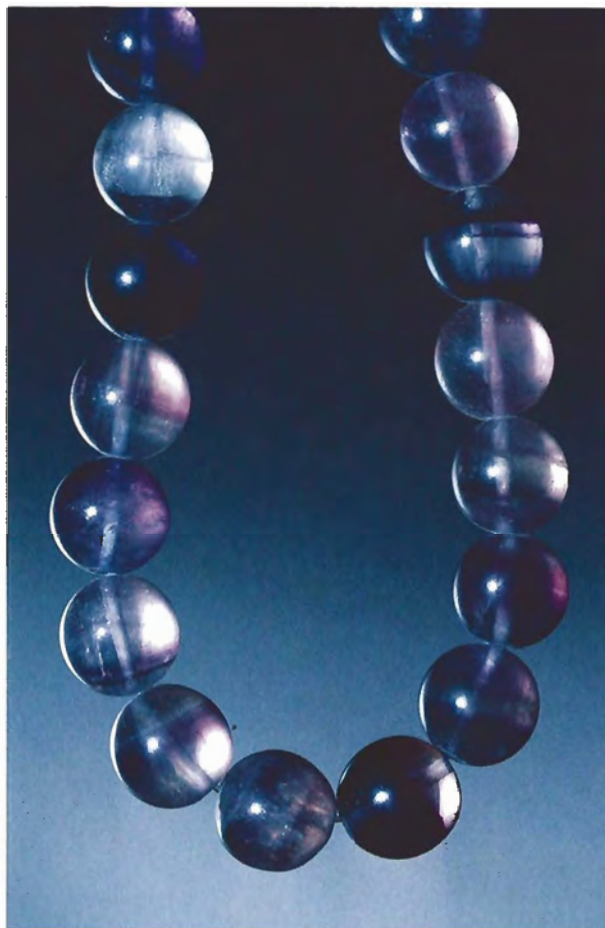


Figure 2. These 11-mm color-zoned fluorite beads were sold as "multi-color amethyst." Photo © Tino Hammid.

euclase-irradiation experiment and verified that this color change will take place.

Fluorite. Strands of typical purple-to-colorless color-zoned fluorite beads were being sold as "multi-color amethyst." As shown in figure 2, these beads are obviously fluorite and should not fool the competent gemologist.

Garnet. Intense green grossular garnets from East Africa in sizes over one carat have all but disappeared from the gem marketplace. Apparently, the deposits that produce this beautiful gem are no longer producing it in large quantities. Some feel that the mines may be played out, while others speculate that they simply are not being worked as heavily as they were in the past.

Kornerupine. Some cat's-eye kornerupines from an unknown locality were being sold by one gem dealer as cat's-eye quartz.



Figure 3. Harold Van Pelt created this unusual fluted three-piece rock crystal quartz container (36.8 cm high) in honor of this year's show mineral. Photo © Harold & Erica Van Pelt.

Moonstone. For the second year in a row, so-called "rainbow" moonstone from India was being marketed at the show. Last year it was virtually unknown, but this year it was one of the popular new gems. Only small stones of 2 ct or less were available last year, but this year gems as large as 15 ct were being sold. The most expensive of these was cut in a well-polished high-domed cabochon that brought out a reddish adularescence. Other moonstones displayed green, blue, orange, and yellow adularescence.

Opal. The breakup of a large old collection of small but very fine Australian black opals resulted in a number of these gems being offered for sale at Tucson this year. The opals had a medium-gray to jet-black body color, which was ideal to show off their intense play of spectral colors.

Peridot. Peridot was available from a number of both classic and new localities. Fine large Burmese gems up to 75 ct were reportedly at the show. One Burmese gem of note was a 5+ -ct star. Both cut and rough peridot from Nordfjordeid, Norway, was available in faceted sizes up to 6 ct. Two relatively new localities for gem peridot—Tanzania and Zambia—were also represented by small faceted gems. The gem peridot potential of these two sources is unknown. A few specimens of well-formed peridot crystals in matrix were available at the main convention center show. Nodules of peridot in basalt from San Carlos, Arizona, were also available.

Quartz. The official theme mineral of this year's Tucson show was quartz, and to celebrate this fact the world's largest known doubly terminated quartz crystal, found in Africa, was on display. This remarkable specimen was more than 2 m (6 ft.) long and weighed 3,454 kg (7600 lbs.).

Also on display in honor of the show mineral was the most recent piece created by Harold Van Pelt (see the article by John Sinkankas in the Winter 1982 issue of *Gems & Gemology* on his unusual carving techniques): a three-piece fluted rock crystal container (figure 3). This unusual container is 36.8 cm (14.5 in.) high; the body has 72 flutes and is only 3-4 mm thick at any point. The body was carved, using special long-shafted tools because of the depth, from a single piece of quartz.

Bi-colored gems of amethyst and citrine quartz, known in the trade as Ametrine, have been marketed for several years. Yet the precise locality of these mixed crystals has been in question until now. Kirby Siber, of Siber and Siber, Switzerland, has purchased gem rough at the mines and provided Gem News with the following updated locality information. The confusion about the exact location of this gem deposit resulted from the fact that it is situated in Bolivia near the Brazilian border about 650 km southeast of Santa Cruz, far inside a highly restricted military area. To compound this problem, the terrain is very rough and the area is difficult to access. The locality is actually a crescent-shaped mining area covering about 60 km.

More "Witches' Brew" quartz, with supposed magical powers, was also seen at Tucson. In actuality, these pieces are manufactured by sawing the tips off crystals of Arkansas rock crystal quartz near their bases, and then gluing an intensely colored slice of glass or small dark-colored transparent stone to the sawed end. The quartz crystal tip would then appear to be brightly colored when a light was shone into it through the color-capped end.

Ruby. A new find of gem-quality ruby was also reported. The eluvial rubies are being mined from an area midway along the border between Laos and Cambodia (Kampuchea). The stones range up to about 1.5 ct and are of good-to-fine gem quality. The internal characteristics of these rubies are very similar to rubies from Thailand and are probably from a similar basaltic source.

Sapphire. Unusually large amounts of intense pink sapphire were seen at this year's show. We did not learn the geographic source of these "hot-pink" gems but it is probable that they are from Sri Lanka. It was rumored that pink sapphires were being heat treated to intensify their color or even to produce ruby, but we were unable to verify these speculations. If such a treatment were possible, then it might involve a heat-induced change in the valence state of preexistent chromium ions.

Scapolite. A number of large faceted intense reddish purple scapolites were available this year (figure 4). These gems ranged up to 27 ct and were said to come from Tanzania. Most purple scapolites are generally rather small, and these are the largest that we have seen to date.

Spodumene. Some translucent pale pink to white cabochon-cut spodumenes were being offered as "sheen phenakite."

Turquoise. "Stabilized" natural turquoise, primarily from Cannanea, Mexico, is probably the most available form of turquoise on the market today, even eclipsing Gilson's man-made turquoise. However, both could be found at this year's Tucson show together with a turquoise substitute imported from Germany. The low-priced substitute is composed primarily of the aluminum hydroxide mineral gibbsite. It is dyed, stabilized with a polymer, and used either alone or mixed with some natural turquoise. Some color stability problems have been mentioned in connection with this turquoise substitute: After a year or so of normal jewelry wear, the blue color reportedly shifts toward gray. This color change is probably due to the slow degradation of the dyed polymer under the influence of the ultraviolet rays of sunlight and many common artificial light sources.

Zircon. Zircons in virtually every color were available this year, including some heat-treated blue stones. One Sri Lankan stone of particular interest was an 11-ct cat's-eye that had the body color of a fine chatoyant chrysoberyl and a sharp bluish eye.

In addition to the opportunity it provides to view a full range of gems and minerals, the Tucson show is also a good place to pick up current gem-related news. This



Figure 4. This intense reddish purple scapolite (8.94 ct) was one of a number of unusually fine Tanzanian scapolites seen at Tucson this year. Photo © Tino Hammid. Stone courtesy of B. Alex Bahtiarian.

year, Mr. Gordon T. Austin, the gemstone commodity specialist with the United States Bureau of Mines, provided a variety of useful information. Mr. Austin informed us that many of the East African nations are pushed for hard currency. They have been gearing up their production of gemstones, most notably tanzanite and all varieties of garnet, to help solve their currency problems.

He also informed us that while reading through the government's monthly import statistics he noted that Ecuador has suddenly become a significant exporter of ruby, sapphire, emerald, aquamarine, and amethyst. He has no explanation for this. Perhaps Ecuador is becoming some sort of a pipeline for gems into the United States.

Another very interesting bit of information provided by Mr. Austin concerns Chinese diamonds. Within the last few months, China and De Beers have signed a joint contract to handle the output from the four currently producing Chinese diamond mines. China, with De Beers's help, hopes to train 500,000 diamond cutters within the next five years and plans to compete with India in the small goods market.

GEMOLOGICAL ABSTRACTS

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COLORED STONES AND ORGANIC MATERIALS

Formation of tourmaline-rich gem pockets in miarolitic pegmatites. D. London, *American Mineralogist*, Vol. 71, No. 3/4, 1986, pp. 396–405.

The conditions of formation of tourmaline-rich gem pockets in miarolitic (small, irregular pockets with protruding crystals) pegmatites are evaluated on the basis of both experimental data on the stability of aluminosilicate pocket minerals (e.g., spodumene) and an analysis of fluid inclusions in crystals from gem

This section is designed to provide as complete a record as practical of the recent literature on gems and gemology. Articles are selected for abstracting solely at the discretion of the section editor and her reviewers, and space limitations may require that we include only those articles that we feel will be of greatest interest to our readership.

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pockets. The development of pockets in tourmaline-rich, rare-element pegmatites occurs during the latter stage of formation at temperatures between approximately 475° and 425°C and between 2800 and 2400 bars pressure. This range of temperature and pressure conditions is comparable to that of late-stage crystallization in geochemically similar, massive (nonmiarolitic) rare-element pegmatites. Whether or not gem pockets form during crystallization seems to depend largely on the timing of tourmaline crystallization. Crystallization of tourmaline at some point during pegmatite formation removes both alkali elements (sodium, lithium) and boron from the residual pegmatite melt. It is suggested that the removal of these components within the crystallized tourmaline has a profound influence on subsequent mineral formation within the pegmatite. Tourmaline formation is rapidly followed by the deposition of other alkali aluminosilicate minerals (e.g., albite) and the release of large volumes of water from the residual pegmatite silicate melt. Exsolution of water from the melt in the form of an aqueous fluid phase then contributes to the formation of miarolitic pockets and their mineral contents during the late stages of pegmatite genesis. This model of pocket formation is discussed in relation to the famous gem pegmatites of Afghanistan and of San Diego County, California, as

well as the large, nonmiarolitic, massive, rare-element Tanco pegmatite in Manitoba, Canada. JES

Jadeite-kosmochlor solid solution and chromian sodic amphiboles in jadeites and associated rocks from Tawmaw (Burma). C. Mével and J.-R. Kiénast, *Bulletin de Minéralogie*, Vol. 109, 1986, pp. 617–632.

This article presents mineralogic data and chemical analyses on the unusual and visually striking chromian pyroxenes and amphiboles from the jade deposits of Tawmaw, Burma. These deposits are world famous for their production of high-quality jadeite.

Most of the jadeite is whitish, grayish, or greenish, but some pieces contain small bright green spots. Detailed study of these pieces reveals that these spots contain not only minor chromite, but also pyroxenes and amphiboles with the highest chromium concentrations ever found in terrestrial rocks. Among the pyroxene minerals described is kosmochlor, which is the chromium equivalent of jadeite, containing up to 30% Cr₂O₃. There exists a wide range of solid solution between kosmochlor and jadeite, but also a miscibility gap of 25%–50% kosmochlor component at temperatures of several hundred degrees Celsius and pressures of 10 kbars. Unusual amphiboles with up to 10% Cr₂O₃ include katophorite, glaucophane, and eckermannite. The exceptional compositions of these minerals result from their formation in a particular chemical environment caused by metasomatic reaction (during metamorphism) between an albitite dike containing chromite xenocrysts and the enclosing serpentinites. JES

Notes on fluid inclusions of vanadiferous zoisite (tanzanite) and green grossular in Merelani area, Northern Tanzania. E. Malisa, K. Kinnunen, and T. Koljonen, *Bulletin of the Geological Society of Finland*, Vol. 58, No. 2, 1986, pp. 53–58.

The authors describe the properties of tanzanite, the gem-quality vanadium-bearing variety of zoisite, from the Merelani area of Tanzania. Crystals of tanzanite occur mainly in boudinaged pegmatitic veins and hydrothermal fracture fillings in a brecciated and hydrothermally altered graphite-bearing diopside gneiss. Associated minerals include quartz, diopside, graphite, calcite, hematite, and sphene, as well as green vanadian grossular garnet. The authors also report compositional data for tanzanite. The material has refractive indices of 1.693, 1.694, and 1.702, and a specific gravity of 3.35. Tanzanite has a striking pleochroism, with red-violet, deep blue, and yellow-green.

Two apparent generations of tanzanite are found at this locality—an older brown type and a younger type that is blue. The brown-to-blue color change brought about by heat treatment is attributed to changes in the valence state of vanadium. The inclusions in tanzanite

are described in detail. Studies of these inclusions suggest that the tanzanites crystallized from a hydrocarbon-rich fluid. Solid inclusions noted in tanzanite include calcite, gypsum, graphite, rutile, sphene, xenotime, quartz, diopside, and tremolite-actinolite. Some of these minerals occur as acicular needles which could impart a cat's-eye effect to some tanzanites. JES

Red and pink tourmaline. C. R. Marcusson, *Jewelers Quarterly*, Fourth Quarter, 1986, pp. 24–27, and 30.

The use of tourmaline in jewelry dates back as far as 1000 A.D. to a Nordic ring set with a red tourmaline cabochon. Another historic tourmaline is the 250-ct red egg-shaped cabochon, dated to the 1500s, that was bestowed as a gift to Kaiser Rudolf II. In 1925, the famous Russian mineralogist Alexander Fersman proved that this gem, originally thought to be ruby, was actually Burmese red tourmaline; it is now located in the Kremlin Treasure Room.

Tourmaline often occurs in spectacular crystals which are highly prized by collectors. Smaller crystals mounted as simple pendants are popular with crystal healers as well as the general public. It is thought by some that wearing tourmaline crystals increases one's charisma. Pink tourmaline in particular is said to be associated with joyfulness, vivacity, and the release of emotional pain.

Tourmaline is generally found in pegmatite dikes, probably the most prolific of the gem-bearing rock types. Marcusson gives an excellent, brief description of how crystals form within a pegmatite body.

Tourmaline rarely occurs in a true red. Usually it is pinkish in hue and often modified by orange or brown. The causes of color in tourmaline are very complex. Generally, pink and red tourmaline are colored by manganese and iron combined with exposure to low-level radiation emitted by other minerals associated with pegmatites. The higher the iron content, the less saturated the color tends to be.

Color enhancement has become more prevalent in recent years. Irradiation can produce dark pink and red stones from very pale material. In general, these colors are darker and less saturated than their natural counterparts. Large pink and red tourmalines rarely are free of inclusions, and the color of extremely clean large stones is often the result of laboratory irradiation. Thus far, treatment of tourmalines by this method is not detectable; consequently, with the greater amount of irradiated tourmaline on the market, the price of natural-color material has dropped.

The author also discusses major localities for red and pink tourmaline, including Brazil, Africa, Madagascar, Asia, and North America.

Marcusson has presented a well-rounded article that delivers interesting as well as useful information on

this beautiful gem. She concludes with some tips on the use of red and pink tourmaline in today's fashions.

Barton C. Curren

Sapphire aus Nigeria und von Sta. Terezinha de Goias, Brasilien (Sapphire from Nigeria and Santa Terezinha de Goias, Brazil). U. Henn, *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 35, No. 1/2, 1986, pp. 15–19.

Blue sapphire from Nigeria has appeared recently on the gem market. The locality is reportedly 50 km north of Jos in northern Nigeria. The sapphires are dark to inky, with strong color zoning. Fluid inclusions and two-phase inclusions, which are sometimes very elongated, have been observed, as well as idiomorphic apatite and rounded zircon.

Blue sapphire has also been found at Santa Terezinha de Goias, Brazil. The clarity seems poor, and the color is reported to be bluish gray, sometimes in a strong color zonation with dark blue. Muscovite and margarite inclusions oriented along the cleavage are prevalent in these stones; some fluid inclusions are also present.

EF

Stars and stripes forever. R. P. Rohrbach, *Lapidary Journal*, Vol. 40, No. 7, 1986, pp. 20–30.

When the term *phenomenal* is applied to gems, certain stones immediately come to mind: cat's-eye chrysoberyl, and star rubies and sapphires. Few lay people have ever heard of a star alexandrite or cat's-eye tsavorite.

Having collected and studied phenomenal stones for the past 20 years, Rohrbach laments the fact that standard reference books on gems pay little attention to all the other gemstones that have been found with these effects—and in an incredible diversity of colors. These include topaz, tourmaline, garnet, beryl, spinel, and obsidian, among others. He explains what causes chatoyancy and the cat's-eye effect, describes how such stones are formed, and gives tips on orientation during cutting. There is also an insert describing a jewelry designer's use of asteriated rose quartz and blue cat's-eye tourmaline in her designs. This article has valuable information for students of gemology and the jewelry arts.

Anne Riswold

DIAMONDS

Argyle—A year on. *Diamond World Review*, No. 39, Summer 1986, pp. 48–49.

The 1986 production of the AK1 pipe at the Argyle mine, in Western Australia, is expected to reach 28 million carats, three million more than the original estimate. Argyle is now the world's largest diamond mine, accounting for 8% of the annual world production of rough. The AK1 pipe yields about 6.8 ct of diamonds per ton of ore, which is five or six times higher than the

world average. This high tenor ensures the mine's continued profitability in spite of the relatively low price obtained for the bulk of its rough (about \$8 per carat).

The Argyle joint venture has agreed to sell 75% of its production to De Beers. Because of the relatively low price of Australian rough, sales to the Central Selling Organization are expected to be less than \$200 million annually. Since this represents only 10% of its total sales, the C.S.O. should have no trouble absorbing the diamond production of Argyle.

Considerable attention was generated by the establishment of Argyle Diamond Sales, an independent cutting and polished marketing operation, in Perth. Reports suggest that it was established as part of an agreement with the local state government and is not really intended to make inroads into the polished market. However, some Australians feel that their country is losing potential export revenue by selling uncut stones. Efforts are being made by various groups to expand the local jewelry industry in order to take better advantage of Australia's abundant gemstones and gold.

Barton C. Curren

GEM LOCALITIES

Kunzite from the Haapaluoma pegmatite quarry, western Finland. S. I. Lahti and R. Saikkonen, *Bulletin of the Geological Society of Finland*, Vol. 58, No. 2, 1986, pp. 47–52.

Small amounts of kunzite occur with common spodumene at the Haapaluoma pegmatite quarry near Peräseinäjoki, western Finland. This is the first reported occurrence of gem-quality spodumene in Finland. The typical zoned lithium-rich pegmatite is emplaced in granodioritic country rocks. Small transparent crystals of morganite and red tourmaline are also found at this locality.

The authors studied one 7-cm-long purple crystal in detail. The kunzite has refractive indices of 1.660, 1.665, and 1.679; a specific gravity of 3.19; and shows a weak orange fluorescence to both long- and short-wave ultraviolet radiation. Additional mineralogic data are presented, as is a discussion of mineral paragenesis in this pegmatite.

JES

INSTRUMENTS AND TECHNIQUES

Application de la résonance magnétique nucléaire à l'étude des gemmes (Application of nuclear magnetic resonance to the study of gems). I. Mallez, J.-M. Dereppe, C. Moreaux, *Revue de Gemmologie a.f.g.*, No. 88, 1986, pp. 7–8.

Nuclear magnetic resonance (NMR) is a nondestructive and potentially quantitative method of observing light elements (e.g., hydrogen, boron, beryllium, lithium,

sodium) in gemstones. However, it cannot be applied to trace elements. The characteristics of the signals emitted by different elements vary from stone to stone, and so can be used to establish the identity of a particular gem. NMR can also help in separating natural from synthetic gemstones; the example of emeralds is discussed. EF

JEWELRY ARTS

Guilloche—engine turning. J. Wolters, *Aurum*, No. 27, 1986, pp. 40–56.

Guilloche, or engine turning, is defined as “the engraving, by means of a machine, of precise, regular patterns and ornamentation consisting of straight or curved lines.” This technique has been practiced since the 16th century, initially only on soft, easily carved materials such as ivory, wood, horn, coconut, and some soft stones. Engine turning on metal began to appear in the late 18th century, when it was applied to a variety of objects including snuff boxes, watchcases, and lockets. In the 19th century, Carl Fabergé coupled *guilloche* with transparent colored enamels, achieving a pinnacle of perfection for the art.

This extensive article, by the director of the Pforzheim Goldsmiths School, gives the history of *guilloche* with descriptions of the machinery involved and the different types of ornamentation that can be produced. Well researched and concisely written, the article is handsomely embellished with 53 photos and plates; even the figure legends are very informative. EBM

Mokume-gane. S. D. Kretchmer, *Aurum*, No. 25, Spring 1986, pp. 24–33.

The goldsmith's art of *mokume-gane* (“wood-grain metal”) is re-emerging after centuries of neglect. The textured, patterned metals are the progeny of sword-making techniques developed in medieval Damascus, where iron and steel were folded and forged to form a strong, tensile laminate. Nonferrous *mokume-gane* originated in Japan about 300 years ago utilizing gold, silver, copper, and *shakudo*, a gold-copper alloy.

Today's gold *mokume-gane* is formed using the traditional Japanese techniques of material removal and subsequent forging, rolling, forming, or twisting of the laminated layers. The metals are further contrasted by chemical patination, which makes the piece appear “as though a trail of small black ants had trekked over it while it was still soft.”

Kretchmer has experimented with both soldering and bonding his own laminates (for details of the author's techniques, see the Spring 1983 issue of *Metal-smith*). Since soldering limits the quality and workability of the material, he bolts billets of 18K gold and *kuromido* (99% copper, 1% arsenic) together and heats them in a reducing atmosphere to 40°–50°C below the

lowest melting point of the metals in the stack. Preformed laminates of different-colored carat gold in stripes and patterns are now available commercially, primarily from Japanese manufacturers.

Pattern development with this technique seems almost limitless, including stripes, whorls, checks, and microscopic chevrons. Kretchmer has also engraved layered billets to create exotic, multicolored panoramas.

This technique is a costly one, however, since a great deal of noble metal must often be removed in order to create a pattern, and must then be refined before it can be reused. Despite the labor and the cost, *mokume-gane* is alluring to the eye and hand, a fusion of the legendary past and a fantastic future. SAT

JEWELRY RETAILING

Display—setting the stage for jewelry sales. S. S. Jensen, *Modern Jeweler*, Vol. 85, No. 11, 1986, pp. 54–57.

Jensen offers advice on jewelry display compiled from interviews with 13 presentation and packaging companies located around the U.S. The article's premise, as voiced by Margaret Furman of Visual Dynamics in San Francisco, is that the store should be viewed as a theater stage, artfully designed to set the mood for the audience (the customers) and enhance the jewels at center front.

With this premise in mind, the jeweler should lavish special attention on store windows, which can entice a new generation of shoppers who are already attuned to visually stimulating displays. Today's windows are uncluttered, skillfully lighted, and changed as often as every two weeks. Clever seasonal or story themes are very effective in window displays, and should be carried through to the inside of the store. Props need not be expensive, and can substantially add to the romance of the jewels. Neutral colors, such as soft grays and pastels, make versatile display backdrops, especially given the present popularity of colored stones.

Accompanied by many photos of professional jewelry displays, this article provides practical, proven advice on jewelry display. SAT

A jeweler's guide to female complexion. J. S. Philby, *Modern Jeweler*, Vol. 85, No. 9, 1986, pp. 48–57.

The third in a series of articles on female hands, face, and complexion, this article suggests that jewelers take advantage of the art of color consulting to match jewelry to a woman's face and hands. Color consulting involves categorizing a woman into one of the four seasons on the basis of her complexion, hair, and eye color. The author explains how to determine a woman's season and how to use the color palette within that season to coordinate her jewelry. Outlines are given to help jewelers identify stone preferences for each appropriate season.

Judi Fiotti

Men's jewelry—tradition and quality sells. S. Mitchell, *American Jewelry Manufacturer*, Vol. 34, No. 12, 1986, pp. 32–36.

AJM investigates the market for men's jewelry through queries of fashion editors, menswear designers, and shirt and jewelry manufacturers.

Now that American men are spending more on vanity items such as skin care products, fragrances and face lifts, can we assume the same will hold true for jewelry?

The consensus is guarded but hopeful. The emphasis in men's jewelry must be on function, quality, and classic styling. Watches are the number one jewelry item bought for and by men. Tie pins, tie bars, cuff links, stud sets, key rings, money clips, signet rings, luggage tags—all these can appeal to even the most conservative men. Gold chains are *passé* and forget about earrings, as those men so inclined can always buy from the far greater selection of women's earrings. Given that women buy 50% to 70% of men's jewelry and that sterling is hot in women's jewelry, it stands to reason that sterling must be seriously considered.

Anne Riswold

New: JVC's action of the month. *Jewelers' Circular-Keystone*, Vol. 157, No. 9, 1986, pp. 40–51.

The Jewelers Vigilance Committee is taking a strong stance by publishing each month the details of a legal action taken against a member of the trade who has failed to follow honest business practices. Executive vice-president of the JVC, Joel Windman, hopes that publicizing an "action of the month" will help keep the jewelry industry "more alert and more informed" about malpractices in the trade and the function the JVC performs in curbing these malpractices. Windman also stresses the responsibility of retail jewelers to stay informed gemologically so that they can check gems and hallmarks on incoming goods, and not have a "blind reliance" on what they are given or told.

This month's publicized action, prompted by written complaints from dissatisfied parties, exposes a misleading advertising campaign to promote diamond sales. It is hoped that publication of this and future actions will focus the trade's attention on how well the JVC has been performing the task of jewelry industry watchdog for the last 75 years.

EBM

SYNTHETICS AND SIMULANTS

Is diamond the new wonder material? A. L. Robinson, *Science*, Vol. 234, No. 4780, 1986, pp. 1074–1076.

The laboratory synthesis of polycrystalline diamond films on semiconductor metal or polymer substrates has been successfully achieved by Russian, Japanese, and American researchers during the last few years. Because of the exceptional physical properties of diamond, should this process become economical for industrial

applications, it would open the door to tremendous advances in cutting tools, optics, and electronics.

The two published manufacturing procedures have the same basis: An organic molecule is dissociated, via a high-energy or catalytic process, and the carbon is deposited as diamond on the substrate. However, the growth process itself is not yet understood. Growth rates range from 1 to 10 μm per hour, and continuous films of more than 1 mm thick have been reported. Although millions of dollars have been invested in this research, some key steps in certain applications are still missing. The author emphasizes that while all the possibilities still appear to be viable, there are "numerous tasks yet to be mastered before potential applications can be actualized."

EF

Différenciation entre les gemmes naturelles et les matériaux synthétiques par microspectrométrie Raman à laser (Separation of natural gems from synthetic materials by laser Raman microspectrometry). M.-L. Dele-dubois, J.-P. Poirot, H.-J. Schubnel, *Revue de Gemmologie a.f.g.*, No. 88, 1986, pp. 13–14.

Raman spectroscopy is a nondestructive method that identifies molecules and polyatomic structures on the basis of their vibration spectra. The Raman microprobe makes the identification of inclusions in gemstones possible with some restrictions: Neither the inclusion nor the host crystal should be too opaque or fluorescent, and the inclusion should be large enough (at least 1 μm) and close enough to the surface of the gem to give a signal that can be differentiated from that of the matrix. Examples are given of inclusions in natural stones that have been identified by this means.

This article (which was originally published in English in the *Journal of Molecular Structure*), is followed by a separate piece that discusses how to identify inclusions in synthetic rubies and emeralds by means of Raman spectroscopy.

EF

TREATMENTS

Farbung und Bestrahlungsschaden in elektronenbestrahlten blauen Topasen (Coloration and irradiation damage in electron irradiated blue topaz). K. Schmetzer, *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, Vol. 35, No. 1/2, 1986, pp. 27–38.

Nigerian topaz that is electron irradiated and then heated to produce a blue color is investigated and compared with blue topaz colored by other treatment methods (gamma ray and neutron irradiation) as well as with natural blue stones from Brazil, Nigeria, and Zimbabwe. The polarized optical absorption spectra of the Nigerian material reveal three strongly polarized absorptions bands, caused by two "X-centers" and one "Y-center." The relative intensity of the bands may vary

according to the type of treatment used; however, no distinctive feature between natural and treated blue topaz can be ascertained. Unfortunately, Dr. Schmetzer discusses spectroscopic results without showing any related spectra.

The electron-irradiated samples exhibit cracks and parting planes parallel to the cleavage plane, as well as a zoned structure: a light blue outer shell, an intermediate zone with a high concentration of macroscopic defects, and a colorless core. This shell-like structure is attributed to the temperature gradient caused by the water used to cool the crystals during irradiation. A patchy dark blue-violet color is sometimes superimposed on the light blue outer shell, and is thought to be related to trace elements because of its patchy pattern. *EF*

Glass fillings in sapphire. K. Scarratt, R. R. Harding, and V. K. Din, *Journal of Gemmology*, Vol. 20, No. 4, 1986, pp. 203–207.

The recent occurrence of glass-filled surface cavities in natural rubies has been well documented in the gemological literature. In this article, the authors analyze the glass filling of a surface cavity in a faceted sapphire, and attempt to establish the origin of such glass fillings. They postulate that they may be (1) a volcanic glass, (2) a man-made glass, or (3) the result of the melting of natural inclusions.

The authors conclude that the glass fillings in rubies and sapphires represent a range of compositions, some of which could be natural. It is unlikely, however, that any of the glass inclusions reported thus far are natural volcanic glass. In the sapphire studied, the glass filling was man-made.

The article is well written, and contains a nice list of references on related topics. *David C. LeRose*

MISCELLANEOUS

Evaluation/decision process for small-scale placer gold mining. M. J. Richardson, *Mining Magazine*, Vol. 154, No. 4, 1986, pp. 312–317, 319, and 321.

Richardson analyzes the process of evaluating small-scale placer gold mining operations. Sampling, feasibility, and equipment selection are among the topics discussed.

Most small-scale placer gold mines fail because of the lack of competent evaluation prior to the purchase of equipment and the commitment to mine the property. First the presence of gold in quantities that will allow profitable mining must be established. Next the overall size and type of deposit must be evaluated. Only then should the miner determine which process he will use to recover the gold and the equipment he will need. Equipment selection is discussed in detail.

The author also discusses specific operations such as excavation and personnel. A backhoe augmented with a bulldozer and/or front-end loader is the most efficient

piece of equipment for excavation. In the search for personnel, Richardson stresses the importance of finding people who have experience in successful small-scale placer gold mining.

Finally, the author presents four questions for prospective miners. If he answers them accurately and honestly, the miner can significantly reduce the risk of his gold mining venture. *Barton C. Curren*

A former-king's ransom. B. Hillier, *Los Angeles Times Magazine*, February 22, 1987, pp. 30–31.

This article, which appeared in a magazine with a circulation of well over a million, proves that the April 1987 auction of the Duchess of Windsor's jewelry—by the renowned London auction house Sotheby's—captured the interest of not only the gemological community but also the popular press. Although brief, the article does serve up a few details about the actual pieces being auctioned, even if it dwells primarily on romantic anecdotes surrounding the famous courtship between King Edward VIII and Wallis Warfield Simpson, the American divorcee he married in 1936 at the expense of his throne. On April 2 and 3, 1987, almost a year after the death of the Duchess, Sotheby's auctioned a jewelry collection that included some 87 pieces by Cartier, the Windsors' "court jeweler," and 23 pieces by Van Cleef & Arpels. The author singles out the Duchess's engagement ring—"a large emerald mounted in gold with small diamonds on the shoulders"—as an item of particular interest. Also described and illustrated are a charm bracelet hung with nine jewel-studded gold crosses and a group of Cartier "great cat" jewels—bracelets in the form of panthers and tigers. The author also cites the royals' penchant for engraving personal messages on the jewelry, including some in facsimile of Edward's handwriting and others that are actually clever puns. The author notes that one of the "most touching mementos of the royal couple" is a diamond-studded gold medallion memorializing their cairn terrier, nicknamed "Mr. Loo." This is certain to be one of many popular articles dealing with the well-publicized Windsor auction. *JMB*

40 years in the hot seat—Dick Frankovich retires. *American Jewelry Manufacturer*, Vol. 34, No. 105, 1986, pp. 28–34, 36, 38–40, 42, 44, 46–47, 50.

This extensive interview with George R. (Dick) Frankovich, recently retired vice-president and executive director of the Manufacturing Jewelers and Silversmiths Association, reveals the development of the association from a small regional group of 200 members to a major national organization.

Frankovich originally joined the group in 1946 as an industrial engineer. He used his expertise in this area to help the jewelry industry convert from war-time production of items such as buttons, buckles, and bullets to the peace-time manufacture of jewelry.

In just two years, Frankovich became head of the

association. He was responsible for the creation of *American Jewelry Manufacturer*, a technical publication designed to reach thousands of nonmembers with the MJ&SA message. In time, it became a strong tool for promoting growth for the organization. During the 1950s, MJ&SA gained a stronghold in Washington, resulting in the passage of legislation beneficial to the industry. One major victory in Washington was the lifting of an excise tax that had been placed on luxuries during the war. Although they only managed to reduce the tax by half (from 20% to 10%), it was an important step for the entire jewelry industry.

MJ&SA has also addressed such issues as free trade, the dropping of tariffs and how it would affect the U.S. industry, the purchasing and pricing of gold after the Treasury closed the door on gold in 1968, as well as the issue of correct gold refinement. The organization has also been extremely influential in the marking and stamping of gold, and headed the action for "plumb gold" in the 1970s.

The organizations with which the MJ&SA has been closely associated, such as the Jewelers of America, and the accomplishments in which they have jointly succeeded are also brought into the interview. The article ends on a note about the future of the organization: Matthew Runci is Dick Frankovich's successor at MJ&SA. The idea of new leadership seems exciting, but Dick Frankovich is definitely a tough act to follow.

Mary Hanns

The Homestake—America's greatest gold mine. J. C. Zeitner, *Lapidary Journal*, Vol. 40, No. 8, 1986, pp. 48–52.

Rumors of gold in the Black Hills of South Dakota started as early as 1833, and in 1863 the G. T. Lee party actually did mine some gold. But because the area was so isolated and the Sioux Indians were at war much of the time, development did not start until 1874, when a party led by General George C. Custer discovered gold on French Creek. After this discovery, little could stop ambitious prospectors.

In February 1876, a party of prospectors led by Moses and Fred Manuel filed lode claims in Bobtail Gulch. That spring, they began work at the open-cut mine they called the Homestake. The mine grew quickly and more claims were filed. Gold camps began to spring up, including the present-day towns of Lead (pronounced *lead*) and Deadwood. The camps grew quickly and attracted many soldiers of fortune, resulting in a rash of gunfights, train and stage robberies, and hangings.

Meanwhile, the Manuels and their partners eventually sold the expanded Homestake mine (then 4½ acres) to Senator George Hearst of California for \$70,000. Hearst and his partners continued to develop the mine and expand to adjacent properties, until their best claims formed a strip 1½ miles long and ½ mile wide. By the late 1800s, 1,500 people were employed by Homestake.

The growing mine suffered many problems. Water was either scarce or overly abundant, cave-ins were frequent, and fires wreaked havoc. Still the mine continued to produce.

The ore body of the Lead-Deadwood area is Precambrian and consists of six major formations. The bottom of the ore body has still not been reached, although the mine is now 8,000 ft. deep. During its 100 years of existence, the Homestake mine milled 115,491,582 tons of ore to produce 31,510,612 oz. of gold and 7,285,784 oz. of silver. Currently, exploration continues more than 1½ miles beneath the surface.

Homestake Mining Company now has mining interests in several states as well as in Canada, Australia, Peru, and the Philippines. It has also diversified outside of the mining industry.

Zeitner has presented a fascinating article on the colorful history of America's greatest gold mine, which has been in continuous operation longer than any other gold mine in the world. *Barton C. Curren*

Treasure houses of the world. P. Bancroft, *Lapidary Journal*, Vol. 40, No. 5, 1986, pp. 21–26.

Subtitled "A traveler's guide to outstanding mineralogical museums abroad," Dr. Bancroft considers the merits of seven museums, four in Western Europe, two in Australia, and one in New Zealand. For each, he gives a brief historical overview and describes the main emphasis of the collection.

Nine color pictures depict specimens in the collections as well as interior shots of the exhibits.

Patricia Gray

Utilisation gemmologique des minéraux des timbres Français (Gemological use of the minerals from the French stamps). J.-P. Poirot, *Monde et Minéraux*, No. 75, 1986, pp. 28–36.

The French government recently issued four postage stamps featuring quartz, calcite, fluorite, and marcasite, and Poirot took the opportunity to describe the gemological use of these four minerals. Poirot, a specialist in gem history, describes in detail the origins of quartz lore, and relates the history of quartz carving. The use of quartz to substitute for other gemstones or in doublets dates from antiquity, and now treatment (especially irradiation) is quite common. Poirot emphasizes that quartz is presently making a come-back in fine jewelry. Calcite is briefly discussed, mainly for its polarizing properties. Fluorite is primarily used for decorative purposes, although cut green fluorites are very much sought after. Poirot insists that what is commonly called marcasite in jewelry is, in fact, pyrite, and that the mineral marcasite has never been cut as a gem. The misnomer arose from the French name *marcassin*, which has been applied by miners to describe both sulfides. *EF*