

GEMS & GEMOLOGY

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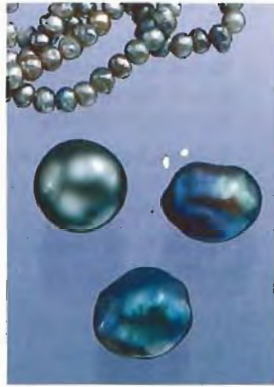
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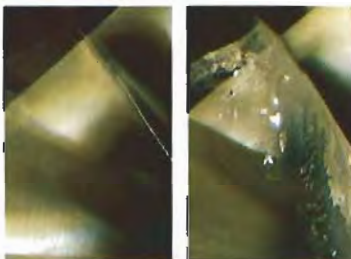
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ABOUT THE COVER: Pearls of the Americas flowed into Spain throughout the 17th and 18th centuries. The calm waters of La Paz Bay, in the Gulf of California, have produced some of the finest pearls from this region. However, the value of these fine, dark pearls led adventurers and entrepreneurs alike to overexploit the pearl oysters, almost destroying the beds several times before the early 20th century. From 1903 to 1914, the pearl-oyster cultivation operation established by Gastón Vives—the first major operation of its kind, not only rebuilt the beds, but also led to the greater recovery of fine pearls as well as mother-of-pearl. The lead article in this issue reviews the fascinating history of pearling in La Paz Bay, and looks at future prospects for pearl culturing in this area.

The loose Baja California pearls (largest about 10 mm) and gold jewelry are courtesy of Pala International, Fallbrook, CA; the necklace (pearls ranging from about 2 to 3 mm in diameter) is courtesy of Caroline Pei, Fionna's, Orinda, CA. Photo © Harold & Erica Van Pelt—Photographers, Los Angeles, CA.

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RUSSIA REEMERGES AS A GEMSTONE GIANT

Richard T. Liddicoat, Editor-in-Chief

As Russia evolves politically and economically, it is also emerging as a major force in the international gem world. Today, the diamond industry is captivated by ongoing contract negotiations between the various elements of the Russian diamond producers and De Beers's Central Selling Organisation. On another level, the gem-quality synthetic diamonds produced in Russia are being treated with respect—and concern. Numerous other synthetic gem materials are also manufactured in Russia and in other republics once part of the former Soviet Union: These include several-kilogram pieces of synthetic malachite, huge quantities of synthetic amethyst, and hundreds of thousands of carats of well-made—and potentially deceptive—synthetic emerald.

One of the most fascinating developments, however, is the renewed interest in mining for colored stones. In the Winter 1994 issue, we reported on newly discovered deposits of ruby in the Ural Mountains; the current issue looks at heightened mining activity in the emerald-rich area near Malysheva, farther north in the Urals. Recent reports have also pointed to the emergence of large quantities of pegmatitic minerals, such as topaz and beryl. And deposits of historic gem minerals, such as Russia's exceptional demantoid garnets, are again being actively explored and developed.

During much of its existence as a political entity, the Soviet Union was lost to the outside world as a source of colored stones. In the Ural Mountains, miners dug for beryllium (as a strategic ore), not emeralds, and most other gemstone mining almost ceased. The same was not true for diamonds, of course, because they had an important role in industry, as well as provided a huge potential for hard currency. After the first of many diamondiferous pipes was discovered in 1954, it took several years to bring the first of the several fabulously rich Siberian kimberlites into production. The West was never informed of the magnitude of the output, but had to rely on estimations based on the apparent quantity of polished goods coming from the large Soviet cutting plants, plus estimates of the quantity of rough marketed through the CSO. Since the Soviets limited the maximum size of the goods shipped to London to under 14 carats, and no Westerner was known to be privy to either the size of the stockpile withheld, or the caratage mined, current information suggests that outsiders' best estimates were far short of the actual numbers. The key questions now are the size of the current stockpile and future reserves.

For the colored stone industry, however—now that entrepreneurial profit is again an acceptable motivating factor in Russia—the possibly enormous potential of the Urals and the almost untouched territory to the east also present exciting possibilities. We look for many new finds over the coming decades, and for Russia and other states of the former Soviet Union to become increasingly important players in the colored stone supply arena.

HISTORY OF PEARLING IN LA PAZ BAY, SOUTH BAJA CALIFORNIA

By Micheline Cariño and Mario Monteforte

The history of Baja California has been closely tied to the exploitation of pearls since the 16th century. Using rudimentary diving techniques for most of this era, European and Mexican entrepreneurs recovered vast amounts of fine, dark pearls from this region. However, years of overfishing inevitably led to decades when the oyster beds were all but barren. Introduction of the diving suit in the 19th century extended the depth of the beds that could be fished, but overexploitation continued largely unchecked. Cultivation of the pearl oyster *Pinctada mazatlanica* by Gastón Vives, between 1903 and 1914, greatly slowed exhaustion of the natural stock. His company, CCCP, represented the world's first large-scale cultivation of pearl oysters, and many of Vives's discoveries are used today in renewed pearl-oyster cultivation and pearl-culturing activities in Baja California.

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Acknowledgments: The authors especially thank the descendants of Don Gastón Vives (Don Juanito Vives, Doña Yolanda Vives de Barrón, and Lic. Gastón Barrón Vives), who donated the early photographs and provided valuable information. In 1987, the senior author conducted a two-hour interview with J. Vives Lucero, the son of Gastón Vives, now deceased. We dedicate this work to the memory of Don Gastón Vives.

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For more than 400 years, the exploitation of pearl resources decisively influenced the history of Baja California, Mexico's northwest peninsula. It represents an important chapter in the world history of pearling. From the 16th century onward, pearls from the Gulf of California have adorned European royalty (figure 1), and many beautiful examples can be found in religious treasures such as those of the cathedrals of Toledo and Seville in Spain. During the 19th and early 20th centuries, mother-of-pearl from Baja California comprised an important portion of the international market for this ornamental material. Yet, surprisingly little has been written about these special Baja California products, either in contemporary accounts dealing with pearl fisheries, cultivation, and pearl-oyster trading, or in the history of the region itself.

Natural pearls of the pearl oyster *Pinctada mazatlanica* are typically baroque or semi-baroque, with a silver to dark gray body color and strong overtones of blue, lavender, and green (figure 2). Sometimes a reddish or purple hue can be seen in pearls obtained from oysters established in deeper, colder water, or from older oysters. White or golden hues are rare. The other pearl oyster indigenous to the Baja California region, *Pteria sterna*, produces smaller but rounder natural pearls, in a wide variety of hues: Purple and violet are in general the most common body colors, with overtones of green, blue, and lavender, similar to those of *Pinctada mazatlanica*, also seen. Some *Pteria sterna* will yield up to 10 pearls in a single oyster, but most are no more than a few millimeters in diameter (called *moralla*, or "coarse sand"). However, we have seen pearls as large as 20 mm in diameter from *Pinctada mazatlanica*, with the region once known for its production of larger pearls. Figure 3 illustrates the broad variety of colors, shapes, and sizes in which pearls from Baja California occur.

The first part of this article concerns the fisheries period, from the 15th through the 19th centuries, including the transition from traditional diving methods to large-scale exploitation through the intensive use of compressed-air

Figure 1. Large dark pearls, undoubtedly from the Spanish empire in the Americas, adorn Queen Isabel of Valois—wife of Spain's King Philip II—in this 1579 oil painting by Juan Pantoja de la Cruz. Vast quantities of pearls were recovered from the Gulf of California and the Pacific Coast of what is now Central and northern South America following Spain's conquest of the region. Photo courtesy of the Prado Museum, Madrid, Spain.



diving gear, such as diving suits. The second part examines Latin America's first aquacultural experiment and the world's first large-scale pearl-oyster cultivation operation (Cariño, 1994), by the *Compañía Criadora de Concha y Perla de Baja California* (Baja California Archives 1). Founded in 1903 by Gastón Vives, the *Compañía Criadora* successfully revived pearling and the pearl-oyster industry in southern Baja California in the early

20th century. This second part looks at the technological accomplishments of this operation and its impact on the local region before it became a casualty of the Mexican Revolution of 1910–1917. Today, following decades of overfishing, pollution of the environment, and massive mortalities due to as-yet-unknown causes, these early efforts serve as the basis for a strong research effort to reinstate a pearling industry in La Paz.



Figure 2. Natural pearls from Baja California occur in a variety of hues. All reportedly from Baja California, the pearls in this 1920s-era multi-strand necklace are about 2–3 mm in diameter; the largest fine loose pearl is about 10 mm. Necklace courtesy of Caroline Pei, Orinda, California; loose pearls courtesy of Pala International, Fallbrook, California. Photo © GIA and Harold & Erica Van Pelt.

EARLY PEARL FISHING IN SOUTH BAJA CALIFORNIA

The long, slender Baja California Peninsula occupies about 1,800 km (1,100 miles)—from 23°N to 32°N—of northwestern Mexico’s Pacific coast, but it has an average width of only 140 km (87 miles). It is separated from the continental coast of Mexican states Sonora and Sinaloa by the Gulf of California. The city of La Paz is located near the southern tip, where the peninsula is farthest from the mainland (figure 4). It is insular in many respects.

Historic La Paz includes the bay and adjacent islands. The oceanographic characteristics (such as stable water temperature, low turbidity, and high quality and concentration of nutrients) of these shores favor the development of pearl-oyster populations with a high yield of fine natural pearls (4%

to 6% at the height of the pearl fisheries—in the 1920s—according to interviews with old fishermen or their families, and as reported in government documents issued at the time). Very few regions along the geographic distribution range of the mother-of-pearl *Pinctada mazatlanica* and the rainbow mabe *Pteria sterna*—the two native species of pearl oysters in the Gulf of California (figure 5)—have comparably favorable conditions. This has made pearl fishing more important in La Paz than in other regions of the Gulf of California and the tropical Pacific coast of America (again, see figure 4; Monteforte and Cariño, 1992). In addition, the coastal topography of La Paz Bay and the tranquility of its waters have made the inlet at La Paz a calm natural port for all kinds of vessels. The Spanish conquerors recognized these attributes of the La Paz area and duly exploited them from the 16th century on, as fishing and other maritime activities largely propelled Spanish colonial expansion in Baja California (Cariño, 1990).

Pre-Hispanic Fishing for Pearl Oysters. Even before the Spaniards arrived, the peninsular aborigines included pearl oysters in their diet. They collected them (along with many other kinds of mollusks) by simply diving head-first off boats into the bay (figure 6), detaching them from the rocks using a wooden pike, and then storing them in crude nets. The most impressive aspect of this technique was their ability to distinguish mollusks from rocks, using only their trained eyes (del Barco, 1973). The Pericues, the ethnic group that lived in the southern part of the peninsula and on the islands, appreciated the beauty of pearls, using them decoratively in their hair (Clavijero, 1789).

When the first Spanish expedition reached the peninsular coast in 1533, the explorers noticed both the Indians’ beautiful pearls and their diving ability. They brought the news of the abundance and quality of these pearls both to the colonists of New Spain (the name the Spaniards had given to what is now mainland Mexico) and to their sponsors in Spain. Their tales awakened the greed of many adventurers and sailors, who subsequently explored and attempted to conquer the peninsula during the 16th and 17th centuries (del Río, 1985). Even the name by which the peninsula was called, *California*, was related to the pearling potential of the Gulf. The origin lies in a popular 16th-century legend in which it was said that “toward the west in the Pacific Ocean [. . . a la Diestra Mano de las



Figure 3. This collection of natural pearls, all reportedly from Baja California, show more of the interesting shapes and colors in which pearls from this area occur. Note that most are baroque, as round pearls from this region are very rare. The largest is 16 × 11 mm; the smallest is 4 mm. The larger pearls usually are recovered from the large pearl oyster *Pinctada mazatlanica*, with the smaller pearls recovered from the smaller *Pteria sterna*. Courtesy of KCB, Santa Monica, California; photo © GIA and Harold © Erica Van Pelt.

Indias . . .] there is an island named California inhabited only by beautiful amazons, governed by Queen Calafia, who ride on griffins and wear nothing but jewels made of gold and pearls" (Meade, 1984; del Río, 1985).

Pearl Oyster Exploitation during the Spanish Colonial Era. After the expeditions of Hernán Cortés in 1535 and 1539, and those of Viceroy Antonio de Mendoza in 1540, the architects of the Spanish empire recognized the importance of conquering and colonizing this geo-strategic area. In particular, the transpacific route of the Manila galleons made it imperative to establish a port in California. However, early attempts failed, due to the peninsula's aridity and isolation.

In the last two decades of the 16th century, the colonial government evolved a strategy to encourage the mapping and exploration of the Baja

California coast without any cost to the royal treasury. Aware of the greed for pearls that possessed many adventurers, the government granted pearl-fishing licenses to those who had the means to search for the needed port. If the license holder failed to show progress, the royal permission to exploit the pearl-oyster grounds was given to someone else.

Beginning with the issuance of the first license in 1586 (*Californiana I*), pearl fishing was incorporated into the *Indias* (the name given to the Spanish colonies in America) legislation that gave the Spanish Crown monopoly rights to exploit the natural resources of these colonies. These resources could only be exploited with specific permission, which was contingent on payment of the *quinto de perlas* (one-fifth of the pearls found) to the colonial administration. During the 17th century, many entrepreneurs acquired pearl fishing



Figure 4. Since the 16th century, the history of Baja California has been tied to the exploitation of pearls, as oceanographic conditions in the Gulf of California support pearl oysters with a high yield of fine natural pearls. The left inset shows a detail of the La Paz area. In the upper right inset, the lavender line along the coasts of Mexico, Central, and northern South America shows the range of pearl oysters *Pinctada mazatlanica* and *Pteria sterna* (adapted from Keen, 1971).

licenses and traveled to the Gulf of California in the hope of making their fortunes: This period has become known in regional history as the “Century of the Pearl Explorers” (Mathes, 1973; del Río, 1985). Sebastián Vizcaíno, who mounted two expeditions (in 1596 and 1602), Tomás de Cardona (in 1611), and Pedro Porter y Cassanate (in 1640), were some of the better-known entrepreneurs seduced by the promise of a bounty of beautiful pearls (Mosk, 1927).

These adventurers encountered many obstacles, such as the difficulty of navigating in the Gulf, a precarious subsistence in arid Baja California, dependence on indigenous labor, and even pirate attacks. Because of these obstacles—and their reluctance to pay the full tax (the *quinto de perlas*)—it is difficult to estimate the success of these ventures and the production from their efforts. Nevertheless, although they rarely claimed any economic gain from the pearl fisheries, they continued to petition for pearl-fishing licenses.

The contradictory reports that the Spanish

Crown received concerning this mysterious peninsula caused King Carlos II to launch an official expedition in the late 17th century (from 1683 to 1685) to evaluate California’s economic potential, in order to help the colonial administration decide whether it should establish a settlement there. After an intensive six-month survey, during which the Indians were forced to extract even the youngest oysters, Admiral Atondo y Antillón recovered only some misshapen pearls of very little value. He reported an alarming impoverishment of the pearl-oyster grounds (*Californiana III*). This early overexploitation of the pearl-oyster populations can be considered Baja California’s first ecological disaster.

Given these poor prospects, the Spanish Crown decided to divert its limited resources to other regions, with greater economic potential, leaving administration of the area largely to the Catholic church. Since the beginning of Jesuit colonization in 1697, the missionaries’ domain had expanded from the spiritual to the material, thus

giving them the power to restrict pearl fishing. As a result, between 1697 and 1740, the pearl-oyster grounds were largely replenished by natural recruitment.

In 1740, a bizarre natural occurrence resulted in the expulsion of thousands of pearl oysters from the ocean onto the northern shores of the Gulf. This rare occurrence (in fact, this is the only one known of such a phenomenon) not only changed the Jesuits' plans to keep California free from all kinds of luxury and vain desires, but it altered the history of the entire peninsula as well. The Indians of the San Ignacio mission told a soldier, Manuel de Ocio, of this spectacular event. Ocio then resigned his military post, collected these treasures from the beaches, and began to sell pearls on the mainland. There he bought all the equipment necessary to exploit the virgin pearl-oyster grounds of the northern Gulf of California (del Barco, 1973). From recent investigations, we have concluded that Manuel de Ocio must have collected the rainbow mabe *Pteria sterna* in particular, since this is the only pearl-oyster species that appears in those northern waters (Monteforte and Cariño, 1992). Although this species produces a pearl that is typically smaller and inferior in quality to that of the mother-of-pearl oyster *Pinctada mazatlanica*, it has a higher pearl production ratio: Today, approximately 2%–4% of the *Pteria Sterna* recovered con-

tain pearls, as compared to less than 0.3% for *P. mazatlanica*, according to interviews with fishermen and personal observations from culturing experiments.

Ocio's success marked the first time in Baja California history that riches obtained by exploiting area resources significantly improved local socioeconomic conditions. After intensively fishing the rainbow mabe pearl-oyster grounds for seven years, in 1748 Ocio used his profits to establish mining activities and raise cattle in the southern peninsula (Amao, 1981). Ocio also understood the importance of controlling navigation in the gulf, over which he obtained considerable influence when he obtained exclusive pearl-fishing licenses in both 1754 and 1759 (Gerhard, 1956). The diverse activities he supported contributed to the establishment of a permanent secular settlement and an economic structure that remained almost unchanged until the early part of the 20th century.

It has been reported that, for a period, the number of pearl oysters Ocio's divers captured was so great, no time was spent opening them; instead, they were thrown on the sand to be opened by the heat of the sun (Crosby, 1982). By 1756, however, production was dwindling, as the overexploited pearl-oyster grounds showed signs of severe impoverishment.



Figure 5. The mother-of-pearl *Pinctada mazatlanica* (left) is the larger and rounder of the two pearl oyster species native to the Gulf of California. The other oyster, *Pteria sterna*, is smaller and has a unique "wing" projection on the ventral area of the shell. All of these shells came from cultivated oysters. The base of each is about 9.5 cm wide; the *Pinctada mazatlanica* is 16 cm high. Photo © Harold & Erica Van Pelt.



Figure 6. Historically, the most common method of harvesting the pearl-bearing oysters was to dive head-first off a small boat and swim down to the oyster beds. This photo was taken in La Paz Bay around 1908.

Only ignorance of the true condition of the pearl-oyster colonies could explain the enduring faith in the revival of the pearl-fishing industry during the last decades of the 18th century. The Marquis José de Gálvez, *Visitador General* of New Spain from 1765 to 1771, tried to create a company with the dual purpose of promoting mining in Sonora and Sinaloa and reestablishing pearl fisheries in the gulf (Navarro, 1964); but despite the involvement of high colonial officialdom, the company only existed on paper. During the late 18th and early 19th centuries, pearl fishing was sporadic. It had become an essentially worthless enterprise due to the deplorable condition of the pearl-oyster grounds that could be reached by the conventional diving method.

After the Revolution for Independence: A Revolution in the Pearl Industry. When it won political independence from Spain in 1821, Mexico also achieved its independence from Spain's monopoly on commercial activities. This coincided with the natural replenishment of the wild pearl-oyster population that resulted from decades of little to no pearl fishing following the 18th-century exhaustion of the resource.

These were the two main factors that eventually led to a revival of the pearl-oyster industry in Baja California, as foreign investors were attracted by the new Mexican political situation and the renewal of the pearl-oyster beds. Baja California

pearls and mother-of-pearl shells again entered the world market, this time with more interesting prospects.

In 1836, a French businessman named Jacques Combier perceived great opportunities in shell exportation (Diguët, 1895), an alternative that the Spaniards had neglected. The nacre of *Pinctada mazatlanica*, in particular, with its fine orient and iridescence, promptly conquered the European markets and led to the establishment of joint ventures between wealthy local businessmen and European companies dedicated to the export of this valuable product, which was popular for buttons, luxury furniture, fine ornaments and jewelry, inlays in wood and metal, and a variety of handicraft (figure 7).

From 1840 on, export of pearl-oyster shells increased steadily. In fact, the shells became a more important income source than the pearls themselves. The entrepreneurs were able to capture as many oysters as they liked, and use virtually all that they captured, income no longer being determined by the capricious find of a pearl. Yet sales of the pearls that were occasionally found inside the oysters resulted in net profits for the entrepreneurs.

It is important to note that in the first half of the 19th century, almost all the pearl-fishing fleets were owned by entrepreneurs from coastal states on mainland Mexico. From 1850 on, however, it became more common for these fleets to belong to

residents of La Paz, Mulegé, and Loreto—all cities of Baja California itself (Baja California Archives 2). Most of the divers were Yaqui and Mayo Indians who lived in Sonora and Sinaloa, but from 1851 on, they began moving to La Paz. This migration was a direct result of a proclamation by the Territorial Assembly of Deputies of Baja California, which imposed higher duties on the *armadores* (those responsible for the administration of the fleets) for divers who did not reside in the territory (Baja California Archives 3).

Largely as a result of these developments, La Paz began a period of prosperity that lasted from the mid-19th century into the 1920s: 75 years that are considered the height of pearl fishing in the Gulf of California. Numerous pearl-fishing fleets explored the waters off La Paz, each employing about 50 divers that still used the same naked-diving method as during Colonial times. Each fleet was usually composed of one or two brigantines (two-masted sailing ships that served as “mother boats”) and several canoes (figure 8). Diving activity was restricted by water temperature and visibility, both of which were best between May and October.

Before the mollusks were opened, they were divided between the *armador* and the divers in a proportion agreed on at the beginning of the diving season. The only payment the divers received were the pearls found in their share; the *armador* kept all the shells—and the pearls in his share. The divers were free to sell their pearls to anyone, but they usually gave them to the *armador* in payment for the food he provided throughout the season (Esteve, 1857).

In 1857, José María Esteve, provisional governor of Baja California, took one of the first measures to conserve pearl resources. He promulgated an ordinance that established four fishing zones in the Gulf of California, but authorized pearl fishing in only one of them annually, thus giving the other three time to recover their natural stocks. Local judges were to oversee the efficient implementation of these measures and designate sites where divers were required to plant adult oysters to help natural repopulation of the pearl-oyster beds. Unfortunately, the lack of funds to enforce these ordinances rendered them ineffective, and overexploitation again ensued. By 1870, the pearl-oyster populations established from 2 to 25 m depth—that is, those that could be harvested by the traditional diving method—were, once again, almost

completely exhausted. Only the introduction of compressed-air diving suits enabled the pearl fisheries to continue operating, since this equipment allowed the exploitation of deeper areas (Mosk, 1941).

NEW TECHNOLOGY BROADENS PEARL FISHING: INTRODUCTION OF THE DIVING SUIT

Beginning in the early 19th century, there were several failed attempts to introduce modern diving techniques in the region. Compressed-air diving gear (called “scaphanders” at the time; figure 9) was not successfully used in this region until 1874, when two divers, an Italian and an American, arrived in La Paz with eight sets of gear they had previously used for pearl fishing in the Gulf of Panama (Diguët, 1895). By exploiting the untouched pearl-fishing grounds located below 30 m, they gained a fortune so great that they retired after only six months, having paved the way for the modern era of pearl exploitation in Baja California. Local pearl entrepreneurs with sufficient financial resources immediately began importing similar equipment from Europe and the United States.

Figure 7. During the 19th and early 20th centuries, the shells (for their mother-of-pearl)—and not just pearls—became an important export for Baja California. Earrings such as these (5.5–6.5 cm long) represent just one of the great many uses of mother-of-pearl. Photo © Harold & Erica Van Pelt.





Figure 8. Pearl-fishing fleets, like the one in this 1914 photo, were a common sight off La Paz from the mid-19th century into the 1920s, the height of Baja California pearl fishing. The fleets usually consisted of one or two “mother boat” brigantines and several canoes.

The use of diving suits not only increased both attainable depth and immersion time (divers were able to descend as deep as 70–80 m and work there for more than two hours at a time, although there were many fatal decompression accidents), but it also extended the diving season, since the temperature of the water and visibility were no longer obstacles. As the equipment became more sophisticated, however, costs also increased, thus limiting opportunities for involvement in the industry to relatively wealthy businessmen and important companies owned by foreign and national investors.

Between 1884 and 1912, President Porfirio Díaz endowed virtually exclusive pearl-fishing rights to five foreign companies. One of the most important was the *Compañía Perlífera de Baja California* (the Pearl Company of Baja California), which collected pearl oysters throughout almost all the Mexican Pacific coastal region (Mosk, 1941). According to observations made in 1889 by naturalist Charles H. Townsend, the *Compañía Perlífera* employed between 400 and 500 men every year and owned about 70 diving units (Townsend, 1889). During the summer, the company worked the pearl-oyster grounds off the Gulf of California coast; in the autumn, it worked those lying off the continent. Huge quantities of shells were kept in its three large La Paz warehouses,

ready to be shipped to European markets, where they would be used for the manufacture of various mother-of-pearl items. In 1889, eight tons were exported. Most of the pearls were sold in Paris and London. Prices for both products were as much as 60 times higher on the international market than locally, assuring large profits for concessionaires (Kunz and Stevenson, 1908).

In exchange for granting exclusive fishing rights, the government imposed various conditions, such as the employment of Mexican workers, the nontransferability of concessions without specific authorization, a prohibition on fishing young oysters, payment of a tax per ton of shell to the maritime customs, and an obligation to start experiments on cultivation. The first two conditions were easily accomplished by almost all the companies, since local labor was very cheap and no company was willing to give up its concession; the following two were scarcely practiced; and the last condition was observed by only one company, as will be discussed later.

In 1893, the *Compañía Perlífera* sold its entire concession to the Mangara Exploration Company, which had been originally created with British capital (Mosk, 1941). In the Gulf of California, the *Mangara* concession included the eastern coast of the peninsula from the mouth of the Colorado River to Cabo San Lucas (extending from the shore

to 10 km seaward), and on the continental Pacific Coast, from the port of Mazatlán south to the border with Guatemala (extending 5.5 km seaward), including the territorial waters of the Marias Islands (Baja California Archives 4; again, see figure 4). However, the concession near La Paz Bay—including the islands of San José, Espíritu Santo, and Cerralvo—remained under the control of local Mexican entrepreneurs.

Mangara Exploration had considerable success, annually collecting between 175 and 200 tons of shells. Despite the enormous profits, however, it paid low salaries and imposed difficult working conditions (Baja California Archives 4). From an ecological perspective, the excessive exploitation of all marine resources, pearl oysters in particular, had once again depleted the natural oyster population. Mangara routinely used explosives, extracted immature oysters, and destroyed the sea grounds without fear of reprisal, due to the lack of government vigilance. Moreover, the large concession held by this company eliminated many opportunities for Mexican fishermen and pearl entrepreneurs (at this time, unsanctioned diving was sternly punished as an unlawful activity). This situation led the people of South Baja California to demand revocation of the Mangara contract and liberation of the pearl fisheries (Baja California Archives 4). In 1912, following the first movement of the 1910–1921 Mexican Revolution, President Francisco Madero rescinded the contract (which was supposed to last until 1932) and indemnified the company with the then-huge sum of 300,000 pesos.

DEVELOPMENT OF PEARL OYSTER CULTIVATION IN BAJA CALIFORNIA

The damage done by Mangara magnified the importance of repopulating the pearl grounds through artificial breeding. This was accomplished on Espíritu Santo Island by Gastón J. Vives in the early part of the century. Only these efforts prevented this resource from being totally depleted by that time.

The Role of Gastón Vives. In 1880, Gastón Vives (1859–1939) was sent from Baja California to France to study medicine. However, his interests turned toward biochemistry, particularly the cultivation of flat oysters. After familiarizing himself with artificial breeding procedures, he decided to try applying them to pearl oysters.

Following his return to Baja California by 1885, Vives held important positions in the local municipal government (he was La Paz's first town councillor from 1894 to 1911; Baja California Archives 5). His political influence worked to his advantage, as he was granted the concession for pearl-oyster fishing in nine lagoons and along one island off the coast of La Paz Bay (Baja California Archives 6). The experience he gained from his early pearl-fishing ventures provided knowledge in the management of diving fleets, the world market for pearls and nacre, and the history of overexploitation in the local pearl fisheries. All of this served to his advantage when, in 1903, he founded the *Compañía Criadora de Concha y Perla de Baja California* (CCCCP).

Meanwhile, in 1893, A. P. Cattet sent a report to the governor of South Baja California in which

Figure 9. With the introduction of compressed-air diving gear in the late 19th century, the divers were able to go far deeper in the water and stay for a much longer period of time, thus greatly extending the range of pearl-oyster beds that were accessible. Helmet and safety rope in place, a diver working for Compañía Criadora de Concha y Perla goes over the side of a "mother boat" off La Paz. Photo circa 1912.





Figure 10. Open for inspection in this undated photo is one of several hundred "incubators," or spat collection devices, used by Gastón Vives in the Compañía Criadora de Concha y Perla. The 9-m³ wooden boxes were covered by 1-cm-mesh galvanized wire that permitted proper water circulation but excluded oyster-hungry predators.

he described pearl-oyster cultivation techniques in "Oceania" (the lands of the central and South Pacific, including Polynesia). After first warning that his specifications might not be valid for different sites or species, Cattet proceeded to explain the specific requirements for the successful artificial breeding of pearl oysters (Baja California Archives 7). He stated that the cultivation structures are best placed at a depth between 10 and 12 m in locations where the water currents do not exceed one knot. He also noted the advantage of coralline and rocky bottoms, as well as the benefits of shade, for the growth and survival of pearl oysters. Cattet's strategy for spat collection involved deploying collectors near dense pearl oyster beds and stressed the need to survey the collectors monthly. He also emphasized that the juveniles must remain in the collectors until they reached at least 4 or 5 cm in diameter (if we assume that Cattet was referring to the French Polynesian *Pinctada margaritifera*, this size would correspond to an age of approximately 2.5 to 3 months), and indicated their proper spacing and extension in the nurseries. We believe that this document establishes that the world's first positive pearl-oyster cultivation results were obtained in the islands of the Tuamotu Archipelago, in French Polynesia.

Vives (who, because of his position and his knowledge of the French language, may have read or even translated Cattet's report) nevertheless holds the distinction of having been the first to integrate such techniques into the large-scale cultivation of pearl oysters, in this case *Pinctada mazatlanica* (Cariño, 1994; Cariño and Cáceres, 1990), which was preferred over *Pteria sterna* because of the larger size of its shell and its superior mother-of-pearl (again, see figure 5). The outstanding scientific work of Vives was recognized by several American and European naturalists, including Leon Diguët (1919) and Charles Townsend (1911), both of whom visited the CCCP when it was active.

Technological and Commercial Aspects. For the CCCP, Vives designed original and efficient devices to function in each of the three phases of cultivation: spat collection, nursery cultivation, and late cultivation. He also built an impressive infrastructure at San Gabriel Inlet on Espíritu Santo Island in La Paz Bay, creating the first pearling station in the world, of which only a few ruins remain today.

For spat collection, Vives manufactured 9-m³ wooden boxes with compartments of 1-cm-mesh galvanized wire (figure 10). This permitted proper water circulation and prevented the entrance of predators. Inside these "incubators," he placed old shells and branches of a local water-resistant bush (*chivato*), as well as live mother-of-pearl oysters that were intended to serve as sources of larvae and spat (Vives, 1917–1919). Several hundred of these boxes were submerged in La Paz Bay at sites selected by Gaston Vives based on their orientation and exposure to water currents.

The incubators remained under water from May to October, the reproductive season of *Pinctada mazatlanica* (Monteforte and García-Gasca, 1994; Monteforte and Bervera, 1994). Vives claimed that spawning and fertilization took place inside the incubators, and that the spat would settle on the substrates provided. However, it is highly unlikely that this is entirely accurate given the reproduction process for mollusks (Alagarwami, 1970; Monteforte and García-Gasca, 1994).¹ Nevertheless, the average spat yield was about 10,000 individuals per box.

At the end of the collecting season, the heavy incubators were transported from the collection



Figure 11. CCCP workers carefully harvest young pearl oysters by hand from an "incubator." Average spat yield was about 10,000 per box.

sites to the pearling station at San Gabriel, where they were pulled ashore onto a concrete platform. There, under a large shed, the CCCP workers harvested the several million young oysters by hand (figure 11). They then transferred them to wire cages that were placed into special channels built at San Gabriel Bay, where the oysters remained during the nursery cultivation stage.

The San Gabriel nursery station was the most outstanding of Gastón Vives's inventions. He made

¹Fertilization in mollusks takes place in water when male and female gametes are released en masse by the individuals. It is a very hazardous process in which only a few ova will successfully meet the corresponding spermatozoid. (Of the almost 40 million gametes released by these species during spawning, only a few individuals will actually reach full size.) After fertilization, the mollusks pass through several microscopic larval stages until, at the final stage (called *Pediveliger*), the larvae begin to seek an appropriate substrate on which to settle. Once settled, the *Pediveliger* metamorphoses into a tiny spat (about 1 mm or smaller), with the shape of an adult, and begins to grow. This process, which takes place completely under water, lasts about 25 days in pearl oysters, during which time the larvae move freely with the currents. It is, therefore, not very probable that all of the larvae stayed in the incubators—constrained only by a 1-cm-diameter mesh—for the 25 to 30 days Vives indicated. Because of their concentration of adult mollusks, however, incubators do offer a higher probability of contact.

good use of the bay's coastal topography to build a dike 500 m long and 10 m wide, which transformed the inlet into a lagoon. Communication between the bay and the lagoon was achieved by means of a complex network of 36 channels and dams using tidal cycles (figure 12). The young pearl oysters (2–3 months old, 1–2 cm in diameter) harvested from the incubators were placed in these channels at a depth of 1.5 to 2.5 m. The oysters were installed in individual compartments in wire cages (1 × 0.3 m; figure 13) on the bottom of the channels, where they remained for six to eight months (the nursery cultivation stage) until they attained a diameter of about 6 cm. The channels were covered by palm sheds which eliminated excessive illumination and heat, but allowed sufficient air circulation to keep the water fresh during the hot season. Channel entrances were protected by fences that prevented the incursion of predators (crabs, lobsters, octopus, borer and carnivorous snails, rays and other large fish, etc.); in addition, guards armed with harpoons were posted at channel entrances and exits to kill any predator that succeeded in passing through the gate.

Figure 12. Palm-frond-covered roofs protect young oysters from too much heat and sun in a section of Gastón Vives's most outstanding invention—the San Gabriel Inlet nursery station. After harvest from the incubators, young pearl oysters were placed here in a complex of 36 channels and dams that harnessed tidal cycles. Fences and harpoon-wielding guards prevented crabs, lobsters, octopus, and other sea-dwelling predators from entering the nursery.





Figure 13. Gastón Vives (right) and his associate, Antonio Ruffo, examine wire cages filled with young pearl oysters ready for the San Gabriel Inlet nursery station.

When the oysters reached around 6 cm, they were taken from the nurseries and returned to the sea for the third and final cultivation stage. Vives used different methods to promote the growth and survival of these oysters and the formation of natural pearls. One innovation was the creation of several hectares of artificial rocky grounds in inlets and creeks chosen for their appropriate ecological characteristics and their high incidence of natural pearls. For these special grounds, Vives used canoes to transport huge boulders from the coastal hills. In addition, he further protected potential pearl-bearing oysters by shielding them with wire mesh and encasing them in individual handmade "suits of armor" with floating cork rudders (figure 14).

After three years, the oysters (16–18 cm in diameter, sometimes larger) were collected by CCCP divers (see, e.g., figure 9) and inspected for pearls in the fishing-fleet "mother boat," under strict supervision (figure 15). During the period 1909 to 1914, there were up to four harvests per year, yielding a total annual production of 5 million shells (10 million valves; 900 tons) for export, and between 200,000 and 500,000 natural pearls of

superior quality (J. Vives Lucero, pers. comm., 1987).

To give some idea of the significance of this production and the randomness with which natural pearls are found in the Gulf of California, we should mention that Manuel de Ocio obtained about 265 kg of pearls between 1740 and 1747, whereas some 55+ years before, Admiral Atondo y Antillón had found virtually nothing. It is estimated that, because of the sites selected and the techniques used, on average approximately 8%–10% of the CCCP-cultivated oysters produced pearls, one of the highest percentages of any known pearling area (Vives, 1908). Toulemont (1992, p. iv) states that "to find a fine natural pearl, it was necessary to open 500 oysters in the Persian Gulf, 5,000 in the Philippines Archipelago, and 15,000 *Pinctada margaritifera* were necessary to find a beautiful black pearl in French Polynesia. In Ceylon, nearly one million oysters were needed to get some dozens of pearls. . . ."

CCCP shells and pearls entered the world market in a relatively straightforward fashion. The mother-of-pearl shells were shipped to European and American markets in large wooden boxes. Gastón Vives personally traveled once or twice a year to New York and Paris to sell his pearls to the most important jewelers (J. Vives Lucero, pers. comm., 1987).

Aside from Vives's business and scientific expertise, it was the excellent reputation of Baja California pearls and nacre (again, see figures 2, 3, and 5) on the international market that was the most important element in the CCCP's rapid growth. At that point in history, both products fed a vigorous industry in Europe and the United States (Coeroli, 1994): The first two decades of the 20th century were the last years before artificial materials, such as plastic and acrylic, replaced natural (mother-of-pearl) nacre and before cultured pearls appeared on the world market (Taburiaux, 1983; Levi and Poirot, 1992).

Other Early Pearl Oyster Cultivation Efforts. In the 1890s and early 20th century, other pearl-oyster cultivation operations were set up, contemporaneous to the CCCP. As we mentioned earlier, these efforts started in French Polynesia with cultivation of the *Pinctada margaritifera cumingi*. Although these were the most advanced operations of the day, the methods involved only rudimentary spat collection using stones and tree branches. Also at

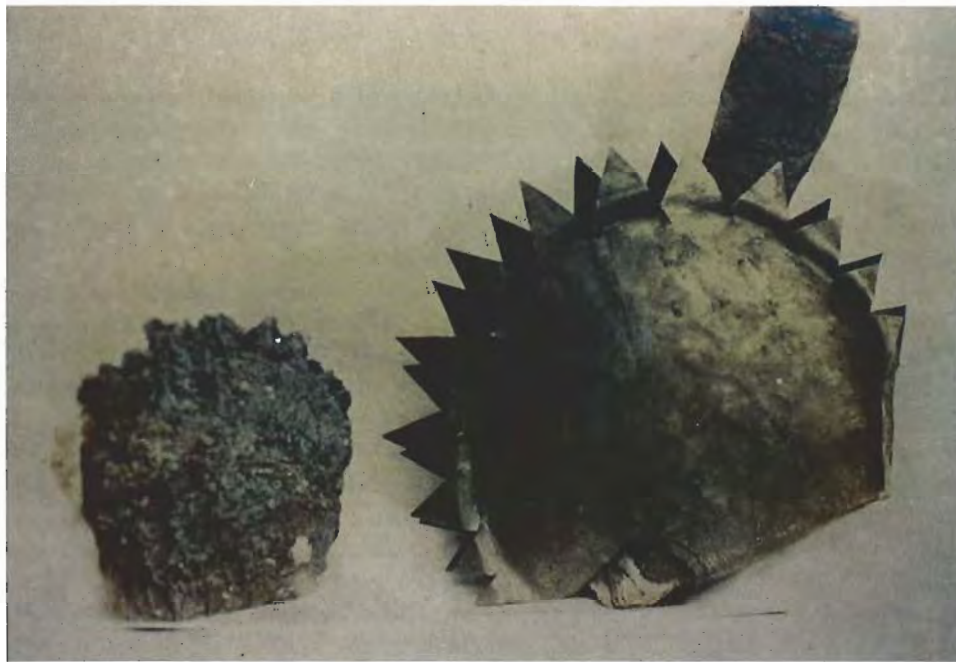


Figure 14. Before being returned to the sea for the third and final cultivation stage, each pearl oyster (like the one at left) was individually protected to discourage natural predators. Some were encased in wire mesh; others—like the one here—were outfitted with handmade spiked “suits of armor.” The cork rudders (top right) provided orientation for the oysters as they were deposited on the sea bottom at the culturing sites.

this time in French Polynesia, laws were enacted banning pearl-oyster fishing during the oysters’ reproductive season and setting aside a portion of the atolls (and also into the atolls) to create reservation areas (Bouchon-Brandeley, 1885). However, neither the scientific research nor the conservationist measures were enough to avoid the continued impoverishment of these resources in the Tuamotu atolls (Ranson, 1955) until the 1960s, when extensive pearl-oyster cultivation and pearl culturing operations were successfully introduced (Coeroli, 1994).

In Ceylon’s Gulf of Mannar, also at the end of the 19th century, several measures were taken to facilitate spat settlement and natural repopulation of the *Pinctada fucata* beds (Hornell, 1905). However, these early measures, which could be considered precursors of pearl-oyster cultivation, did not give the expected results. Eventually, the ephemeral spawning season of the species and the constant overexploitation combined to destroy the oyster beds (Jameson, 1912).

Among the rare successful ventures of the period, in addition to that of Gastón Vives, only those of Cyril Crossland (from 1905 to 1923) and Kokishi Mikimoto (which began in 1890) are noteworthy.

Cyril Crossland headed the world’s second most successful large-scale pearl-oyster-cultivation operation, at Dongonab Bay in the Red Sea (Crossland, 1931, 1956). Employed by the Sudanese government for this purpose, Crossland made sub-

stantial advances in the cultivation of *Pinctada margaritifera* (spat collection, nursery cultivation, and late cultivation). Each stage required the design and refinement of several devices and strategies for

Figure 15. Under the ever-watchful eyes of CCCP supervisors (right), workers on a “mother boat” search for pearls in just-harvested, three-year-old cultivated oysters (about 16–18 cm at their longest dimension).



their installation. In 1911–1912, he shifted from an experimental level to a large-scale commercial enterprise, obtaining a harvest of 3 million spats. Between 1914 and 1920, World War I disrupted production; but in 1920, with more scientific knowledge and better technology, Crossland harvested more than 4 million spats, which resulted in 1.7 million commercial-size pearl oysters. In 1921, he collected a record 9 million spats, recovering 4.5 million oysters at the nursery cultivation stage. At the height of activity, Crossland employed as many as 300 persons. (Unfortunately, we know of no published record of the number of pearls produced.) In 1923, however, the Sudanese government canceled Crossland's contract because of decreasing prices for mother-of-pearl shell in the international markets. Within a few years, the pearl-oyster fisheries in the Red Sea—no longer replenished by Crossland's "breeding center"—were severely impoverished.

Cyril Crossland's work, because of its complex technology, is the only one comparable to that of Gastón Vives. However, large-scale pearl-oyster cultivation in Dongonab Bay started 10 years after the CCCP.

Kokishi Mikimoto's operation could also be considered a highly successful experience in the cultivation of pearl oysters. Having started in 1890, by 1896 Mikimoto had made his first commercial harvest of cultured blister pearls in the market (Jameson, 1914). Nevertheless, his pearl-oyster cultivation techniques were as rudimentary as those employed at the time in French Polynesia: the simple deposition of rocks on the sea bottom of some protected areas to provide substrates on which the pearl-oyster spat (*Pinctada martensii*) could settle. During this period, he did not have any farms comparable in size to that of the CCCP. Mikimoto's success depended primarily on having the appropriate environmental conditions and the excellent response of *Pinctada martensii* to aquaculture management. The successes at Dongonab and La Paz Bays were the result of extensive experimentation and the refinement of methods and equipment to control the environments in which the pearl oysters grew. Although cultured pearls were competitive with natural pearls by the 1920s, Vives never proposed producing the former during his attempts to re-establish the San Gabriel pearling station; he preferred not to alter the processes of natural pearl formation (Vives, 1918). While Mikimoto was clearly the pioneer in pearl culturing, Vives led the way in pearl-oyster cultivation.

Socioeconomic and Ecological Impact of the CCCP. In only 11 years (1903–1914), Vives created an internationally recognized pearl-oyster breeding empire. The CCCP also had a significant impact on the local socioeconomic structure, as well as on the regional marine ecology.

During its most productive years (1909–1914), the CCCP employed between 400 and 500 workers (Cariño and Cáceres, 1990; Cariño, 1994), representing almost 6% of the registered population of La Paz (which was about 8,647 in 1910; Baja California Archives 8). Most of these workers were based at the San Gabriel pearling station and were involved in the cultivation process itself or in such activities as manufacturing cultivation devices, piercing and transporting stones, and the like. Sailors, divers, and other fleet support personnel were also part of the CCCP work force. All employees were strictly supervised. Due to the magnitude of its operations (direct or indirect), its accumulation of capital, and the size of its work force, the CCCP was the most important enterprise in the region during the first decades of the 20th century.

Species conservation through continuous replenishment of the natural mother-of-pearl beds was the CCCP's most important ecological contribution (Estrada, 1977). Vives proved that through extensive and large-scale aquaculture, it is possible to rationally manage a pearling resource despite intensive exploitation.

From 1911 on, Vives's political fortunes began to decline. That year, he was the first local administrative official tied to the regime of President Porfirio Díaz who was publicly asked to resign (Baja California Archives 9). The June 1914 arrival in La Paz of a revolutionary detachment commanded by Colonel Miguel L. Cornejo dealt a mortal blow to the CCCP.

Before becoming a revolutionary, Cornejo had also been a pearling entrepreneur, a rival of Vives (Baja California Archives 10), and he did not miss this opportunity to ruin his bitter enemy. All the equipment, pearl oysters, pearls, shells, and any other property of Gastón Vives was confiscated or destroyed. Vives was forced to flee aboard an American steamboat (Vives, 1914). From 1916 on, Vives repeatedly petitioned the federal government to reissue his concession and return his unjustifiably appropriated property so that he might renew his aquacultural activities (Baja California Archives 10). In 1918, and again in 1930, he tried to interest both American and French businessmen in reviv-



Figure 16. Cultured blister pearls, like those shown here, have been recovered recently from 26-month-old cultivated *Pinctada mazatlanica* oysters. The cultured pearl in the pendant is about 15 mm in diameter; the two in the earrings are each about 9 mm. Note that the nacre has an average thickness of 2.3 mm. Courtesy of the Pearl Oysters Research Group, CIBNOR; photo © Harold & Erica Van Pelt.

ing the CCCP (Vives, 1918; J. Vives Lucero, pers. comm., 1987), but all his efforts were unsuccessful.

PEARL OYSTER CULTIVATION TODAY: THE LEGACY OF DON GASTON VIVES

After hundreds of years of arbitrary or poorly managed exploitation of the pearl oyster *Pinctada Mazatlanica*, the organized farming of these mollusks was finally accomplished in the early 20th century—and destroyed within a few short years. As Cattet stated in his 1893 report, and contemporary scientists and pearl-oyster cultivation technicians have confirmed (see, e.g., Monteforte, 1990), the transfer of aquaculture procedures from one species to another does not assure success, as it is necessary to adapt many details of each procedure to the specific species and to local biotic and abiotic characteristics. Since Gastón Vives's delineation of these essential conditions for La Paz Bay, there have been many failed attempts to reinstate mother-of-pearl farming and pearl culturing in Baja California. However, the recently established Pearl

Oyster Research Group of the Northwestern Center of Biological Research (Grupo Ostras Perleras, Centro de Investigaciones Biológicas del Noroeste—CIBNOR) has succeeded in applying extensive cultivation techniques and repopulation strategies, to accomplish the production of cultured pearls, the first positive results in 90 years (Monteforte and Aldana, 1994; Monteforte and Bervera, 1994; Monteforte and Wright, 1994; Monteforte et al., 1994a and b). We believe that this recent success is due to our focus on the bioecology of the species and their response to different cultivation manipulations—the same factors that Vives had considered critical (Vives, 1908).

The Mexican Government now recognizes that pearl-oyster cultivation and pearl culture are strategic alternatives for regional socioeconomic development. Although the current CIBNOR operation is limited—five researchers managing several experiments with a stock of about 8,000 oysters of different generations—we have already produced some high-quality 12–15 mm cultured blister pearls

(figure 16), and we anticipate a harvest of approximately 1,000 cultured blister pearls by February-March 1996. From periodic checking of the oysters, we believe that at least 70% of these will have the rich, distinctive colors of Baja California pearls. Results with round pearls have been much more modest, because of limited facilities. Although the failure of earlier attempts (subsequent to Vives) at

pearl-oyster cultivation and pearl culturing has produced much skepticism in Mexico, recent successes in the production of cultured blister pearls from both *Pinctada mazatlanica* and *Pteria sterna* have generated renewed interest in establishing a pearling operation in La Paz. We are confident that, once again, Baja California pearls will grace the world market.

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AN UPDATE ON THE URAL EMERALD MINES

By A. F. Laskovenkov and V. I. Zhernakov

The emeralds of the Ural Mountains, in what is now called the Russian Federation, have been known for more than 160 years. They were famous worldwide during the early part of the 20th century. However, because little information was made available about these deposits in recent years, many in the gem industry concluded that they had been exhausted. This article reveals that mining and processing are ongoing in the region, with significant reserves of gem-quality emerald still to be exploited. In addition, the reopening of four mines promises to increase commercial production.

The famous emerald mines of Russia's Ural Mountains have been worked almost continuously since 1831. Over the next century, annual production of rough emerald and green beryl sometimes reached 2.5 million carats. During World War II, mining concentrated on the production of beryllium ore, but today emerald recovery has again become the primary focus, with Russian emeralds now appearing as center stones in fine contemporary jewelry (figure 1). Contrary to popular belief, there has never been a prolonged interruption in emerald production from this area.

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This article briefly reviews the history and geology of the Ural emerald deposits and then discusses recent developments in mining and processing. For almost three decades, the present authors have studied the geology of the deposit and the mineralogy and gemology of the emeralds produced there (e.g., Laskovenkov, 1991). The information presented in this article is based primarily on the authors' own observations and conclusions. It supplements, to some extent, previous works (Zemjatchensky, 1900; Mikhejev, 1913; Fersman, 1913, 1923, 1925; Pyatnitsky, 1929; Vlasov and Kutukova, 1960; Sinkankas, 1981; and Schmetzer et al., 1991).

HISTORY

The discovery of emeralds in this region (figure 2) is attributed to a local peasant, Maxim Kojevnikov, who reportedly found emerald crystals in the roots of a fallen tree near the Takovaya River in the fall of 1830. Organized mining began soon after, in January 1831.

For most of the 19th century, Uralian emeralds were not available for commercial exploitation, but rather they were considered the property of the Russian crown. In 1898, however, the growing cost

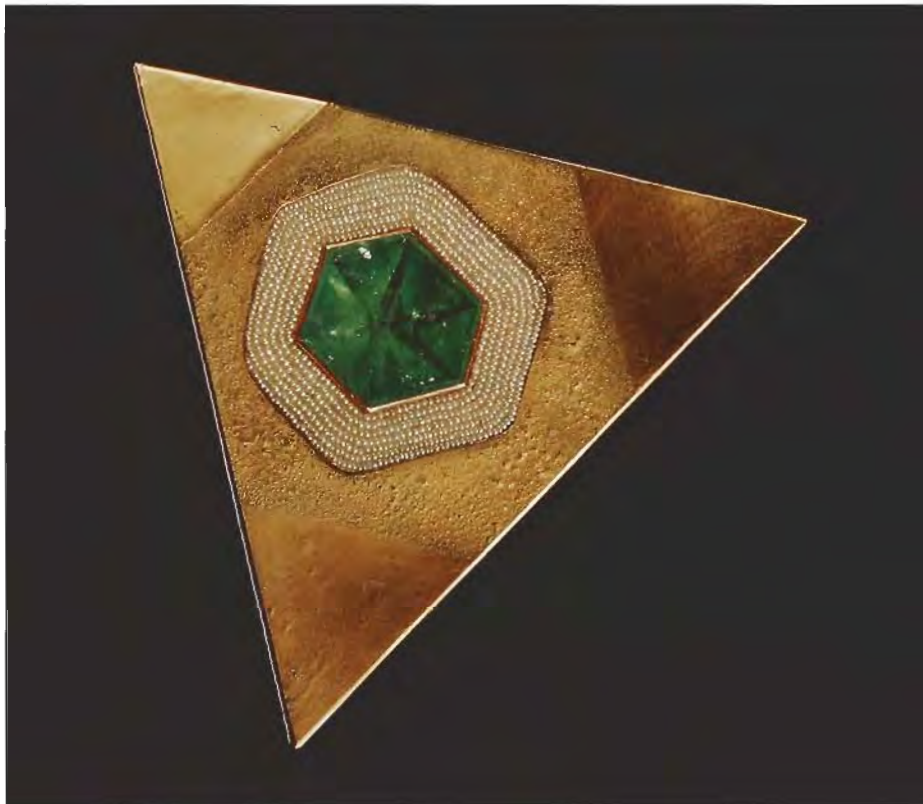


Figure 1. Emeralds from the Ural Mountains are increasingly appearing in contemporary jewelry, like this 21.07-ct stone set with keshi pearls and 24k gold in a pin designed by Michael Zobel. Photo by Fred Thomas.

of operating the mines impelled the Tsar to lease them to the English- and French-held New Emerald Company. The lease lasted 18 years, until 1916, during which time more than 40 million carats of emerald rough were exported (Gomilevsky, 1914; Fersman, 1925).

In 1918, the Soviet government established itself as sole owner of the mines. Five years later, in 1923, the government leased the mines to the Russkiye Samotsvety State Trust, which conducted large-scale mining of emeralds and sold them worldwide through export organizations (Fersman, 1923).

Until the 1930s, production from the Uralian deposits played an important role in the world emerald market, exceeding that from Colombia in some years, when as many as 2.5 million carats of gem crystals were recovered. The rough was cut and polished in jewelry workshops in Ekaterinburg, Paris, London, Berlin, and New York, by such famous jewelers as Cartier, Tiffany, Chaumet, and Fabergé.

Although the search for beryllium ore dominated mining in the area during the 1940s and 1950s, significant quantities of emeralds and green beryls (as much as 3–4 million carats per year in the 1950s) were recovered as a by-product

of beryllium production. Since the early 1970s, however, with the discovery of new, more profitable beryllium deposits elsewhere and the increase in world demand for gem emerald, mining attention has gradually shifted back toward emeralds, with annual production as high as 8–10 million carats.

Although a sophisticated complex was developed by Malysheva Mines Management to mine and process the emerald rough, good cutting technology was not equally well developed. As a result, only about 20,000 carats of good-quality cut emeralds were produced per year. Lower-quality translucent to transparent rough was sold to various Indian gem companies. In 1987, cutting stopped completely because of the comparatively low yield of higher-quality finished stones from the raw material. With the establishment of the Russian-Panamanian-Israeli joint venture known as Emural, set up in 1991 by Russian and Israeli companies, Russian emeralds are now being cut on modern equipment using the latest technology to serve the world market.

Until 1945, emeralds were mined from deposits at Aulsky; Mariinsky, the main deposit; Perwomaisky, formerly called Troitzky; Krupsky,

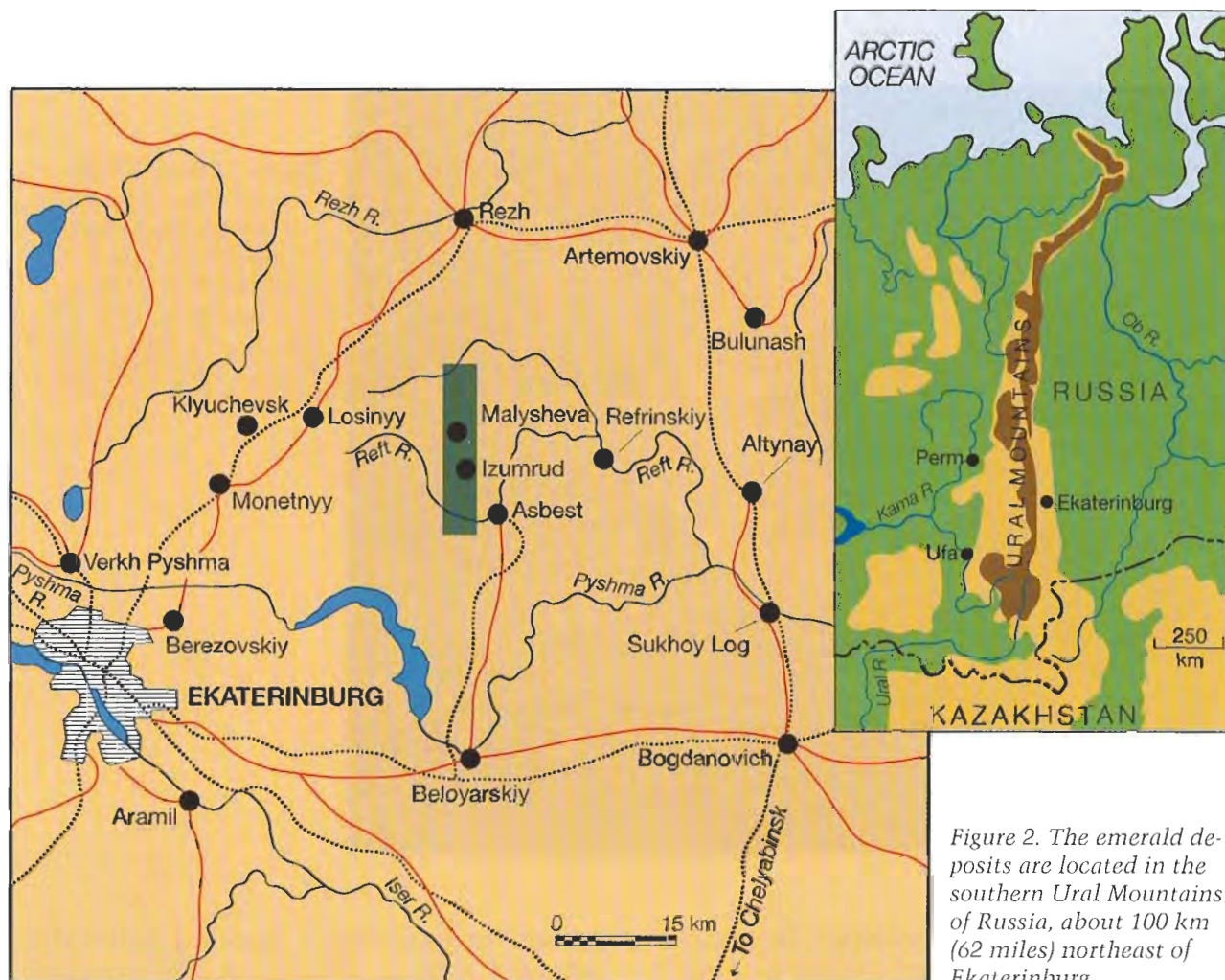


Figure 2. The emerald deposits are located in the southern Ural Mountains of Russia, about 100 km (62 miles) northeast of Ekaterinburg.

formerly Lubinsky or Tokovsky; Sverdlovsky, formerly Stretjensky; Tsheremshansky; Chitny; Krasnobolotsky; and Ostrowsky (figure 3). Since 1945, only the Aulsky, Mariinsky, Chitny, and Tsheremshansky deposits have been worked. At present, emeralds and other beryllium minerals (including alexandrites) are mined only at the Mariinsky deposit.

Although no new emerald deposits have been discovered in the Urals since 1945, recent geologic work has proved that there are significant reserves at Perwomaisky, Krupsky, Sverdlovsky, and Krasnobolotsky, as well as at Mariinsky. Preparations are being made to mine emeralds at the first three, and to mine both emeralds and alexandrites at Krasnobolotsky.

LOCATION AND GEOLOGY

The emerald deposits in this region of the Ural Mountains are located about 100 km (62 miles) by road northeast of Ekaterinburg (formerly Sverdlovsk), in the Russian Federation (again,

see figure 2). The area can be reached from that city by train or car.

The numerous deposits are found in schists that lie in a zone that extends north-south for a distance of 20 km (about 12.5 miles) along the eastern contact of the Adui gneiss-migmatite complex, the core of which is an Upper Paleozoic granite mass (again, see figure 3). Concordant igneous bodies of Middle Paleozoic age, which are of ultrabasic and intermediate (between felsic and mafic) composition, are interspersed among amphibolites and other schists. All rocks are highly fractured, faulted, and folded, and are stretched out into lenses. The emerald deposits themselves are located within the amphibolite zones. The formation of emerald-containing glimmerite (a rock high in mica, in this case phlogopite) bodies is related to contact-metasomatic phenomena in the fracture zones, following the effect of acidic pneumatolytic-hydrothermal solutions on the ultrabasic rocks. These emeraldiferous glimmerite ore bod-

ies frequently occur as a complex branching system; when close together, they form ore suites that look like columns in the best mining areas. The ore bodies average 1 m thick and 25–50 m (82–164 feet) long, but ore bodies as long as 100 m (328 feet) have been found. The strike of the emerald-bearing zone and the individual ore bodies is southerly, with a steep—65° to 80°—dip to the east (Vertushkov et al., 1978).

The glimmerite bodies are zoned, with a central, highly micaceous section that consists of 95%–99% phlogopite. Smaller pods and lens-shaped masses of plagioclase, tourmaline, quartz, and actinolite are usually present in this high-mica region. A talc or talc-tremolite zone is conformable around the central area. As a rule,

Figure 3. This geologic-structural diagram of the region in which emeralds have been mined in Russia shows that the emerald deposits lie in a narrow strip between the Adui granite mountain-mass to the west and the diorite complex to the east.

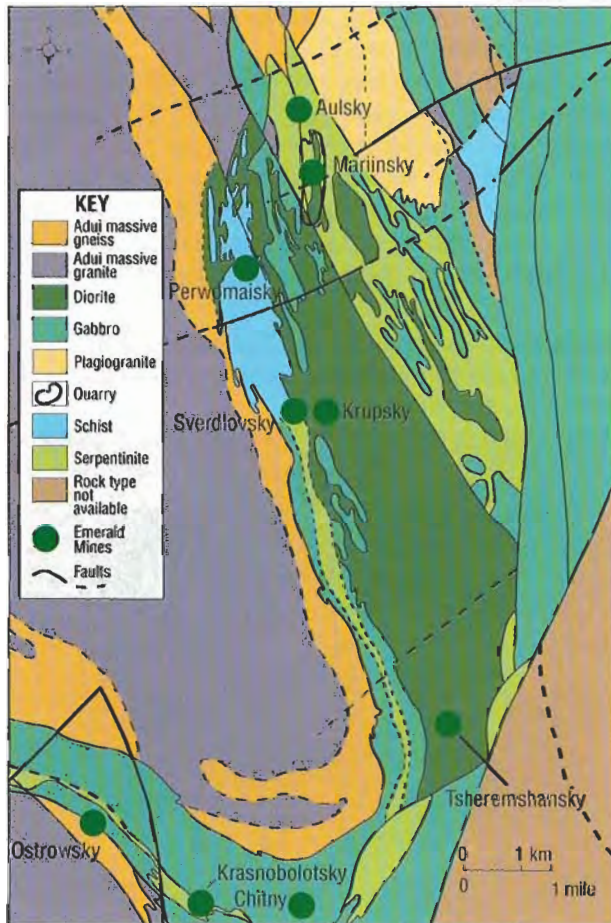


Figure 4. At the Uralian deposits, emeralds typically occur as single crystals, like this 8 × 9 × 12 cm specimen.

emeralds are found only in the highly micaceous zones, although they do occur rarely with plagioclase, quartz, actinolite, or talc. The emeralds typically occur as individual crystals (figure 4) or as subparallel (figure 5) or—less commonly—radiating (figure 6) groups of crystals. Sometimes rounded aggregates of emerald crystals, tightly enclosed in phlogopite, are recovered. Emeralds usually occur in very unevenly distributed concentrations or “pockets.” Associated minerals are phenakite, green beryl, chrysoberyl, alexandrite, euclase, bromellite, apatite, and fluorite.

The morphology of Uralian emerald crystals has been studied extensively by Zhernakov (1980) and Schmetzer et al. (1991), and depends entirely on the conditions of formation. Typical emerald or green beryl crystals are 2–3 cm (about 1 inch) long, although specimens 9–12 cm long are not uncommon (again, see figure 4). Rarely, they exceed 14 cm (over 5 inches). Crystal aggregates usually consist of two to three crystals, but aggregates of eight to 10 crystals have been seen.



Figure 5. Also found in the Ural Mountains are subparallel groups of emerald crystals. The longest crystal in this specimen, currently in the Fersman Mineralogical Museum, is 7.5 cm. Photo by Jeff Scovil.

PROSPECTING

In the early days, prospecting and mining were often carried out at the same time, since most of the emerald deposits outcropped on the surface. Systematic prospecting began in the 1950s, when sufficient labor and materials were invested in the region to exploit both the emeralds and beryllium ore. At present, the deposits at Mariinsky, Perwomaisky, Krupsky, and Sverdlovsky have been explored to an average depth of 500 m (1,640 feet) by means of bore holes and underground workings.

To prospect for emeralds, we use both geophysical and mineralogical techniques. Neutron-

activation analysis is widely employed, in the form of special portable "beryllometers," to locate emerald occurrences on the basis of the beryllium content of the surrounding rock. The identification of minerals known to be associated with emeralds has also proved helpful. To determine potential emerald content, bulk samples of as much as 200 tons of ore are processed in a concentration mill. The bulk samples are taken throughout the entire deposit, from layers 2.5–3 m (8–10 feet) thick at 100-m intervals along the ore zone. Experience has shown that this is the most efficient and reliable method of prospecting under these very complicated geologic conditions, in which concentrations of emeralds are distributed extremely unevenly.

MINING

Until 1970, the main emerald deposit, at Mariinsky, was worked by open-pit or underground mining to depths as great as 100 m. Along with emerald, beryllium ore—containing beryl, beryllium, margarite, chrysoberyl, phenakite, bertrandite, and bavenite—was recovered for industrial uses.

Today, this deposit is mined only for emeralds and only by tunneling (figure 7). It is worked year-round, at horizons more than 250 m (820 feet) below the surface. To minimize damage to the emerald crystals during extraction from the host rock, the miners (figure 8) use specially designed blast-hole patterns together with

Figure 6. Less commonly, the Uralian emeralds occur as radiating groups of crystals. This specimen is 8 × 9 × 14 cm.





Figure 7. Today, all mining at Mariinsky is done underground. As evident here, the tunnels are quite large, well lit, and well equipped.

sequential firing by “low-impact” explosives. In some instances, explosives are avoided altogether, and the host rock is broken by means of expanding plastics and hydraulic wedge devices inserted into the fractures.

The emeralds are removed from the mined ore in special concentration mills (figure 9), where the ores are disaggregated during slow rotation in a drum as they are washed by water. This ore material is then separated into five

sizes by a complex screen system, after which the gem material is manually sorted out on a low-speed (15 cm per second) conveyor belt by highly skilled workers (figure 10). Even today, the most reliable instrument in sorting is the human eye.

PHYSICAL AND CHEMICAL PROPERTIES OF URALIAN EMERALDS

Uralian emeralds and green beryls are typically

Figure 8. In this tunnel at Mariinsky, miners prepare to remove the emerald-bearing ore.



Figure 9. Disaggregation of the emerald-bearing rocks at the Malysheva processing plant is accomplished in a rotating drum, or scrubber.





Figure 10. Highly trained workers sort out emeralds on a slow-moving conveyor belt at the Malysheva processing plant.

bluish green of varying intensity (figure 11), but some are slightly yellowish green. The finest gems are light to medium green. As reported by Zhernakov (1980) and, more recently, Schmetzer et al. (1991)—and confirmed by our own physical, chemical, and spectroscopic analyses—the green color is due to the presence of chromium. We have found typical chromium contents of 0.15–0.25 wt.% Cr_2O_3 with contents as high as 0.38 wt.% in areas near inclusions of chrome

Figure 11. Uralian emeralds are typically bluish green and of varied saturation. These emeralds, 0.5 to 6 ct, illustrate the effect of different cuts.



spinel. Admixtures of iron, titanium, vanadium, cobalt, and nickel can also be responsible for variations in the coloration (Zhernakov, 1980). Other elements detected in Uralian emeralds, in addition to those intrinsic to the mineral structure, include Mg, Ca, Na, Rb, Cs, Sc, and F.

A detailed study of inclusions observed in Uralian emeralds, as well as other gemological, spectral, and chemical characteristics of this material, was published by Schmetzer et al. (1991). In summary, and confirmed by our own observations, the internal features of the emeralds are characterized by zoning, mineral, and two-phase (usually liquid-gas) inclusions, and cracks caused by crystal-lattice stress. The zoning is caused by the uneven distribution of color-causing trace elements during crystal growth; the zoning parallels the basal pinacoid or prism faces. The quantity and nature of mineral inclusions varies widely and usually depends on the nature of the enclosing rock: For example, emeralds from phlogopite schist contain phlogopite, and those from talc schists contain talc, tremolite, and chromite. Frequently seen in faceted emeralds are phlogopite crystals, actinolite needles, liquid-gas inclusions, and minute fractures. The liquid-gas inclusions may occur as elongate channels; some channels display a symmetric “fencing” parallel to the optic axis.

LARGE SPECIMENS PRODUCED

The Ural emerald mines have produced some remarkable specimens, both historically and recently (i.e., since 1978). Perhaps the most famous is Kochubey's emerald, an 11,000-ct crystal of intense “grass” green color that was found in 1831. It is now at the Fersman Mineralogical Museum of the Russian Academy of Sciences, in Moscow.

A 3,370-ct emerald of excellent color, named Glorious Ural Stone, was mined in 1978. It is now in the State Treasury of Valuables of Russia (Gokhran). Also in the State Treasury of Valuables is the group of six crystals named Miner's Glory (approximately 10,000 ct and $10 \times 12 \times 30$ cm), which was found in 1989. The year 1990 gave us two very rare and beautiful emeralds: the unusually clean 4,400-ct ($6 \times 7 \times 10$ cm) New Year's Stone and the 37.5-ct faceted Vitaly emerald (figure 12).

SUMMARY AND CONCLUSIONS

Large quantities of emeralds have been mined from deposits in the Ural Mountains, about 100

km northeast of Ekaterinburg, since 1831. Although during and immediately following World War II, the mines were worked primarily for beryllium ore, today they are exploited exclusively for the typically bluish green gem emeralds and green beryls. Little information on these deposits was released during the last 60 years, so many believed that they had been exhausted. However, geologic information gathered over the last three decades reveals that only about 30%–35% of known reserves have been worked to date.

Currently, only the Mariinsky mine is being worked, and production figures are not available. However, plans to begin mining at Perwomaisky, Krupsky, Sverdlovsky, and Krasnobolotsky promise an even greater supply of rough in the near future. The apparent success of the Emural joint venture in modernizing the cutting of the Urals production should further increase the availability of fine cut Russian emeralds and green beryls in the world marketplace.



Figure 12. The 37.5-ct Vitaly emerald is one of the largest stones faceted from rough found at the Ural emerald mines.

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A VISUAL GUIDE TO THE IDENTIFICATION OF FILLED DIAMONDS

By Shane F. McClure and Robert C. Kammerling

A microscope with various types of lighting is the most practical and reliable method to detect fracture filling in diamonds. All of the filled diamonds examined to date have shown flash effects in a variety of colors. Also seen in some stones are evidence of flow structure, trapped bubbles, incomplete filling at the surface, crackled texture, an apparent color to the filler, cloudy filled areas, and surface residue. This article is accompanied by a chart that illustrates the various features seen in filled diamonds, plus features observed in unfilled fractures with which they might be confused.

Today, the ability to identify fracture-filled diamonds is critical for anyone involved in buying and selling diamonds, or in appraising, manufacturing, or repairing diamond-set jewelry. Two research projects conducted by staff members of the GIA Gem Trade Laboratory and GIA Research (Koivula et al., 1989; Kammerling et al., 1994) showed that careful examination with a binocular microscope is both the most practical and the most reliable method of detecting this treatment. Nevertheless, we continue to see and hear of cases where the treatment was detected too late: after a jewelry repair or cleaning procedure had damaged the filling in a stone (see, for example, figure 1).

Although the various reports published to date are, collectively, quite comprehensive in their presentation of the diagnostic features, we

recognized the need to place the key information in a visual format that could be readily referenced by the jeweler/gemologist when actually examining diamonds under magnification. The accompanying chart has been produced with this practical application in mind. The following discussion briefly reviews both the important microscopic techniques to use and the key identifying features of this treatment, as illustrated on the chart. Also examined are those features seen in some untreated fractures that might be mistaken for features typical of filled stones.

PREPARATION FOR USING THE CHART

The first step in using the chart to identify fracture filling in diamonds is to familiarize yourself with the suite of diagnostic features. Study the illustrations on the chart and, if available, those in published articles. If possible, borrow known filled diamonds from your suppliers or colleagues, so you can examine them first-hand. It is important to recognize that the filling procedure is effective in disguising a variety of inclusion features, such as fractures (figures 2 and 3) and knots (figure 4). We also recommend that you acquaint yourself with the microscopic features of *unfilled* diamonds that might be confused with those in filled stones; the most com-

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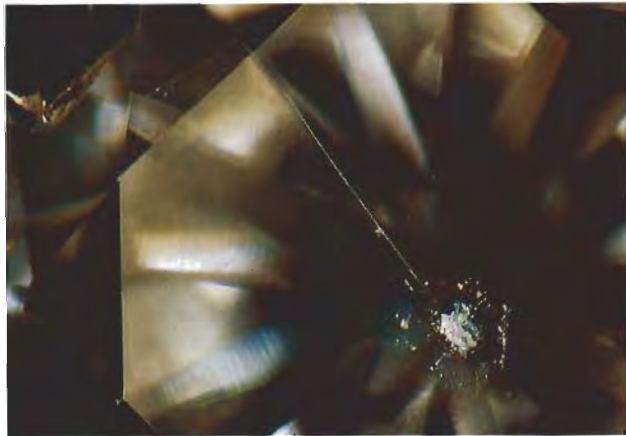


Figure 1. The change in appearance of this filled diamond before (left) and after (right) a prong-retipping experiment graphically illustrates what a jeweler might face should fracture filling not be detected before direct heat is used to perform a simple jewelry repair procedure. Photomicrographs by Shane F. McClure; magnified 32 \times .

mon of these are illustrated on the chart. The misidentification of an unfilled diamond as filled can also have serious consequences.

Next, review the various microscope lighting techniques that might be called on to detect one or more types of features. The methods we have found most useful include—in addition to standard dark-field lighting—fiber-optic illumination, polarized light, and the shadowing technique (as illustrated at the bottom of the chart). For additional information on lighting techniques, see Koivula, 1982a and b; Koivula et al., 1989; Koivula and Kammerling, 1990; Hurlbut and Kammerling, 1991; Scarratt, 1992; Kammerling and McClure, 1993; and Kammerling et al., 1994.

TECHNIQUES FOR EXAMINING DIAMONDS FOR EVIDENCE OF FRACTURE FILLING

Begin your examination for potential fracture filling essentially the same way you would begin examining the diamond for standard diamond clarity grading, that is, with the microscope set at relatively low magnification (10 \times) in conjunction with standard darkfield illumination. At any stage of the examination, you can increase the magnification to resolve a particular feature further.

First hold the diamond at the girdle—in a stoneholder or tweezers if it is unmounted—in its face-up position, so you are looking through the table and crown facets. Rock the stone back and forth slowly while you look for evidence of

filling. The movement is important, as some features—such as flash effects—are seen only at certain angles. Next, turn the stone over, so you are looking through the pavilion facets, and continue the examination. Finally, check the diamond while you are holding it table-to-culet. Remember that a careful, methodical examination not only helps you minimize the possibility of overlooking evidence of fracture filling, but it also helps you document the *extent* of treatment in stones where multiple breaks have been filled.

Note that although the microscope is set up for darkfield illumination, secondary reflections from facets can produce localized areas of brightfield illumination. It is therefore important to look, for example, for those flash-effect colors seen in brightfield as well as those seen in darkfield. Furthermore, experience has shown that filled breaks often may be positioned such that some portions of the break show darkfield flash-effect colors (the background is dark) while other portions show brightfield flash-effect colors (the background is light). Additional lighting methods, such as fiber-optic illumination, can be called on as required.

Testing mounted diamonds can be especially challenging. For example, prongs may cover a portion of a stone where a filled fracture breaks the surface. Mountings can also restrict the angles of observation. This is an important consideration, as the most reliable diagnostic feature of filled diamonds—the flash effect—is seen



Figure 2. All commercial filling procedures investigated by the authors are very effective in improving the face-up appearance of diamonds. This is readily apparent in these photos of a 0.20-ct diamond with large, highly visible reflective fractures before filling (left) that are considerably less visible after filling (right). Photomicrographs by Shane F. McClure.

only within a narrow range of viewing angles. When testing mounted stones, it is therefore critical to view them carefully and in as many directions as possible. With jewelry-set diamonds, the use of supplemental lighting techniques—fiber-optic illumination in particular—can take on added importance (and may allow you to see a reflected flash effect; see “Flash Effects,” below).

An additional test that may be used on both mounted and unmounted stones is the application of water. Orient the stone under the microscope so that the surface exposure of the suspect fracture is clearly visible. While looking at the fracture, pass a small, wet brush across its entry point. If water enters the fracture (seen as a brief reduction in the relief of the fracture), then the fracture is probably not filled. Although it is not always easy to see the water flow into the fracture, with a little patience you can see (in the fracture) the movement of the water and gas bubbles as the fluid evaporates rather rapidly in response to the heat generated by the light source. Note that the failure of water to enter the break does not necessarily mean that it is filled, as some unfilled fractures will not receive water in this way.

DIAGNOSTIC FEATURES: A REVIEW

Following is a brief review of diagnostic features that have been documented to date in fracture-filled diamonds from one or more commercial treaters. All are illustrated on the accompanying chart. As with other gem identification procedures, always look for more than one feature for confirmation before reaching a final conclusion.

Flash Effects. To date, we have seen flash-effect colors in every diamond known to be filled that we have examined. This is the most consistently encountered diagnostic feature of fracture-filled diamonds.

In *darkfield illumination*, the most commonly encountered colors are yellowish orange and violet to purple to pink. Less commonly, a pinkish orange darkfield flash effect may be seen. Rarely, yellow, blue, green, and red may be visible against a dark background.

In *brightfield illumination*, the most frequently seen flash-effect colors have been blue to bluish green, and green to yellow, which correspond to the complementary colors (opposite on the color wheel) of those seen in darkfield. Violet has also been seen in some atypical samples.

Figure 3. This reflective feather is easily seen without magnification before filling (left), but only small, unfilled areas near the surface are visible after filling (right). Photomicrographs by Shane F. McClure; magnified 40 \times .



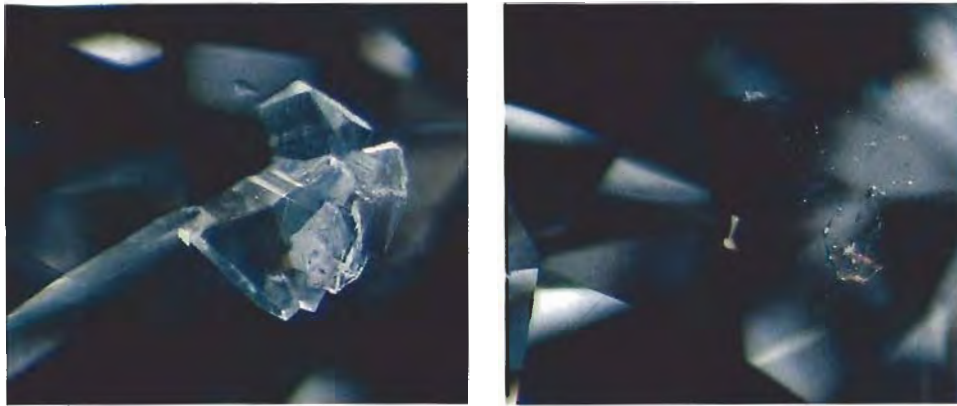


Figure 4. The interfaces around this knot are quite apparent before filling (left), but the knot is barely visible after filling (right). Photomicrographs by John I. Koivula; magnified 20x.

In both darkfield and brightfield illumination, a filled break may exhibit one color in one area and another color in another area—or even multiple colors—at a single angle of observation. When a single-color flash effect is encountered, it is often violet in darkfield. In addition (again, in both darkfield and brightfield), the flash color may change in all or part of the filled break as the stone is rocked back and forth very slightly.

Recently, in several isolated diamonds, we noted a “reversal” of the flash-effect colors normally observed in darkfield and brightfield illumination. In these instances, the colors observed in darkfield were blue to green, whereas those seen in brightfield were yellow, orange, and/or pink.

Flash-effect colors may also vary in intensity. In some treated stones, the flash colors are quite intense and easily seen using standard darkfield illumination (some may even be noted without magnification). In other stones, though, the flash colors may be quite subtle and require fiber-optic illumination to detect. In our experience, the darkfield flash color is similar in intensity to the corresponding brightfield flash color in any given filled diamond. Another point to keep in mind is that flash colors may be seen indirectly, that is, as reflections within the diamond. In fact, the reflection of a flash color is often seen before the filled fracture is located.

The feature of some unfilled breaks that is most likely to be confused with a flash effect is thin-film iridescence. Although thin-film iridescence usually appears as a multi-colored rainbow-like effect, occasionally only a few colors are apparent. These few colors are generally restricted to yellow and orange or blue and purple. Also, no complementary colors will be seen

when the fracture is viewed in brightfield. One reliable method to distinguish iridescence from flash effect is by the viewing angle: Iridescent colors in unfilled breaks are generally best seen at a viewing angle roughly perpendicular to the plane of the break, whereas flash effects are usually detected when the stone is viewed almost parallel (edge-on) to the break. Polarized light may also prove useful in making the distinction: Iridescent fracture colors will shift in position as the polarizer is rotated, whereas flash-effect colors will only turn darker and more vivid (i.e., they do not shift hue laterally as the polarizer is rotated).

Occasionally, surface-reaching breaks in untreated diamonds contain an orangy brown staining of naturally occurring iron compounds that might be mistaken for an orange flash effect. Such staining, however, should be visible through a broad range of viewing angles, whereas the similarly hued flash effect can be seen only within a very narrow range of viewing angles.

Although not encountered very frequently, a natural radiation stain in a feather might also be confused with an orange flash effect. However, like iron compound staining, and unlike flash effects, radiation stains should also be visible in many directions of observation. In addition, you should be able to see the radiation stain extending from the break into the stone.

Flow Structure. A filled break may look as if a glassy substance has flowed into it. This is an appearance unlike anything seen in unfilled breaks.

Trapped Bubbles. These voids in the filling substance—areas of incomplete filling—may be fairly large and noticeably flat, or they may be small

and occur in groups in an overall "fingerprint" pattern. Trapped bubbles are highly reflective in darkfield illumination, with those that are relatively large and flat producing mirror-like reflections. These bright inclusions are often the first indication that a fracture has been filled.

Incomplete Filling at the Surface. These areas are usually extremely shallow and generally look like fine, white scratches or "ribbons" in darkfield illumination. They may result from a partial removal of the filling during cleaning of the diamond.

Crackled Texture. Cracks in the filling material, producing a web-like texture reminiscent of mud cracks in a dry lake bed, are encountered relatively infrequently in filled diamonds. This feature is usually associated with areas of fairly thick filler. Such crackled areas have also been noted in filler within laser drill holes.

In some filled breaks, we have detected extremely fine, nearly parallel whitish lines that may be minute fractures within the filler. This is a very subtle feature and one that we have only been able to see using intense fiber-optic illumination.

Apparent Color of Filler. In relatively thick areas of filler, a light brown to brownish yellow or orangy yellow color may be detected. This "body color" of the filling substance used by at least one treatment firm may also be seen in filled cavities and in laser drill holes.

Cloudy Filled Areas. These are areas of reduced transparency that resemble white clouds in the filler.

Surface Residue. To date we have noted two features that appear to be residue from the filling process: (1) cloudy markings around the entry points of some filled breaks, and (2) an essentially colorless substance at the surface. This should not be confused with "burn" marks on the surface of a diamond, which result from excessive heat when the diamond was on the polishing wheel. Such burn marks usually cover larger areas, are not associated with fractures, and cannot be removed without repolishing. Note, however, that burn marks can be seen on filled as well as unfilled diamonds.

THE JEWELER'S RESPONSIBILITY

A point often reinforced in the trade press is that it is the responsibility of jewelry professionals to disclose gemstone treatments at every step in the distribution pipeline (see, e.g., Diamond, 1994). There is no excuse for avoiding this responsibility with fracture-filled diamonds, as the treatment can be detected using the basic microscopy techniques and looking for the features described and illustrated in this brief report and the accompanying chart. It is important to remember that, because the treatment is less than permanent, the unwary may only discover that a diamond is filled by damaging the filler while retipping prongs on a ring, or by merely leaving a filled stone for an extended period of time in an ultrasonic cleaner.

Equally important is the risk of misidentifying an untreated diamond as fracture filled. Such a mistake may not only hurt your relationship with your customer or with your customer's supplier, but it might also expose you to financial liability or damage your reputation in the community. It is, therefore, critical that you know the potentially confusing features of unfilled diamonds as well as the characteristics of their treated counterparts.

CONCLUSION

Magnification is the most valuable and practical means of detecting diagnostic features in filled diamonds. Keep in mind, however, that there are also microscopic features in *unfilled* diamonds with which these can be confused. Flash effects are the most diagnostic feature of filled diamonds; yet they can be confused with thin-film iridescence, iron compound-based staining, and even natural radiation stains in unfilled diamonds. The key to making the distinction is to consider such critical subtleties as the angles of observation in which the effects are visible. Additional clues that a fracture is *not* filled include high relief and a feathery appearance. Gas bubbles in the filler, representing areas of incomplete filling, are also diagnostic of filling; yet minute gas bubbles could conceivably be confused with pinpoint inclusions if only the inclusions themselves were considered. The key to making these distinctions is to become thoroughly familiar with *all* of the features seen in filled diamonds, as well as with those features in unfilled breaks with which they might be confused.

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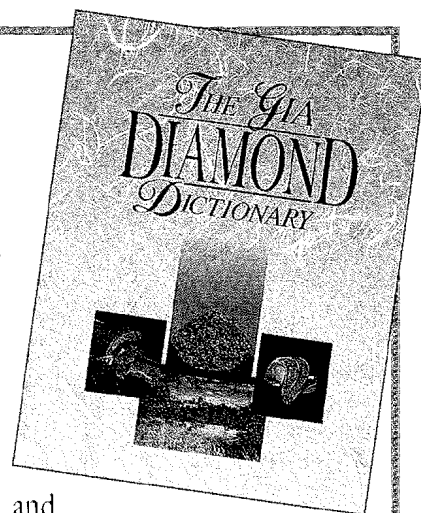
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GEM TRADE LAB NOTES

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AZURITE and ANTLERITE Rock

Many blue and green minerals owe their color to copper, including the gem minerals turquoise (a phosphate), chrysocolla (a silicate, which may be seen as inclusions in chalcedony), and azurite and malachite (carbonates). Copper minerals of more unusual compositions often cannot be distinguished from more common species using standard gem-testing methods. For example, ajoite, shattuckite, and papagoite could be mistaken for chrysocolla, and green minerals such as brochantite, atacamite, and pseudomalachite, among others, could be mistaken for malachite.

In November 1994, the West Coast laboratory received a variegated blue and green oval cabochon (see figure 1) for identification. Microscopic examination revealed at least four different materials in the 3.33-ct cabochon: (1 and 2) blue and green opaque materials, plus (3) a gray translucent material, in the body of the stone; and (4) a very dark blue substance in surface cavities. The spot refractive index was about 1.7 (poor polish precluded more accurate measurement). A specific gravity of 2.87 was determined hydrostatically. The stone effervesced to a minute amount of dilute hydrochloric acid placed on its base, and the cavity substance melted when approached with the thermal reaction tester ("hot point"). This evidence suggested that the stone was azur-malachite; however, given the many possible blue and green minerals (see above



Figure 1. Testing revealed that this 3.33-ct oval cabochon is a rock consisting primarily of blue azurite, green antlerite, and quartz. The foreign material seen in surface cavities is probably a colored polymer.

for examples), we conducted advanced testing to identify the phases present.

X-ray powder diffraction of the blue and gray materials showed them to be azurite and quartz, respectively. However, the green material was not the more usual associate of azurite, malachite, but rather was antlerite, a copper hydroxysulfate. Azurite and antlerite may occur together in oxidized zones of copper ore deposits. The dark blue substance seen in the cavities was a colored foreign material, probably a polymer of some sort. Therefore, we concluded that this cabochon was a rock consisting of azurite, antlerite, and additional minerals. We further noted that—as is

typical for rocks—petrographic testing would be necessary to fully characterize this material, and that a colored foreign material was present in surface cavities.

MLJ, SFM, and Dino DeGhionno

DIAMOND

With Strain Phantom

In the Fall 1993 Gem Trade Lab Notes section (pp. 199–200), we reported on a 3.01-ct, light yellow diamond with a phantom inclusion—a sharp-edged diamond octahedron that was visible only when viewed between crossed polarizers (phantoms are usually outlined by inclusions of another substance, which makes them easy to see in ordinary light).

As crystals grow, the conditions under which they form can change. Phantoms in quartz, for instance, often represent periods when the quartz crystal stopped growing, and particles of chlorite, iron-oxide, or other minerals were deposited on the surface of the still-incomplete crystal; when crystal growth resumed, the foreign materials (now trapped inside) outlined the previously existing crystal faces. Those phantoms in diamonds that are visible only with polarized

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

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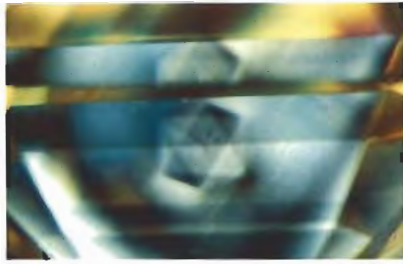


Figure 2. When viewed between crossed polarizers, this 1.42-ct Fancy Intense yellow diamond revealed a strain phantom with unusual internal strain features. Magnified 20 \times .

light may have been formed by an abrupt change in the pressure or strain under which the diamond crystal was growing, without any foreign substance having coated the pre-existing crystal faces.

Last winter, the West Coast laboratory received a 1.42-ct diamond for examination. With crossed polarizers, we saw high-order strain with a particularly interesting strain phantom (figure 2): an octahedron showing a dark line through one vertex and a dark plane perpendicular to it. We do not know what might have caused these internal strain features. Note that because the strain phantom was only visible through crossed polarizers, it did not affect the clarity grade (VVS₁) of the (natural color) Fancy Intense yellow diamond.

MLJ and Patricia Maddison

Treated-Color Pink Diamond

Over the last few months, the East Coast laboratory examined three treated-color pink diamonds, one of which was mixed in with a large parcel of natural-color stones. Unlike most treatments, treated (i.e., irradiated and annealed) pink color in diamond is rarer than natural pink color. The East Coast lab examined its first treated-pink diamond about 1959 (*Gems & Gemology*, Spring 1959, p. 268), when reactor-irradiated stones first became commercially available. Renowned British gemolo-

gist Basil Anderson, to whom we subsequently sent the stone for examination, reported that this was the first reactor-treated pink diamond he had seen as well.

In diamonds, the pink color produced by treatment is usually so highly saturated that a natural equivalent was extraordinarily rare before the discovery of fancy-color diamonds at the Argyle mine in Australia. Thus, from about 1960 to 1980, we were suspicious of any intensely colored pink diamond submitted to the laboratory. Now that some diamonds from Argyle equal treated-color pink stones in saturation, it has become even more important to know the identifying characteristics of this treatment.

In our experience, all treated-pink diamonds have a characteristic strong orange fluorescence to both long- and short-wave ultraviolet radiation. In addition, they consistently show a diagnostic visible spectrum—with sharp lines at 595, 617, and 658 nm, and an emission line at 575 nm—that is readily seen with a hand-held type of spectroscope. The first treated-color pink diamond seen in the laboratory

Figure 3. Uneven distribution of color, as illustrated by the pink and yellow zones in this 0.43-ct round brilliant diamond, is characteristic of treatment. Magnified 18 \times .

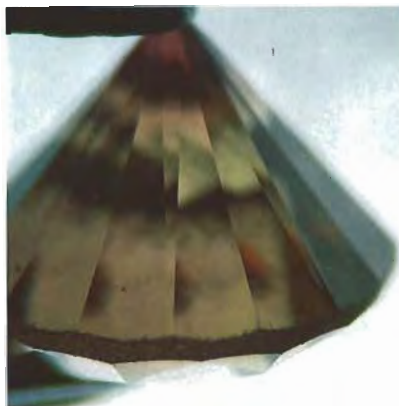


Figure 4. The color distribution in this 0.39-ct round brilliant is more even than that shown in figure 3. However, the diagnostic fluorescence and spectrum proved that the stone had been treated by irradiation and subsequent annealing.

clearly showed this characteristic spectrum and fluorescence, even though it weighed only 0.01 ct. Depending on the treatment procedure and the distribution of nitrogen, microscopic examination may reveal an uneven distribution of the color, with distinct zones of yellow and pink (Gem Trade Lab Notes, Summer 1988, pp. 112–113). The 0.43-ct round brilliant in figure 3 displays such color zoning, while the 0.39-ct round brilliant in figure 4 was evenly colored. Both stones, as well as a 0.47-ct round brilliant (not shown), were easily identified by their fluorescence and spectra.

Treated-color pink diamonds are uncommon because they require a rare starting material, type-Ib diamond, which contains small amounts of nitrogen dispersed as single atoms in the crystal structure [see the discussion of diamond types by E. Fritsch and K. Scarratt, in *Gems & Gemology*, Spring 1992, pp. 38–39]. Most type-Ib diamonds are small (less than 1 ct), and their natural color is usually a highly saturated orangy yellow. Such stones are rarely considered candidates for treatment because of the

value in their intrinsic yellow color. One diamond treater said that all of his treated pinks are produced accidentally, when a parcel of yellow-to-brown melee just happens to contain the needed starting material. Interestingly, most yellow synthetic diamonds are type Ib (or mixtures including a large type-Ib component), and such diamonds will turn pink to red if treated with radiation and heat (see T. Moses et al., "Two Treated-Color Synthetic Red Diamonds Seen in the Trade," *Gems & Gemology*, Fall 1993, pp. 182–190).

Another category of pink diamond sometimes shows strong orange fluorescence: pale-toned diamonds that are type IIa (containing no nitrogen detectable by infrared spectroscopy). Such natural-color pink diamonds are distinguished from treated pink diamonds by their much lower color saturation, by their diamond type, and by the fact that features in the visible spectrum are weak, usually detectable only with the extra sen-

sitivity of a recording spectrophotometer. *GRC and IR*

Unusual Diamond Crystal

Most gem-quality diamond crystals are regular or distorted octahedra, with rounded and irregular crystal forms being less common. On rare occasions, we are shown diamonds with unusual crystal forms. One such example was an aggregate of two rounded crystals, reported in the Spring 1992 Lab Notes section (p. 52).

Another unusual diamond crystal was just seen at the East Coast lab: Not only is the 13.24-ct crystal irregular in shape, but it also has a large "tunnel" etched through its center (figure 5). While our first thought was that this was another kind of intergrowth, the optical properties indicated that it was a single crystal. Careful microscopic examination of the surface in and around the tunnel revealed grooves and channels, which suggests that an etching process formed this hole. We also noted

both green and brown radiation stains at one end of the tunnel. *IR*

SYNTHETIC DIAMOND Suite

Although the trade press has warned many times over the past two years of the imminent influx of Russian gem-quality synthetic diamonds, to date the GIA Gem Trade Laboratory has not seen them in significant quantities. Nevertheless, an occasional diamond submitted to the laboratory for determination of color origin is unmasked as synthetic. Three examples were described in earlier Lab Notes: "Synthetic Yellow Diamond Crystal" (Fall 1993, p. 200), "Faceted Yellow Synthetic Diamond" (Winter 1993, p. 280), "Synthetic Diamond: Treated-Color Red" (Spring 1995, pp. 53–54). All three had properties consistent with synthetic diamonds produced in Russia [see J. Shigley et al., "The Gemological Properties of Russian Gem-Quality Synthetic Diamonds," *Gems & Gemology*, Winter 1993, pp. 228–248].

A few months ago, a client submitted two cut-corner rectangular modified brilliants (0.30 and 0.41 ct) and one round brilliant (0.30 ct) to the East Coast lab for origin-of-color reports (figure 6). All three stones had several properties in common: a saturated yellow color; a strong-to-weak yellow-green long-wave UV fluorescence in a cross-shaped pattern, seen only through the table facets (figure 7); a similarly distributed, but generally weaker (moderate-to-faint), reaction to short-wave UV; and an absorption spectrum—observed with a desk-model prism spectroscope—consisting of a vague absorption generally increasing toward 400 nm. Two stones exhibited weak green transmission luminescence, and two showed weak absorption at 527 nm when examined at low temperature. All were weakly attracted to a magnet.

In diffused light with magnification, we observed vague color

Figure 5. Although this unusual 13.34-ct rough diamond appears to be some sort of intergrowth, it is actually a single crystal with what appears to be an etched hole through the center.





Figure 6. All three of these diamonds (from left, 0.41, 0.30, and 0.30 ct), which were submitted to the laboratory for origin-of-color reports, proved to be synthetic.

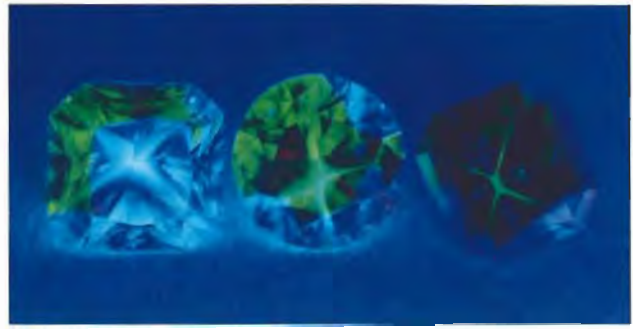


Figure 7. When examined through their tables, all of the synthetic diamonds shown in figure 6 revealed a yellow-green cross-shaped fluorescence to long-wave UV radiation.

zoning of lighter and darker yellow in all three stones. Only when the samples were immersed in methylene iodide did we also see a distinct colorless cross within a medium yellow body color in all three. All revealed extensive clouds of pinpoint inclusions as well, some in the form of curved stringers (which we have never observed in natural diamonds). One stone contained what appeared to be large globules and droplets of residual flux (figure 8). Energy-dispersive X-ray fluorescence (EDXRF) analysis of one of these inclusions by GIA Research revealed Fe and Ni. Infrared spectroscopy showed that all three stones were a low-nitrogen mixture of type Ib and Ia diamond, with A aggregates dominating B aggregates.

All these properties were consistent with those reported by Shigley et al. (1993) for as-grown Russian synthetic diamonds (that is, that had not been irradiated and annealed to alter their color). This is the first time the lab received more than one synthetic diamond from one client at one time. Furthermore, two of these were of higher quality than other Russian synthetic diamonds described to date, and many of the diagnostic properties were less distinct than those previously reported. Consequently, a thorough microscopic

examination is needed to distinguish such stones from natural diamonds.

RCK, IR, and Emmanuel Fritsch

JADEITE JADE, with Misleading Inclusions

An entry on page 117 of the Summer 1994 Lab Notes section described metallic inclusions of two types (probably pyrite and pyrrotite) in an unusually translucent jadeite cabochon. Since then, the West Coast laboratory has seen two other examples of natural-color

jadeite with potentially confusing inclusions.

The first piece (which measured approximately $49.50 \times 27.66 \times 7.87$ mm) was an especially clear—translucent to semitransparent—mottled green-and-white carving of a woman, a child, and a fish. All of the properties were consistent with natural-color jadeite. With magnification, however, we saw small white crystals in the white areas (figure 9, left). In a cursory examination, these white crystals might be mistaken for devitrification features in glass imitations of jadeite. (By devitrification features, we mean individual crystals and crystal groups that grew after the glass cooled or from residual unmelted material [see figure 9, right].) However, examination under higher magnification revealed that they lacked the dendritic nature typical of many devitrification features; also, the surrounding aggregate material was not optically isotropic. Because none of these inclusions reached the surface of the sample, we could not determine their identity.

The second piece was a 26.70-ct translucent green oval double cabochon, with unusual darker green “inclusions” that looked like fuzzy balls of lint at high magnification (figure 10); with reflected light, we were able to see that one

Figure 8. EDXRF analysis of one of these surface-reaching droplets—which were observed in one of the stones shown in figures 6 and 7—indicated that it contains iron and nickel, elements found in the fluxes used to synthesize diamond. Magnified 30 \times .



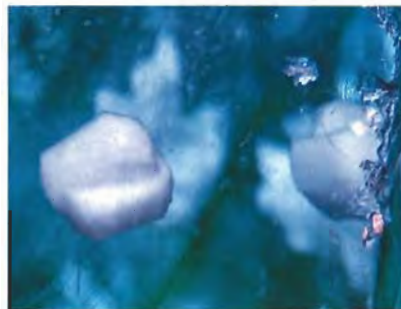


Figure 9. White crystals in jadeite (left, at 12× magnification) could be mistaken for devitrification features in manufactured glass (right.)

of them broke the surface (figure 11). The “inclusions” appeared to consist of small clusters of jadeite grains with a second substance, probably another mineral, coating the grain boundaries. Again, not enough material was present to identify the boundary mineral conclusively.

The “inclusions” in this second piece were interesting because, with only a cursory examination, they could be mistaken for selectively impregnated spots caused by some unknown (or miscalculated) treatment. However, magnification revealed that most of these spots were completely enclosed in the cabochon, with no access to its surface. Also, Fourier-transform infrared spectroscopy (FTIR) revealed no evidence of polymer impregnation.

MLJ and John I. Koivula

Figure 10. These unusual small, dark “inclusions” were found throughout a 26.70-ct jadeite cabochon. Magnified 10×.



OMPHACITE Rock Carving

Nephrite and jadeite, both correctly called jade, are members of two separate mineral groups that contain several other distinct minerals. However, no other members of these groups are properly considered jades, as they differ from either nephrite or jadeite in chemistry or, more importantly, structure. For example, chatoyant actinolite, which is chemically identical to nephrite, is an amphibole-group

Figure 11. When we examined one of the jadeite cabochon’s dark green inclusions in reflected light at higher (40×) magnification, we found that a less reflective substance was coating the boundaries between jadeite grains in the “inclusion” regions. (Because of the light scattering, this substance appears white in the microscope.)



mineral. Although members of the trade often incorrectly call it “cat’s-eye jade,” it is not jade at all, because it has a *parallel* fibrous structure and not the *interlocking* fibrous structure characteristic of nephrite jade. Similar examples could be cited for the pyroxene group, to which jadeite belongs.

Last fall, the West Coast lab received for identification an opaque, mottled green-and-white carved mask, which measured about 22.8 × 22.1 × 7.4 cm (figure 12). Only limited standard gemological tests could be performed. Because of the mask’s size, determination of specific gravity was impractical. The combination of curved surfaces and a poor polish resulted in our obtaining only a vague spot R.I. of 1.62. The mask was inert to both long- and short-wave UV radiation, and magnification revealed an aggregate appearance.

Because these data were insufficient to identify the material, X-ray powder diffraction analyses were performed on microscopic scrapings from the mask. From these analyses, it was determined that the mask was composed primarily of omphacite, plus some feldspar and possibly traces of other minerals. However, we could not characterize the item completely (as would be possible with petrographic analysis), because our testing was limited to nondestructive methods.

Omphacite is a pyroxene-group mineral, intermediate in composition between jadeite and diopside; it is fairly common in Mesoamerican “jades” (see, e.g., G. E. Harlow’s article in *Natural History*, August 1991, pp. 4–10, and W. F. Foshag’s article—where he calls omphacite “diopside-jadeite”—in *American Mineralogist*, Vol. 40, No. 11–12, 1955, pp. 1062–1070). Although omphacite is chemically similar to jadeite, it is neither jadeite nor a jade.

MLJ and RCK



Figure 12. This mask was identified as a rock consisting primarily of omphacite (a pyroxene mineral) plus feldspar and possible additional minerals. Consequently, it is not jade.

CULTURED PEARL, With a Damaged Nucleus

Baroque cultured pearls often have thick layers of conchiolin between the nacre and the bead nucleus. When a gap forms in this layer, the nucleus can come loose from the nacre. Drilling such a pearl can be hazardous, as either the nacre or the bead might break. One way to work around this hazard was discussed in the Summer 1990 Lab Notes section (p. 155). In that instance, an X-radiograph was taken to determine where to drill without breaking the nacre.

Drillers are not always so fortunate. We suspect that a loose bead scenario was responsible for damage observed in a light gray baroque pearl that was part of a cultured pearl necklace tested at the West Coast laboratory last fall. X-radiographs (figure 13), taken during routine testing, revealed a large void with what appeared to be fragments of a bead nucleus in one of

the pearls. Examination through the drill hole confirmed loose pieces of shell-like material within the cavity. We could even see evidence of a drill hole in one larger fragment.

Although we can only speculate as to what happened, we believe that the bead was probably

in a void, or loosely surrounded by conchiolin, and had detached before or during the drilling process. There may even have been several drilling attempts, during which the bead moved and broke into pieces, much of it being reduced to powder by the drill bit. The remaining fragments were then free to tumble within the large void. This can be clearly seen in figure 13, from the different positions of the fragments in the two views.

Although the nacre on this pearl has lost the support provided by a bead nucleus, its shape and thickness give it enough strength to be used for a necklace.

Cheryl Y. Wentzell

DYED QUARTZITE, Imitating Jade

Because of its great abundance and its good durability, colorless quartz is often dyed various colors to imitate other gems. In fact, it is one of the oldest "impostors" in recorded history, with the dyeing of quartz to imitate emerald referred to as early as the first century A.D. (see, e.g., K. Nassau, "The Early History of Gemstone Treatments," *Gems & Gemology*, Spring 1984, pp. 22-33). Dyed green quartz is still commonly used as a simulant, with

Figure 13. Readily seen in these X-radiographs of a strand of cultured pearls is a 10.10 × 9.30 × 8.00 mm cultured pearl with a large void that appears to contain several loose fragments (note the different positions in the two views) from a broken bead nucleus.

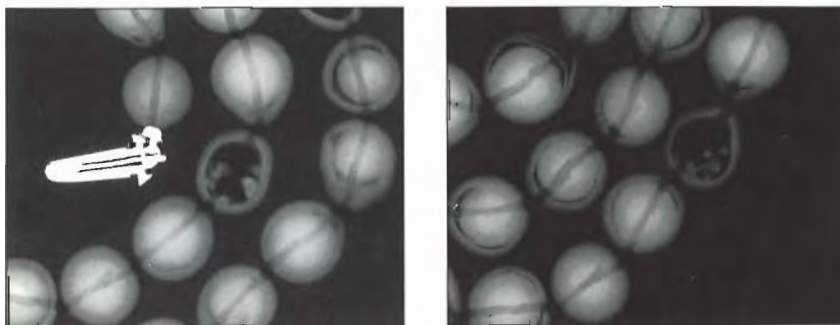




Figure 14. The approximately 30.25 × 15.98 × 5.50 mm dyed quartzite cabochon in this ring makes a convincing imitation of jadeite.

single-crystal material treated to imitate emerald and with translucent-to-nearly opaque quartz, as well as quartzite (a metamorphic rock composed primarily of quartz grains), dyed to imitate jadeite.

In November 1994, the West Coast lab received for testing a ring set with a translucent mottled-green oval cabochon, about 30.25 × 15.98 × 5.50 mm, that resembled fine-quality jadeite (figure 14). Standard gemological testing, including a 1.55 spot R.I. and the aggregate structure seen with magnification, identified the stone as quartzite. Microscopic examination also revealed dye concentrations in fractures and between grains of the aggregate structure, with the presence of dye further confirmed by the characteristic "dye band" centered at about 650 nm, which was seen with a desk-model prism spectroscope.

To learn more about the treatment used for this stone, we analyzed it with infrared spectroscopy.

This revealed key absorption features at about 2900 cm^{-1} in the mid-infrared, similar to those of the synthetic resin Opticon and those documented in some bleached and impregnated "B jade" (see E. Fritsch et al., "Identification of Bleached and Polymer-Impregnated Jadeite," *Gems & Gemology*, Fall 1992, pp. 176–187). However, the absorptions in the treated quartzite were only about one-tenth as strong as those that have been documented in impregnated jadeite. This is probably because a much smaller quantity of polymer is used to carry the dye into the treated quartzite. (For more on the quantitative method used to evaluate infrared absorptions in treated jadeite, see the article "Type-B Jadeite: New Polymers and Estimating Amount of Wax," by E. Fritsch, *Jewellery News Asia*, November 1994, pp. 106–108, 110.)

RCK

Figure 15. Although this 21.28-ct "star ruby" was somewhat included, had a good color, and appeared to be native cut, gemological testing proved that it was a synthetic ruby with a diffusion-induced star and "fingerprint" inclusions.



SYNTHETIC RUBY, With Diffusion-Induced "Fingerprint" Inclusions and Asterism

The East Coast laboratory received for identification what appeared to be a star ruby (figure 15). The somewhat included 21.28-ct cabochon had a moderate star and a color reminiscent of rubies from Burma. It appeared to be native cut, with an extremely thick girdle. The desk-model prism spectroscope revealed a ruby spectrum. When we first examined the piece with a microscope, only fingerprint inclusions were evident; at higher magnification, however, we saw obvious curved striae. The stone was really a Verneuil (flame-fusion) synthetic ruby. Therefore, the fingerprints were induced, as was the surface-diffused star. GRC

Cat's-Eye SAPPHIRE

Although asterism is a fairly common phenomenon in corundum gems, chatoyancy is encountered only rarely (described as "extremely rare" in the 5th edition of Webster's *Gems* [edited by P. Read], Butterworth-Heinemann, Oxford, 1994). In our experience, a cat's-eye effect in corundum—natural or synthetic—is usually produced when the cutter orients the axis of the star in an asteriated stone off-center, so that only one "leg" of the star is seen across the dome of the cabochon.

Earlier this year, the West Coast lab received for identification a 1.91-ct, semitransparent, mottled greenish blue oval cabochon that displayed distinct chatoyancy (figure 16). Standard gemological testing proved that it was natural sapphire. When we examined the stone with magnification, however, we were surprised to see that it had almost no acicular rutile crystals, which are typically the cause of asterism in corundum. Instead, we



Figure 16. Chatoyant sapphire, such as this 1.91-ct ($13.99 \times 5.19 \times 2.54$ mm) stone, is very unusual.

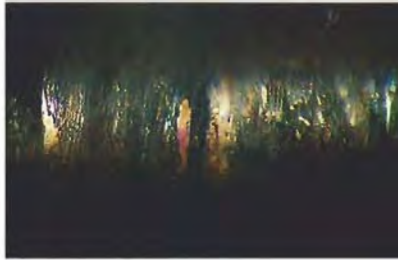


Figure 17. The cat's-eye effect seen in the sapphire shown in figure 16 is caused by the reflection of light from these numerous parallel, liquid-filled channels. Magnified 20 \times .

detected a series of nearly planar, parallel, liquid-filled "fingerprints" (figure 17). Light scattering from these caused the chatoyancy. Magnification also revealed diffuse color halos around crystal inclusions, evidence that the stone had been heat treated. RCK

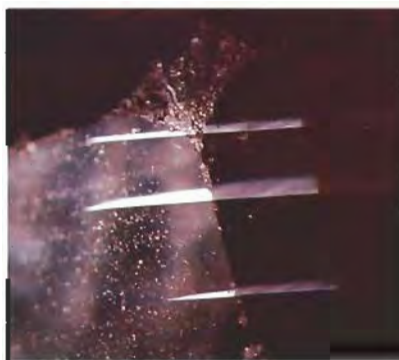
SYNTHETIC SAPPHIRE, Color-Change with Twin Lamellae

Probably the flame-fusion synthetic corundum seen most frequently in the GIA Gem Trade Laboratory is vanadium-doped, color-change synthetic sapphire (which appears greenish blue in fluorescent or natural light and pinkish purple in incandescent light). Many of the clients who submit such material for identification do not even suspect that it is a form of corundum: They believe we will establish whether it is natural or synthetic alexandrite (chrysoberyl). Identification of these Verneuil synthetic sapphires is generally straightforward, as they typically show (1) a single vanadium-related absorption band at about 474 nm (resolvable with a desk-model spectroscope), and (2) curved striae (when examined with magnification using darkfield illumination).

In November 1994, however, the West Coast lab received for identification a 1.43-ct transparent emerald-cut stone, which measured

about $6.85 \times 5.73 \times 3.80$ mm. It exhibited a distinct color change, appearing bluish green in daylight-equivalent fluorescent light and pinkish purple in incandescent light. Examination with a binocular microscope did not reveal any solid (mineral) inclusions or any voids (i.e., gas bubbles or negative crystals). However, readily noted was a series of laminated twin planes, which were clearly visible through the table facet (figure 18). Although this feature is not proof of origin, it

Figure 18. A series of twin lamellae, an uncommon feature in flame-fusion synthetic corundum, can be clearly seen in this color-change synthetic sapphire, which also revealed curved striae. Magnified 25 \times .



usually indicates natural corundum. Further examination with magnification—this time looking through the pavilion facets—revealed curved striae, which proved the stone was synthetic.

Descriptions of twinning in Verneuil synthetic corundums appear sporadically in the literature (see, for example, W. F. Eppler's "Polysynthetic Twinning in Synthetic Corundum," *Gems & Gemology*, 1964, Vol. 11, No. 6, pp. 169–174 and 179, as well as J. M. Duroc-Danner's "Polysynthetic Twin Lamellae in Synthetic Verneuil Sapphire," *Journal of Gemmology*, 1985, Vol. 19, No. 6, pp. 479–483). Twinning is not the only confusing feature that may be seen. In flame-fusion synthetic corundums, the gemologist may rarely come across inclusions of undissolved alumina (R. Webster [edited by P. Read], *Gems*, 5th ed., 1994, Butterworth-Heinemann, Oxford, pp. 405–406); triangular cavities containing gas bubbles (Spring 1991 Lab Notes, p. 45; Webster's *Gems*, pp. 405–406); and even needle-like inclusions (Winter 1990 Lab Notes, p. 298).

All these atypical inclusions and growth features should serve as a warning to the reader: Do not make a gem identification based on a superficial microscopic examination or on the first inclusion(s) seen. ALL internal features in the gem should be studied from a variety of viewing angles before a decision is reached. RCK

PHOTO CREDITS

Figures 1 and 16 were photographed by Maha DeMaggio. The photomicrographs in figures 2, 9 (left), 10, 11, 17, and 18 were taken by John I. Koivula; the photomicrograph in figure 9 (right) was by Jeffrey E. Appling, JEA Jewelry Appraisals, Salinas, California. The photos in figures 3 and 5 were taken by V. Cracco. Nicholas DelRe supplied figures 4, 6–8, and 15. Shane F. McClure provided figures 12 and 14. The X-radiographs in figure 13 are by Cheryl Y. Wentzell and Patricia Maddison.

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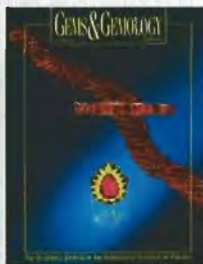
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DIAMONDS

More firms processing fracture-filled diamonds. Although the Fall 1994 article on fracture-filled diamonds (Kammerling et al., *Gems & Gemology*, pp. 142–177) only specifically covered products by Yehuda, Koss, and Goldman Oved, it cautioned that other firms are also treating diamonds to decrease fracture visibility. After noticing an ad in *Mazal U'Bracha*, the editors asked the advertisers—David Levy & Max Dahan, of Ramat Gan, Israel—for more information. In May, Mr. Dahan kindly provided the details that follow. (We plan to examine some of the the stones in question at a later date.)

The firm's laboratory opened in August 1991; about 30,000 carats of diamonds have been treated in the last 30 months, according to Mr. Dahan. These stones ranged from 1 point (0.01 ct) to 20.50 ct. In a recent 1,500-ct sample of diamonds they treated, about 25% (by weight) were one-third carat and smaller; about 20% were 40-to-90 points; about 25% were 1 ct; and the remaining 30% were 1.5 ct and larger. Mr. Dahan states that there is practically no limit to the size or shape of diamonds that can be treated. He added that the greatest demand in treated diamonds now is for those with an apparent clarity of SI₁ after fracture filling.

Mr. Dahan further noted that the durability of the treatment depends not only on the chemical composition of the glass, but also on the physical dimensions and position of the fracture. For instance, a filled fracture running through the table is less sensitive to damage by ultrasonic and steam cleaning, but more sensitive to damage by ultraviolet radiation; whereas a filled fracture at the girdle of the stone is less sensitive to ultraviolet radiation, but more susceptible to damage by cleaning techniques.

Synthetic diamonds misrepresented as Canadian rough. Pacific Gemological Associates (PGA) of Vancouver, British Columbia, reported on a new variation on one of the trade's oldest tricks.

A client with significant interests in mineral exploration in northern and western Canada brought to PGA's attention a package of diamond microcrystals. These diamonds were being represented as a typical core result for a property in Saskatchewan in which the clients had been asked to invest. Examination of the stones, however, proved that all were synthetic.

Initial observation of the parcel alerted PGA, as *all* the crystals were about the same size, color, and shape (very atypical for a mine-run sample). Furthermore, the crystals had an elongated, modified octahedral (possibly cubo-octahedral) habit. More significantly, stones examined in detail showed evidence of metallic flux inclusions and "stop-sign" graining. All these features were reminiscent of the synthetic diamonds described by Shigley et al. in, for example, "The Gemological Properties of the DeBeers Gem-Quality Synthetic Diamonds" (*Gems & Gemology*, Vol. 23, No. 4, 1987, pp. 187–206).

This is the first time that PGA is aware of synthetic diamonds being misrepresented as natural to mining and investment industries.

COLORED STONES

Large aquamarines from Nigeria. The firm G.R.K. Gems, of New York City, had an impressive display of large, transparent aquamarines from Nigeria at Tucson this past February. The stones, which were fashioned in Jaipur, India, ranged from 9.52 ct to 436.15 ct (a 48 × 35 mm emerald cut). The 47 stones in the collection had a combined weight of 2,500 ct.

Clinochlore and other rare collector stones from the former Soviet Union . . . In the Spring 1995 Gem News (pp. 65–67), we described some rare gemstones from Canada that were seen at the Tucson gem shows this year. Also in evidence were a number of rare collector stones from various republics of the former Soviet Union. Samir Pierre Kanaan, of Paris, France, loaned one of the editors (EF) some of these for examination, the results of which are detailed here. Although none of these is durable enough for use in jewelry, all made for very interesting faceted stones. Mr. Kanaan also indicated that a number of small colorless crystals of leucophanite, (Ca,REE[rare earth element])CaNa₂Be₂Si₄O₁₂(F,O)₂, are coming from Russia, and are suitable for faceting.

Also found recently was color-change *clinocllore*, (Mg,Fe²⁺)₅Al(Si₃Al)O₁₀(OH)₈, in an unspecified area of Russia. Russian geologists call it "corundophilite," an obsolete name for this species. We examined several small rough fragments and two faceted gems (a 0.43-ct hexagonal rose cut and a 0.25-ct cut-corner rectangular modified step cut). Because of clinocllore's perfect cleav-

age, it is very difficult to facet and tends to shatter if not handled carefully. The faceted stones were dark green in fluorescent illumination or daylight, and changed to a dark brownish reddish purple in incandescent light. We found that the gemological properties for both, as reported below, were essentially identical.

Because of the poor polish, we were able to obtain approximate indices of refraction only for $\alpha = 1.585$ and $\gamma = 1.600$, and none for β . We determined a specific gravity of about 2.73 and observed a weak-to-moderate pleochroism of orangy red and purple. Both stones were inert to long- and short-wave ultraviolet radiation. Mohs hardness, according to the mineralogical literature, is 2–2½.

With the hand-held spectroscope (confirmed by spectrophotometry), the stones showed total absorption to nearly 470 nm, with a faint line at about 470 nm, intense absorption between 550 and 620 nm, and lines at about 660, 680, and 690 nm. Energy-dispersive X-ray fluorescence (EDXRF) analysis confirmed the presence of magnesium, aluminum, silicon, and iron as major constituents. It also detected lesser amounts of chromium, nickel, and vanadium. The color change can be attributed to absorption caused by chromium (Cr^{3+}).

Görgeyite, $\text{K}_2\text{Ca}_5(\text{SO}_4)_6 \cdot \text{H}_2\text{O}$, a rare hydrated potassium calcium sulfate associated with salt deposits, has also been found in an undisclosed area of Russia. We studied a near-colorless, 0.64-ct rectangular step cut. The indices of refraction were $\alpha = 1.556$ and $\gamma = 1.587$ (because of the crystallographic orientation of the table, we could not determine β). The specific gravity was 2.91. The sample was inert to both long- and short-wave UV radiation, and revealed no spectral absorption features in the hand-held spectroscope. With magnification, we saw many small healed fractures and feathers, as well as a cleavage plane—containing what appeared to be a liquid film—running through the stone. EDXRF confirmed the presence of the major constituents sulfur, potassium, and calcium. *Görgeyite* has a reported Mohs hardness of 3½.

A number of transparent crystals of *kaliborite*, $\text{KHMg}_2\text{B}_{12}\text{O}_{16}(\text{OH})_{10} \cdot 4\text{H}_2\text{O}$, have been found in the salt-bearing beds of the Inder uplift near Inder Lake in Kazakhstan, north of the Caspian Sea. We examined a near-colorless 0.43-ct rectangular step cut. On this biaxial stone, we determined indices of refraction of $\alpha = 1.503$, $\beta = 1.524$ to 1.530, and $\gamma = 1.549$. The specific gravity was 2.11. The gem was inert to both long- and short-wave UV, and produced no spectrum in the hand-held spectroscope. A group of many low-relief, colorless, rounded-to-flattened crystals were visible with magnification in one area of the stone; we found them to be highly birefringent. EDXRF analysis confirmed the presence of magnesium and potassium, the only two major constituents we could identify. No impurities were noted. The reported Mohs hardness for *kaliborite* is 4–4½.

Preobrazhenskite, $\text{Mg}_3\text{B}_{11}\text{O}_{15}(\text{OH})_9$, also comes from the Inder deposit in Kazakhstan. We studied a near-

colorless, flat, 0.09-ct rectangular stone that was only partially faceted (the pavilion was a rough crystal surface). The indices of refraction were approximately equal for α and β , both about 1.570, and $\gamma = 1.599$. The specific gravity was 2.47. Both long- and short-wave UV radiation produced a faint yellowish orange fluorescence. No absorption lines were visible in the hand-held spectroscope. Magnesium was the only major constituent that could be detected by EDXRF analysis. The stone was filled with small, low-relief, flattened-to-rounded crystals that were highly birefringent. Because *preobrazhenskite* is known to enclose *kaliborite* and *boracite* crystals during its growth in this deposit (see Roberts et al., *Encyclopedia of Minerals*, 2nd ed., Van Nostrand Reinhold, New York, 1990), it is possible that the inclusions are one of these two species. *Preobrazhenskite* has a reported hardness of 4½–5 on the Mohs scale.

... and other unusual gems seen at Tucson. Among other unusual gems that the editors encountered at Tucson was a 29.65-ct oval faceted *sillimanite*, reported by the vendor (John Bachman, Boulder, Colorado) to have been mined in Orissa, India, at the same deposit that is producing many cat's-eye *sillimanites*. Although the stone was pale yellow under incandescent light, Mr. Bachman said that it appeared pale green in daylight.

Neal Littman, of San Francisco, California, had a 434-ct faceted "rainbow" *calcite* that displayed exceptionally strong dispersion. This stone was faceted by Art Grant, of Hannibal, New York, who also cut the 1,156-ct gem described by Drs. Cornelius Hurlbut and Carl Francis in the article "An Extraordinary *Calcite Gemstone*," *Gems & Gemology*, Winter 1984, pp. 222–225. The twinning that is responsible for the exaggerated dispersion shown by this material was clearly seen through the stone's table facet. Mr. Littman also had a 3.35-ct iridescent *andradite* cabochon that exhibited its phenomenon in the form of a distinct eye that was predominantly blue with golden yellow seen at one end.

Mark H. Smith, of Bangkok, showed the editors a 56.94-ct green *sphene* from Sri Lanka that was shield-cut to showcase the stone's strong dispersion. He also had a 21.46-ct, faceted pale-green *sillimanite* and a 4.02-ct near-colorless, transparent faceted *chrysoberyl* from Sri Lanka.

Phenomenal feldspars from India. Feldspars that display both adularescence and chatoyancy are not new to the gem market. In the editors' experience, many cat's-eye moonstones are of Indian origin. These stones usually have a grayish white body color, although we also see stones that are medium light greenish gray or light to medium light brownish orange.

At Tucson this year, the editors saw some chatoyant moonstones with an atypical darker orange body color. According to Manu Nichani of Temple Trading, Encinitas, California, this material became available last year from deposits near the city of Madras, in the south-



Figure 1. These two phenomenal feldspars, a 1.65-ct cat's-eye moonstone (left) and a 2.39-ct sunstone, are from the state of Tamil Nadu, in southern India. Courtesy of Temple Trading; photo by Shane F. McClure.

ern Indian state of Tamil Nadu. (These deposits have also produced the more common colors previously mentioned.) When one of the editors (RCK) remarked that the fairly dark color of this new material (figure 1) was similar to that of some sunstone feldspar of Indian origin, Mr. Nichani said that the latter material is also mined in Tamil Nadu, near the city of Trichy. Furthermore, the two mining areas are less than 100 miles (160 km) apart.

Michael Randall, Gem Reflections of California, San Anselmo, had some interesting sunstones that displayed weak, four-rayed asterism. Although he did not know the exact locality, they were reportedly from southern India.

Temple Trading was also selling faceted "rainbow moonstone" (actually labradorite feldspar). These 5 × 10 mm marquise cuts were well oriented to show the phenomenon across the table when examined face up.

Parti-colored fluorite from Brazil. Fluorite from China has been on the market in great quantities for several years. We regularly see this material at gem shows in a variety of forms, including mineral specimens, carvings, and beads. In our experience, the vast majority of this material is banded in green and purple. What caught the eye of one of the editors at the booths of some Brazilian dealers at the February 1994 and 1995 Tucson shows were parti-colored fluorite cabochons, most of which had areas of bright yellow as well as green and/or purple (see, e.g., figure 2). According to one dealer, this material came from the state of Santa Catarina in southern Brazil, having formed hydrothermally in pockets in a basaltic lava flow.

This material was available from several Brazilian firms at the 1995 Tucson show. In addition to the multi-colored cabochons seen last year, we also encountered faceted stones. Some of these had been fashioned to show

three colors. Others were bicolored (purple/yellow, yellow/green, and purple/green). One of the editors also encountered a few stones that were only one color, including some step-cut medium-toned green stones that looked very much like light-toned emeralds. The sources of the material seen this year were reported by various dealers as being either in the Brazil-Peru or Brazil-Argentina border areas.

Unusual opal carvings. Much opal occurs as thin seams in a host rock. To make use of such material, lapidaries often fashion it into assembled stones, including doublets and triplets. They may also fashion it to include the matrix with the opal: For example, so-called boulder opal from Australia typically has a thin layer of opal on top of the ironstone matrix in which it formed.

In Tucson this year, we noted two novel types of gem carvings that incorporated both opal and its matrix. The first (figure 3) were transparent to semitransparent, slightly milky opals from Oregon that were "illusion carved"—cut from the back to produce a three-dimensional effect when viewed from the front of the stone—into scenes of deer, elephants, and fish. In forest or savanna motifs, the yellowish brown matrix formed the ground on which the animals stood; in the aquatic scenes, the matrix formed the seabed and seaweed. The material was preformed in the United States and then carved in China, according to the vendor, Eric Braunwart, of Columbia Gem House, Vancouver, Washington.

The second type was offered by Donald K. Olson and Associates of Bonsall, California. This firm has two artists in their group who create opal intarsia. Some of these carvings have a three-dimensional effect from layers of dendritic opal that have been backed with scenic

Figure 2. These five fashioned fluorites (1.81 to 30.01 ct) are from Brazil. The largest is from the southern state of Santa Catarina. Photo by Maha DeMaggio.





Figure 3. This carving creatively incorporates Oregon opal and matrix into its design. Courtesy of Columbia Gem House; photo © GIA and Tino Hammid.

slabs of other gem materials, for example, agate. About 50 such "pictures" are produced annually.

Update on opal from Ethiopia. The Spring 1994 Gem News noted that there was a new source for opal, Ethiopia (pp. 52–53). In May of this year, Dr. Paul Downing of Majestic Opal, Estes Park, Colorado, provided an update on opal from this northeast African nation.

According to Dr. Downing, opal is being recovered from an area known as Yita Ridge in the Menz Gishie District of Shewa Province, about 240 km (149 miles) northeast of Ethiopia's capital, Addis Ababa. Dr. Downing believes that this deposit is different from the one we described earlier, which we had been told was in

Figure 4. These sapphires (from left—0.73, 0.91, and 1.43 ct) are from southern Madagascar, an increasingly important source of colored stones. Photo © GIA and Tino Hammid.



the far south of the country, possibly in Harerge Province, not far from the Kenya border. This apparently new deposit is being commercially worked by a joint Ethiopian–U.S. firm, the Ethio-American Resource Development Corporation, which holds a claim through Ethiopia's Department of Mines and Energy.

The deposit appears to be quite extensive, with the opal found in rhyolite nodules. Gem-quality material ranges in body color from colorless to yellow to orange to dark reddish brown ("caramel"), and exhibits strong play-of-color in many hues and patterns. A small amount of transparent-to-translucent material has been fashioned as cabochons, and some transparent material has been faceted. Although the find is still in the exploration phase, some of the fashioned material is now entering the U.S. market.

The deposit also produces porous white hydrophane opal; when soaked in water, it exhibits strong play-of-color. Dr. Downing is experimenting with this material in an effort to produce marketable impregnated opal.

Sapphires from Madagascar. Commercial quantities of fine sapphire are now being produced on the island of Madagascar. Recently, we had the opportunity to conduct gemological tests on eight Madagascar sapphires, loaned to GIA by Bill Marcue, of D.W. Enterprises, Boulder, Colorado. (Three of these stones are shown in figure 4.) The following properties were determined: color—medium to medium dark blue to slightly violetish blue; color distribution—even in four of the stones and fairly pronounced banding in the other four; diaphaneity—transparent; R.I.— $n_o = 1.768$ to 1.769 , $n_e = 1.759$ to 1.760 ; birefringence—0.008 to 0.009; pleochroism—distinct dichroism in slightly greenish blue to green-blue (extraordinary ray) and violetish blue to violet-blue (ordinary ray), varying with depth of body color; Chelsea filter reaction—inert (appeared the same color as the filter). All eight stones were inert to long-wave UV, and three were inert to short-wave; the other five fluoresced a very faint-to-weak, uneven, chalky greenish blue to short-wave UV. When examined with a desk-model spectroscope, all of the stones showed at least a faint absorption line at about 451 nm; five showed an additional absorption line at about 460 nm; and two of these five had a further, weak 470-nm line. In addition, five of the stones exhibited a weak "chromium" line at about 694 nm, which appeared to be an emission line. Luminescence spectroscopy confirmed that this line was due to emission.

Magnification revealed a number of features. In addition to the color banding mentioned above, we also noted "burst" primary fluid inclusions and discoid fractures around negative crystals (both evidence of heat treatment), partially healed "fingerprint" inclusions, and crystal inclusions whose nature could not be determined because of the heat treatment.

Chemical analysis performed on one sample with energy-dispersive X-ray fluorescence spectroscopy

revealed, as expected, that aluminum was the major constituent. Iron accounted for about 0.5 wt.% (as FeO) and titanium for 0.036 wt.% (as TiO₂). There was also a trace amount of gallium, as is common in natural sapphires. Chromium was not detected. The weak emission line mentioned previously is typically due to minute amounts of chromium, well below the detection limits of our instrument. The UV-visible absorption spectrum showed that the blue color is due to a broad absorption centered at around 700 nm, which is typical of the iron-titanium charge transfer when measured in a direction perpendicular to the optic axis. No other absorptions appeared to contribute to the blue color. We observed small peaks at about 377, 387, and 451 nm. These are typical of Fe³⁺ and have been observed in blue sapphires from many localities. We also noted an additional very weak "shoulder" at about 460 nm.

Although we do not know the specific locality for these stones, a recent, brief report by C.C. Milisenda in the *Zeitschrift der Deutschen Gemmologischen Gesellschaft* (Vol. 44, No. 1, 1995, pp. 3-4) describes sapphires from a new occurrence near Bekily in Madagascar's southwestern Province of Toliara. The properties reported for these stones are similar to those determined for our eight samples.

An indication of the perceived commercial significance of Madagascar's sapphire deposits can be found in a March/April 1995 *ICA Gazette* report that 43 Thai gem dealers have invested in a new company formed to develop the deposits in southern Madagascar. This company, the Gems Industry Corporation, was negotiating for several mining leases and plans to import heavy mining equipment.

Sapphires and other gems from Tanzania. The Spring 1995 Gem News section included an entry on sapphires from a new deposit in the far south of Tanzania (pp. 64-65). One of the editors (HAH of the SSEF Swiss Gemmological Institute in Basel, Switzerland) has provided more information about the gems from this new locality. He has also learned more about the locality itself from dealer Werner Spaltenstein, of Multicolor, Bangkok, who has claims in this area.

The SSEF received its first parcel of mixed faceted stones from this source in August 1994. They ranged in color from blue to purple to "mauve;" some were very bright while others had a dull appearance. Most were no larger than 1 ct. In overall appearance they were reminiscent of darker suites of Uмба sapphires and garnets that this editor has seen. In January 1995, SSEF received a second, larger parcel (about 1,000 carats) of rough stones, reportedly from the same deposit (see, e.g., figure 5).

The mining areas, said to be in the Songea District, are adjacent to the Muhuwesi Forest Reserve, about 200 km (320 miles) west of the Indian Ocean coast. One area village is called Puchapucha. Various mining claims have been staked along the riverbeds in the area, where the

Muhuwesi and Mtetesi rivers converge. In this savanna terrain, the riverbeds show discontinuous outcrops of what appear to be igneous and metamorphic rocks. Pegmatites, pyroxenites, amphibolites, and gneisses are expected to be found. To date, gemstone pebbles are being collected from the surface gravels by hand; no shafts have been sunk, nor has any machinery been used. Some 200 diggers are working the river gravels under waterfalls and at rapids when the water is low. Although production figures are vague at best, Mr. Spaltenstein estimates that about 20-30 kg (44-66 pounds) of alluvial gem rough is recovered each month.

Most surprisingly, these gemstone gravels strongly resemble gem concentrates from Sri Lanka with respect to mineral content, colors, and degree of mechanical wear. However, East African "specialties" are also encountered in the mineral mix. To date, the editor has identified blue sapphire (in good-quality "Burma" to "Ceylon" colors, which could produce cut stones up to 5 ct), fancy sapphires (including pink, purple, brown, gray, and green), and some ruby; spinel in light-to-dark blue, purple, violet, and almost black; garnet, including yellow-to-brown grossular (and a polycrystalline hessonite-colored type), tsavorite, pyrope-almandine (including rhodolite), spessartine, and malaia; chrysoberyl in yellow to

Figure 5. Reportedly from a new source in southwestern Tanzania, these mixed rough gems are part of a parcel of about 1,000 carats. The largest piece is approximately 10 mm long. Photo courtesy of Dr. Henry A. Hänni, SSEF.



green to brown (some cat's-eye material and alexandrite has also been reported); tourmaline in brown to yellow and green; rock crystal quartz, citrine, and amethyst; zircon in yellow, brown, and green; kyanite; and violet scapolite. Gold and diamonds have also been found. The editor believes that the area will produce additional, rarer gem materials in the future.

Spessartine garnet from Namibia. The vivid orange spessartine garnets that had such an impact at the Tucson show when they debuted two years ago (and which were subsequently confirmed to be from Namibia; see Spring and Winter 1993 Gem News, pp. 61 and 293, respectively) were again on hand this year. Colgem Ltd., of Ramat Gan, Israel, which first introduced the material, again had a large selection at the 1994 and 1995 Tucson shows. They showed what they purport to be the largest faceted Namibian spessartine cut to date, a 29.77-ct cushion shape, and the largest "eye-clean" stone cut to date, a 14.77-ct triangular mixed cut.

Israel Z. Eliezri of Colgem said that the material was initially marketed under the trade name "Hollandine" garnet, but now most of the trade—and Colgem—are using the term "Mandarin" garnet.

Chemical analyses show that the material averages 85 mol.% spessartine (manganese garnet), 12.5 mol.% pyrope (magnesium garnet), and 2.5 mol.% grossular (calcium garnet), according to Mr. Eliezri. This accounts for the purity of the stones' orange color, as manganese is the only element present that produces the orange color in these garnets. Rough with a small iron content is also recovered, but this material has an undesirable brown component and so is not being cut.

At Tucson this year, Nicholas DelRe, of the GIA Gem Trade Laboratory in New York, learned of another,

Figure 6. This 0.66-ct cat's-eye spessartine garnet is from a deposit in Namibia. Photo by Nicholas DelRe.

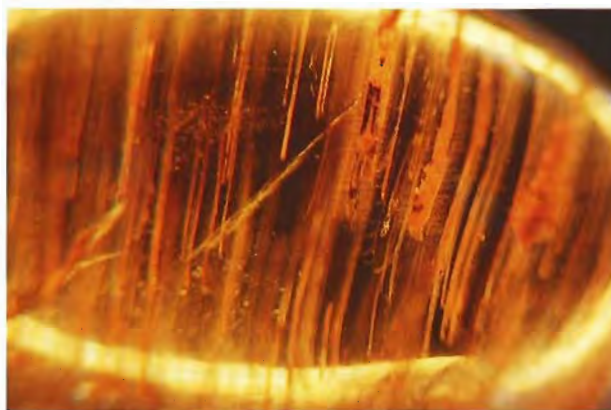


Figure 7. Some inclusions in the stone in figure 6 are hollow tubes; others are birefringent acicular crystals, possibly tremolite. Photomicrograph by Nicholas DelRe; magnified 30 \times .

relatively new find of spessartine garnet in Namibia from Alan Roup of G.E.M. Ltd., Jerusalem, Israel. Because the material is found in a schist matrix (unlike the other Namibian find), much of the garnet is included. Mr. Roup believes that many of the inclusions are tremolite. Mr. DelRe acquired one specimen for examination, a 0.66-ct cat's-eye cabochon (figure 6). The gemological properties of this gem were: color—orange; optical character—singly refractive; R.I.—over-the-limits (greater than 1.81); S.G.—4.10; ultraviolet fluorescence—inert to both long- and short-wave UV. The absorption spectrum, seen with a hand-held prism spectroscope, was consistent with that of spessartine garnet—a cutoff at 435 nm, with weak bands at 460, 480, and 520 nm. With magnification, two types of inclusions were noted (figure 7). Some were apparently hollow tubes, but others, which appeared to be doubly refractive when examined between crossed polarizers, were probably tremolite, as Mr. Roup suggested.

Production of spessartine from both deposits is estimated at less than 40 kg per month, according to Chris Johnston (reported by E. Wright, "Dealers Weigh Mandarin's Fate," *Colored Stone*, Vol. 8, No. 4, July–August 1995, pp. 1, 20, 22, 24). In the same article, Howard Boltz estimates gem yields of 20% from the rough garnet. Clean faceted stones weighing more than 1 ct continue to be rare.

SYNTHETICS & SIMULANTS

Amber simulant: Natural resin in plastic. One simulant seen at every Tucson show since at least 1993 is a form of reconstructed amber. Reportedly produced in the former Czechoslovakia from Baltic amber (Spring 1993 Gem News, p. 63), this material is visually similar—with its eye-visible, veil-like grain boundaries—to other pressed



Figure 8. This 8.32-ct cabochon (19.13 × 19.23 × 7.03 mm) consists of plastic with embedded fragments of natural resin. Photo by Maha DeMaggio.

amber that the editors have seen. Recently, the editors came across another material that was labeled variously "pressed," "reconstructed," "reconstituted," and "synthetic" amber. Two firms from Poland that were marketing the material at the 1995 Tucson show independently confirmed that it was produced in Gdansk, a Polish city on the Baltic Sea. A promotional flier from one of the firms said that the starting material was "small pieces of amber taken from the deep ground or from washing up on the shore in the Baltic region. . . . After being ground they are set in fresh tree sap. After drying they are refinished, polished, and hand-made into jewelry and other artifacts."

This material was available in many forms, including round and oval cabochons in a range of sizes, star shapes for hanging on cords, heart-shaped cabochons with bails for use as pendants, and flexible bracelets, produced by stringing oblong shapes on double strands of elastic cord. It is visually distinct from true pressed amber because it displays very clearly defined irregular transparent-to-semi-transparent yellow-brown fragments in a lighter-toned transparent yellow groundmass (figure 8). We purchased several samples and tested one 8.32-ct round cabochon to document its gemological properties.

The spot R.I. was 1.56, and hydrostatic weighing revealed an S.G. of 1.24. Under crossed polarizers, strong anomalous double refraction with strain colors was noted. When exposed to long-wave UV radiation, the body of the cabochon fluoresced a moderate greenish yellow, and the included fragments fluoresced a moderate bluish white. Under short-wave UV, the body fluoresced a faint yellowish orange, and the fragments were inert. When touched gently with a thermal reaction tester, the cabochon produced an acrid odor. However, when a sur-

face-reaching fragment was similarly tested, it produced a resinous odor.

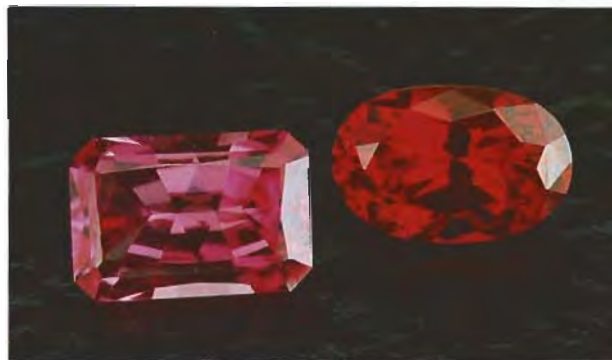
Fourier-transform infrared (FTIR) spectroscopy was conducted on a second piece of this material. One of the amber-like fragments showed strong absorption peaks at 4057, 4250, 4358 and 4431 cm^{-1} ; moderate peaks at 4636, 4672, and 5876 cm^{-1} ; and weak absorptions at 5252, 5674, and 5807 cm^{-1} . These features are all consistent with those of a reference sample of natural amber that we also tested. The matrix material showed a strong absorption peak at 1725 cm^{-1} and weak absorptions at 1503 and 1673 cm^{-1} , features consistent with those of an unsaturated polyester resin.

We concluded that the cabochon consists of plastic in which fragments of a natural resin—probably amber—are embedded. Similar materials have been examined previously in both the GIA Gem Trade Laboratory and the Gem Testing Laboratory of Great Britain (see "Amber in Plastic," Gem Trade Lab Notes, *Gems & Gemology*, Fall 1983, pp. 171–172, and "Amber 'Imitation,'" *Journal of Gemmology*, January 1989, pp. 296–297).

A shortage of raw amber has led many factories in the amber centers of Gdansk and Krolewicz to produce a simulant developed in Germany called "polybern," according to Dr. Patty C. Rice, in her book *Amber, the Golden Gem of the Ages* (2nd rev. printing, 1987, Kosciuszko Foundation, New York). This consists of small amber chips embedded in synthetic resin (the name is derived from "poly" for polyester resin and "bern" from the German name for amber, "bernstein"). Dr. Rice reports that large amounts of a Polish-produced material, which contains less natural amber than "polybern" and has a layered appearance, have entered the market. We believe that we have seen both types of these materials.

Interestingly, at an April 1995 gem show in Santa Monica, California, one of the editors came across some identical-appearing material being offered as "reconstructed" amber, with a prominently displayed note

Figure 9. These synthetic corundums are being marketed as "recrystallized sapphire" (left, 0.66 ct) and "recrystallized ruby" (0.65 ct). Photo by Maha DeMaggio.



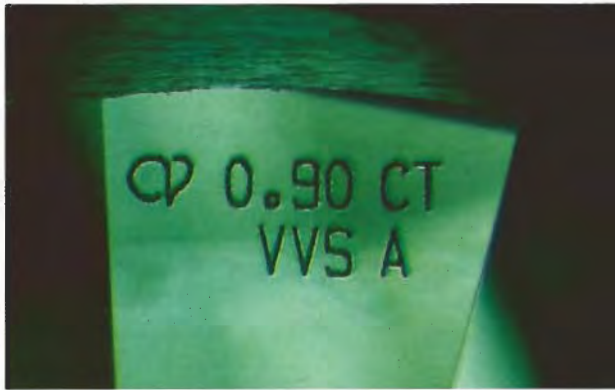
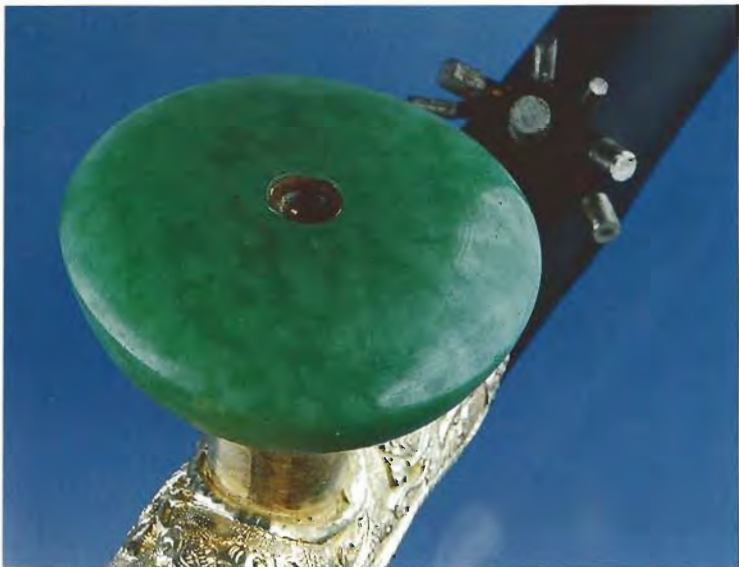


Figure 10. A trademark, carat weight, and quality grade—in characters about 0.15 mm high—are included in this laser inscription on the pavilion of a synthetic emerald. Courtesy of Kyocera Corporation.

describing it as amber chips in synthetic resin. This was the first time that the editor had seen such material so unambiguously identified. Even the gemologically naive would know what they were purchasing.

Update on “recrystallized” corundum. An entry in the Spring 1995 Gem News section (p. 71) mentioned synthetic corundum that was being marketed as “recrystallized ruby” and (pink) “recrystallized sapphire” by the TrueGem Company, of Las Vegas, Nevada. Subsequently, we obtained (through third parties) three faceted samples for examination. One was a 0.66-ct pink rectangular mod-

Figure 11. This pipe bowl (59.10 × 59.90 × 40.05 mm) from Vietnam, is composed of a partially devitrified glass. Photo by Maha DeMaggio.



ified brilliant; the other two were red oval modified brilliants, weighing 0.54 ct and 0.65 ct (see, e.g., figure 9). All three had numbers inscribed on their girdles (see the next entry for more on inscribed stones).

Gemological examination of these three stones revealed the following properties: diaphaneity—transparent; color distribution—even; pleochroism—orange pink/purplish pink (the 0.66 ct), orange red/purplish red (the other two); optic character—uniaxial negative; color filter reaction: red (all three stones); RI—1.760–1.768 (0.66 ct), 1.762–1.770 (other two); birefringence—0.008; SG—3.99 to 4.01; luminescence to long-wave UV—strong, even red, with no chalkiness observed; luminescence to short-wave UV—moderate to strong, even red, with no chalkiness observed (strongest in the 0.66 ct stone); spectroscopy—typical ruby/pink sapphire spectrum (all three stones). The pink stone appeared “clean,” that is, inclusion-free, when observed with the microscope; however, growth banding was visible in both red samples when viewed with immersion and brightfield illumination, and in one red stone we saw curved striae.

To complete our characterization of these stones, we obtained “semiquantitative” chemical analyses with X-ray fluorescence spectroscopy, using a Tracor-Northern (Spectrace) 5000 system and analysis conditions typically employed by GIA for corundum samples. The following elements were determined quantitatively: aluminum, chromium, titanium, vanadium, iron, and gallium. In all three stones, the concentrations of these elements were consistent with a pulled synthetic product, such as that grown by flame fusion or Czochralski pulling. These concentrations are *not* consistent with those seen by GIA Research in natural rubies and pink sapphires. Because the manufacturer states that the last step in “recrystallization” is Czochralski pulling, our results were not surprising.

Laser-inscribed synthetic colored stones. One unusual feature of the three “recrystallized” synthetic corundums described in the previous entry is that all had identification numbers inscribed on their girdles. Lasers have been used for many years to inscribe information on diamonds. For example, the GIA Gem Trade Laboratory offers laser inscription of the appropriate Diamond Grading Report number or other message on a stone’s girdle.

At Tucson this year, representatives of the Kyocera Corporation showed us a laser inscription on a pavilion facet, just below the girdle, of one of their synthetic emeralds. The inscription characters were about 150 μm (0.15 mm) high and included a trademark (a stylized CV for “Crescent Vert”), the stone’s carat weight, and its quality grade (figure 10).

A Kyocera representative explained that, in the past, the firm had only marketed their synthetic gem materials in Japan in jewelry, never as loose stones. This Kyocera-produced jewelry is hallmarked so that it can be easily identified. However, the firm has begun marketing some loose stones in Japan. The purpose of the laser inscription



Figure 12. Magnification reveals gas bubbles and fibrous inclusions in the specimen shown in figure 11. Photomicrograph by Maha DeMaggio; magnified 40 \times .

is to make these loose stones as easily recognized in the Japanese market as Kyocera's gem-set jewelry.

Partially devitrified glass imitation of jadeite. During a visit to ruby and sapphire localities in Vietnam, *Gems & Gemology* Editor Alice S. Keller and one of the Gem News editors (RCK) also spent some time in Ho Chi Minh City. Of particular note was one area of the city where gemstones were offered in shops selling a diverse range of goods that also included antiques and handicrafts of more recent production. Among the items of ethnographic interest were opium pipes fashioned from a number of materials, including ivory, bone, bamboo inset with mother-of-pearl, and a bright green, mottled substance that superficially resembled jade. (The use of jade in opium pipes is described by B. Rapaport in "The Chinese Opium Pipe: The Art and Beauty of an Evil Custom," *Arts of Asia*, Vol. 25, No. 2, March/April 1995, pp. 66–77.) A pipe with bowl (or "damper"; figure 11) and end fittings composed of this latter material was purchased and subsequently examined gemologically at GIA.

The material was a fairly saturated, slightly yellowish green, similar to what is known in the trade as "apple jade." It had a mottled appearance, with somewhat circular, semitranslucent whitish areas surrounded by areas of somewhat higher transparency and slightly more saturated color. Magnification revealed numerous spherical gas bubbles throughout the piece, as well as hemispherical cavities that broke the surface. Also observed were bundles of fibrous inclusions corresponding to the areas that appear white to the unaided eye (figure 12). This internal scene is reminiscent of what is seen in the partially devitrified glass imitation of jade known by the trade name "Meta Jade." However, this pipe-bowl material differed significantly in its macroscopic appearance: "Meta Jade" typically exhibits angular, fibrous patches of lower transparency within an essentially transparent groundmass.

We determined the following gemological properties for the pipe bowl (with those of a sample "Meta Jade" in parentheses): spot R.I.—1.51 (1.48); absorption spectrum—general absorption below 510 nm and above 590 nm (general absorption below 480 nm and above 560 nm); long-wave UV fluorescence—weak yellowish green (faint yellowish green); short-wave UV fluorescence—moderate yellowish green (inert); Chelsea filter reaction—negative (negative).

X-ray powder diffraction analysis confirmed the presence of a crystalline fluorite phase, thereby verifying partial devitrification of the glass. EDXRF analysis revealed more iron in the Vietnamese material as well as the presence of rubidium, yttrium, and zirconium (absent in the "Meta Jade" sample).

On the basis of our investigation, we determined that the Vietnamese imitation of jade was a partially devitrified glass with properties similar to, yet distinct from, those of the Japanese-manufactured product known as "Meta Jade."

Iridescent hematite simulant. At Tucson this year, we came across a hematite-rich rock (most likely a slate or shale) from the Prescott, Arizona, area that was being marketed as "Iridescent Specularite." The material had a near-metallic luster and black body color. The iridescence forms when the surface oxidizes. According to the miner, Robert Poley, of Prescott, Arizona, this is accomplished in one of two ways: either the material is left exposed to weather on the mine dump, or pieces (such as the one in figure 13) are placed with an iron nail in a bucket of water. Protective surface coatings are not used because they interfere with the optical phenomenon. The iridescent layer is very thin and would probably be removed by polishing.

Kyocera plastic-impregnated synthetic opals. One of the more unusual manufactured products seen at Tucson this year was impregnated synthetic opal in a wide range of

Figure 13. The iridescent layer on this piece (10.03 \times 6.63 \times 1.39 cm) of "Iridescent Specularite," most likely a hematite-rich slate or shale, was produced by oxidation. Photo by Maha DeMaggio.

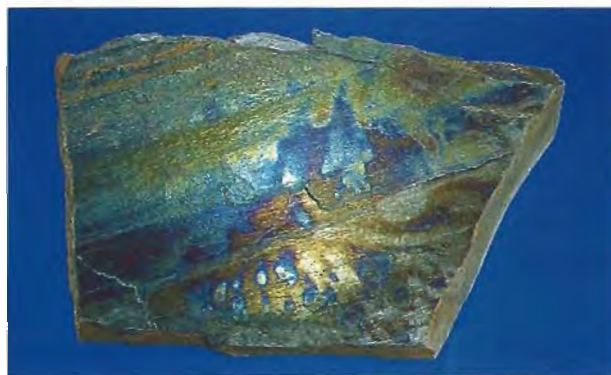




Figure 14. These six polished freeforms (ranging from 3.59 to 4.30 ct) are typical of the Kyocera polymer-impregnated synthetic opals. Photo by Maha DeMaggio.

body colors (figure 14). This material was being displayed by representatives of Kyoto-based Kyocera Corporation and their U.S.-based subsidiary, Kyocera America, San Diego, California. The different body colors were reportedly produced by impregnating the synthetic opal with various colors of polymers. This material is now being test marketed in Korea and Japan.

To characterize this material, we studied 20 samples, including 13 freeform polished pieces (3.06 to 4.48 ct) and seven cabochons (0.21 to 0.57 ct). We determined the following gemological properties: color—a wide range (see table 1); diaphaneity—semitransparent to semitranslucent; color distribution—even body color, all samples showing play-of-color; no pleochroism; singly refractive with strong anomalous double refraction; Chelsea filter reaction—red; R.I.—1.455 to 1.470 for the polished free forms, and 1.461 to 1.468 for the (more easily measured) cabochons; SG—1.88 to 1.91 (low for natural gem-quality opal). Luminescence to ultraviolet radiation, and the spectrum seen with the hand-held spectroscope, depended on the color of the stone (again, see table 1). Also, the spectra seen with the hand-held spectroscope were highly dependent on the orientation of the sample, as is typical for opals in general.

With the microscope, we observed a clearly recognizable “lizard skin” pattern with a curved, slightly irregular columnar structure (giving a more natural appearance). Some stones showed growth layers perpendicular to the columns.

Because there had been debate about whether this material was a true synthetic opal (that is, composed of ordered arrays of silica spheres), we investigated further using a scanning electron microscope with attached ener-

gy-dispersive X-ray fluorescence (EDXRF) analysis instrumentation. Two freeforms were chosen for examination, washed in isopropyl alcohol, and mounted on aluminum stubs without further processing. Both specimens showed oriented layers of approximately 100-nm-diameter spheroids (figure 15). Only silicon was detected using the attached EDXRF system; however, carbon and oxygen are not detectable with this instrument, and conditions were not optimal for the detection of heavy elements. We regard these observations as sufficient proof that the material is synthetic opal.

Next, we examined all 13 freeforms with Fourier-transform infrared (FTIR) spectroscopy, concentrating on the region between 6000 and 4000 cm^{-1} (samples are opaque at longer wavelengths). All spectra were virtually identical, showing a double peak at 5810 and 5725 cm^{-1} (in the same region, but different in detail, as peaks seen in plastic-treated natural opal), an opal peak at 5262 cm^{-1} , a low broad peak at 4660 cm^{-1} , and five peaks at 4383, 4343, 4270, 4166, and 4058 cm^{-1} . (Again, these last five peaks were in the same region, but different in detail, from peaks seen in plastic-treated natural opals.) The “plastic” peaks (5810–5725, 4660, 4383–4058 cm^{-1}) were similar to those seen in samples of polypropylene and polystyrene. However, because the “diagnostic” peaks for plastics are found in regions of the infrared where opal is opaque, it was impossible to determine precisely which plastic is in the Kyocera plastic-impregnated synthetic opals. This infrared spectrum has also been seen—with slightly different peak assignments—by DuToit et al. (“Lab Report,” pp. 58–59, *JewelSiam*, Vol. 6, No. 3, June–July 1995).

Jeffery Bergman of Gem Source, Bangkok, Thailand, has shared some information about apparently similar material he examined. He heated samples to 600°C to burn off the plastic and study the base material; according to this test, the plastic-impregnated synthetic opals that he examined were about 20% plastic by weight (with the highly absorbent, chalky residue still showing play-of-color).

Platinum alloy as an ornamental material. Opaque ornamental gem materials, such as hematite and marcasite, are now enjoying renewed popularity. Another opaque “gem,” actually a manufactured material with a high platinum content and metallic luster, is marketed as “Platigem.” It was developed by researchers at the metallurgical firm Mintek, in Randburg, South Africa. Recently, Dr. Herman Steyn, director of the Physical Metallurgy Division, provided GIA with samples for examination.

“Platigem” is an intermetallic compound of platinum, aluminum, and copper. We examined five faceted samples, ranging from 1.09 to 12.63 ct (three are shown in figure 16). The “stones” had the following gemological properties: color—light yellow to brownish pink, evenly distributed in all; luster—metallic; diaphaneity—opaque; R.I.—over-the-limits of the standard gemological refra-

TABLE 1. Color-dependent properties of Kyocera polymer-impregnated synthetic opals.^a

Color	UV Fluorescence		Absorption spectrum (nm)
	Long wave	Short wave	
White	wk. purplish blue	mod. blue	wk. 500, wk. 550, wk. 580 bands
Purplish pink	str. orangy pink	mod. orangy pink	470–580 band
Orangy pink	wk. pink	wk. pink	general absorption 500–580
Reddish orange	mod. pink orange	wk. to mod. pink orange	470–550 band
Orangy yellow	wk. yellow	mod. to str. orangy yellow	diffuse band at 500–530 580 band, 610 band
Light blue	wk. blue	v. wk. blue	545, 580, 630 bands
Blue	v. wk. blue	v. wk. blue	540, 580, 630 bands
Grayish blue	inert	inert	470 cutoff, 515 band, 550–650 band
Gray	v. wk. greenish yellow	wk. greenish yellow	420–430 band, 445–460 band, 545, 580, 630 bands
Dark gray	wk. greenish yellow	v. wk. greenish yellow	470 cutoff, 545, 580, 630 bands
Dark brown	mod. orange	mod. orange	470 cutoff, 490–590 band, 635 band
Black	inert	v. wk. orange	440 cutoff, wk. 470 band, 530–550 band, 590–620 band

^a v. = very, wk. = weak, mod. = moderate, str. = strong

tometer (greater than 1.81); ultraviolet fluorescence—none (inert to both long- and short-wave UV radiation); absorption spectrum—no features noted with a desk-model spectroscope; reaction to magnet—none (not attracted). Specific gravities ranged between 8.66 and 8.77. Mohs hardness, determined on just one sample, was about 5½. When examined in reflected polarized light, the specimens appeared isotropic, with no obvious pleochroism.

Figure 15. A scanning electron microscope reveals the structure of the polymer-impregnated synthetic opal: layers of 100-nm spheres. The dark stripes are artifacts due to charge build-up on the surface of the stone. Magnified 10,000×; photomicrograph by Mary L. Johnson.

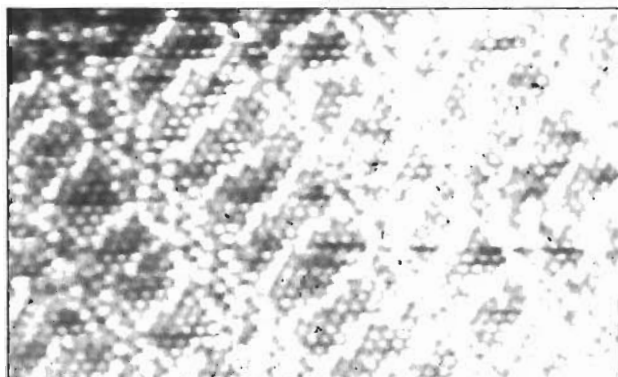


Figure 16. "Platigem," a platinum-aluminum-copper intermetallic compound, comes in a subtle range of colors. These stones weigh, from left, 12.63, 10.52, and 11.63 ct. Photo by Maha DeMaggio.

Several "Platigem" compounds are used to produce these interesting gems. They are made from the brassy yellow intermetallic compound PtAl₂, mixed with 5 wt.% to 25% wt.% copper (which provides an orange-to-"copper" pink color). Information about these compounds appeared in the *Journal of Materials Science* (J. Hurley and P. T. Wedepohl, "Optical Properties of Coloured Platinum Intermetallic Compounds," Vol. 28, 1993, pp. 5648–5653). PtAl₂ has the same crystal structure as fluorite, and the composition can be approximately determined from the unit-cell spacing, according to the authors. To further understand our samples, we took an X-ray powder diffraction pattern of one brownish pink stone. Except for four faint lines, the diffraction pattern could be matched with that of a cubic compound with a unit-cell edge of 5.958 Å (595.8 pm), which implies about 21% copper in this particular compound. Note that this pattern does not at first resemble that of fluorite, since some lines that are faint in the fluorite pattern are prominent in the "Platigem" diffraction pattern.

"Platigem" is a trademarked name, and the intermetallic compounds themselves have been patented. Mintek also developed an 18k gold alloy, "Spangold," which exhibits an interesting surface effect as a result of phase transformations.

INSTRUMENTATION

New gemological spectrometer at Tucson. Martin Bell, of River Gems, Albuquerque, New Mexico, and John Allaman, of Sarasota Instruments, Osprey, Florida, showed some of the capabilities of a prototype gemological spectrometer at the Tucson show. The goal of this instrument is to improve on the hand-held spectroscope, which many jewelers find difficult to use.

A gem to be tested is placed in an integrating sphere and illuminated with a flash lamp. The light transmitted by the stone is directed through an optical fiber to a diffraction grating, which disperses the light on a diode-array detector. The resulting spectrum is displayed on the screen of an attached laptop computer. Currently, the resolution is about 3 nm. The developers hope to have the instrument ready to sell in 1995, for less than US\$10,000.

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Reviews

SUSAN B. JOHNSON, EDITOR

FANCY-COLOR DIAMONDS

*By Harvey Harris, 180 pp., illus., publ. by Fancoldi Registered Trust, Liechtenstein, 1994. US\$175.00**

Harvey Harris's wide-ranging dissertation on the history, folklore, and science of colored diamonds is noteworthy in that it is the only book in print that is devoted exclusively to colored diamonds. The author graciously acknowledges Tino Hammid's exquisite photographic images as the book's most impressive attribute. However, readers need to be mindful that colored-diamond photographs, even superb ones like Mr. Hammid's, cannot always accurately depict the subtleties of tone and saturation actually seen in fine colored diamonds. These stunning photographs might easily distort a potential buyer's expectations.

The first two chapters of this book, which deal primarily with the history of fancy-color diamonds in the context of global diamond production and marketing, are good reading. Mr. Harris points out that the remarkable prices we now attribute to rare "fancy colors" are a recent phenomenon. He underscores this observation with an anecdote about two almost identical 1¼-ct fancy green diamonds cut from the same rough. The first stone sold in 1962 for \$500 per carat. Now, a little more than three decades later, its twin is for sale at "a strong six figure price."

The chapters immediately following these two—those that address the technical provenance of colored diamonds, including the causes of

color, faceting, treatment, and synthesis—have problems. The chapter explaining causes of color is disappointing. Augmenting the text are absorption spectrograms for several fancy colors. However, the author does not lay adequate foundation for the general reader to understand spectral absorption data and the attendant terminology. This would not be a deficiency in a purely technical text written for professionals; however, in a book that appears to be directed to a more general readership, subjects such as spectral analysis need greater clarification.

Mr. Harris's treatment of laboratory grading reports and their pivotal role in today's colored-diamond market depicts the GIA fancy-color grading system as inscrutable and inadequate. However, GIA's recent publication (in this journal) detailing their color-grading methodology and improved color-grading system negates the substance of this criticism.

Three final chapters focus on the romance of colored diamonds in jewelry, at auction, and in the limelight. Mr. Harris relates compelling stories of the famous, the infamous, and the unusual members of this unique subset of gems. This well-written section is highly interesting and entertaining reading. To his credit, the author candidly admits that some of his stories may be apocryphal.

Of concern, however, is the fact that errors and distortions of technical terminology and scientific fact appear frequently throughout the book, misinforming and misleading the general reader. For example, the author states that: "Even D-E-F col-

orless diamonds contain approximately 3 to 14 percent gray (or else you couldn't see them)." In fact, the reason we are able to see a colorless diamond in air is because the diamond's refractive index (R.I.) is very different from that of air. Place a D-flawless diamond in a clear liquid having the same R.I. as diamond and it will disappear. You can see an approximation of this refractive phenomenon by dropping a clear ice cube into water. Whether a D-flawless stone contains the level of gray he attributes to it is highly questionable; however, he lays no foundation for his assertion. Mr. Harris's statements regarding the unknown cause of color in fancy orange diamonds are also questionable in light of current information. However, because he provides no references or technical foundation for this claim, verification is not possible. This illustrates another serious weakness: the absence of supporting references throughout the technical sections.

Fancy-Color Diamonds is nicely written and earns high marks for presentation, photography, and historical perspective. However, the book fails when it attempts to leapfrog from general-interest information, which is quite good, to subjects that require technical erudition on the part of both the writer and the reader.

SHARON WAKEFIELD
Wakefield Gemological Laboratory
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**This book is available at the GIA Bookstore, 1660 Stewart Street, Santa Monica, CA 90404. Telephone (800) 421-7250, ext. 282.*

GEMOLOGICAL ABSTRACTS

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COLORED STONES AND ORGANIC MATERIALS

Precious layer opal with a complex sedimentary formation process as colloid chemical precipitation, sedimentation and evaporation. H. Harder, *Neues Jahrbuch für Mineralogie, Monatshefte*, No. 3, March 1995, pp. 121–126.

Experimental work leads to the conclusion that the formation of layer opal in desert conditions is controlled not only by evaporation but also by the enrichment and separation of SiO₂ from the primary alkaline weathering solutions. Neutralization by CO₂ vapor may result in an oversaturation and a slow precipitation of Al(OH)₃, together with a strong colloid chemical enrichment of SiO₂. After deposition as porous jelly opal, the primary water-rich layer opal can slowly dry out to a solid opal, which may rarely form a layer of precious opal. RAH

Siberian sapropelic coal: A unique type of workable jet. S. Glushnev, *Journal of Gemmology*, Vol. 24, No. 5, 1995, pp. 349–353.

True jet is a compact hydrocarbon-impregnated wood that enjoyed immense popularity during the late Victorian era and again in the 1930s. With renewed interest in this relatively soft gem material, old and new sources are being sought. One such source in

Siberia has been known at least since the late 19th century, although the material found there is actually sapropelic coal, which lacks the traces of wood structure (from ancient conifers) that characterize true jet. Sapropelic coal is unconsolidated mud, composed chiefly of algae. However, it has many characteristics of true jet, including density, workability, and solid black color. This article provides extensive information on the composition and properties of this material, which also was exploited for industrial uses. Most known deposits have been worked out, but potential new sources exist. CMS

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DIAMONDS

De Beers to split CDM with the Namibian government. *Diamond World Review*, No. 84, 1994-5, pp. 60, 62, 64.

Most diamonds in Namibia have been found in Diamond Area 1, a 480-km-long stretch of Atlantic Ocean coastline that includes the mouth of the Orange River. Here, alluvial diamonds are found in onshore and offshore sands; they are believed to have come from kimberlites in the interior of South Africa, transported to the coast by the Orange River. Up to 95% of diamonds in this area may be gem quality; reserves have been estimated to be between 1.5 and 3 billion carats.

The first diamond was discovered in Namibia in 1908, by a former De Beers laborer. The country, then known as South West Africa, was a German protectorate. What would become Diamond Area 1—named the "Sperrgebiet," or "forbidden territory"—was prospected and mined exclusively by the Deutsche Diamant Gesellschaft. During World War I, South West Africa came under the control of South Africa, which allowed nine German companies restricted mining rights to this area; in 1920, Ernest Oppenheimer created Consolidated Diamond Mines of South West Africa (CDM), which bought these holdings and negotiated an exclusive mining agreement meant to last until 2010. In 1975, De Beers purchased CDM.

Namibia's independence in 1990 caused a reevaluation of CDM's exclusive control over Diamond Area 1. In November 1994, after more than two years of negotiations, De Beers Centenary and the Namibian government signed a comprehensive agreement governing De Beers's operation in that country. CDM is to be reconstituted as the Namdeb Diamond Corporation, which will be equally owned by the Namibian government and De Beers. Both parties will also have equal representation on the board of directors and in the new management committee. Areas formerly held by CDM will now be held under 25-year mining licenses, held under renewable three-year prospecting licenses, or "relinquished immediately." Namdeb will continue to sell all its production through the Central Selling Organisation, subject to review of the sales agreement every five years.

Mining techniques in Diamond Area 1 include open-pit mining of near-shore areas, which are protected by sea walls and pumped dry; mining the more distant ocean floor using boats with giant vacuum pumps; and conventional open-pit mines at Elizabeth Bay and along the Orange River. MLJ

De Beers vs. the bear market: Who will win? R. Shor, *Jewelers' Circular-Keystone*, Vol. 166, No. 6, June 1995, pp. 122-135.

The turmoil in the rough diamond market since 1992 has been the subject of many, usually pessimistic, arti-

cles in trade and financial journals. This in-depth, factual article is essential reading for anyone involved in any aspect of the diamond world. Particularly timely, it appears as the De Beers-Russia contract nears expiration (at the end of 1995).

Although that agreement is apparently in shambles, De Beers is confident that Russia will sign a new one with provisions designed to do basically one thing—limit Russia's non-CSO sales. However, Russia wants to sell *more* diamonds outside the CSO, and some officials even want seats on De Beers's board. Some believe that De Beers plans to wait until Russia's diamond stockpiles are depleted and then offer financial help to refurbish producing mines as a contract incentive. Russian mine production is down significantly from 1986 levels, so they will have little with which to rebuild depleted stockpiles without increased production. Negotiations are complex. Three Russian agencies and one from Sakha, all with different agendas, are involved.

Meanwhile, Botswana, Namibia, and South Africa have stable, realistic governments that have good relations with De Beers and share the desire for a healthy diamond industry. By contrast, the chaotic political situations in Zaire and Angola have had disastrous effects on production. There are two "wild cards" in contract negotiations. One is the Argyle mine (present contract expires in early 1996), because "the flood of smaller, lower-quality diamonds is the industry's biggest long-term problem." Wild card number two is the onset of Canadian production, the extent of which is not yet fully known; it is expected to begin in about three years.

Notwithstanding all of the factors that could have a detrimental effect on the diamond market, the article concludes that "it will take some time for De Beers and the CSO to put things back in order. But once they do, look for diamond prices to rise, particularly if demand revives in Japan." AAL

Diamonds go public in India. P. Chanakya, *Mazal U'Bracha*, Vol. 10, No. 65, March 1995, pp. 41-47.

Over the last few decades, Bombay's diamond trade has gone from a cottage industry to a huge factory-based export business. When the Indian government declared export earnings tax free in the 1980s, Indian diamond manufacturers became wealthier still. Throughout this metamorphosis, however, the diamond trade remained a privately held industry controlled by a few families, without the accountability or open financial dealings required of publicly held companies.

In March 1993, the Indian rupee became fully convertible against foreign currency. Earnings from the rupee's former high exchange rate disappeared, along with the quick profits that could be created with the "financial adjustments" possible for private companies. Many diamond firms went bankrupt, and manu-

facturers started going public to attract investors. More than a dozen diamond manufacturers are now listed on Indian stock exchanges.

The primary stock issues of these companies have been generally successful, with investors confident that the diamond companies can provide the desired investment safety, liquidity, capital appreciation, and return. AC

The glass filling of diamonds. Part 1: An explanation of the colour flashes. J. B. Nelson, *Journal of Gemmology*, Vol. 23, No. 8, 1993, pp. 461-472.

Probably nothing is of more immediate concern to the retail diamond industry than the fracture filling of diamonds. Whereas all previous reports and studies have been concerned primarily with such matters as recognition of the treatment and characteristics of the filling material, this paper is the seminal scientific explanation for the flash-effect colors that are diagnostic of this treatment.

The "flash effect" can be explained by means of the same scientific concepts used to explain the "Brown-McCrone optical dispersion staining" microscopic technique, used by the author since 1963 to identify small transparent substances, such as asbestos minerals. After describing the special equipment required for this technique (e.g., an objective with both annular and central stops), as well as technical considerations (e.g., the CIE Chromaticity Diagram), the author applies the information presented to an explanation of the flash effect in filled diamonds.

The essential point is that diamond and the glass fillings have distinctly different dispersion curves in the visible region; that is, the indices of refraction of a diamond and its filling for a specific wavelength (generally) will be different. When these indices do not coincide, optical discontinuities manifest themselves as the flash effect. The greater the differences between the dispersions of diamond and its filling, the more intense the flash colors become. The colors observed are affected significantly by the type of illumination (darkfield versus brightfield) used and by the orientation of the filled diamond with respect to the light source; the author illustrates these points with several examples. The flash colors of filled diamonds are not interference colors (as in labradorite) or dispersion colors (as in the "fire" of diamond). AAL

The glass filling of diamonds. Part 2: A possible filling process. J. B. Nelson, *Journal of Gemmology*, Vol. 24, No. 2, 1994, pp. 94-103.

This paper continues the study of filled diamonds (see preceding abstract) in which the chemical composition and some physical properties of the filling material are postulated from published information on Yehuda-treated stones. The filling material must be a glass with a high refractive index, approximating that of dia-

mond. It also must have a low melting point (about 450° C) and low viscosity, so that it can easily enter and fill the fissures when it is slightly above its melting point. Based on certain published data (a phase diagram; melting points of certain compounds), Dr. Nelson concludes that the filling material is composed of three components: bismuth oxide (Bi₂O₃), lead oxide (PbO), and bismuth chloride (BiCl₃). Physical and optical measurements of glasses containing these components (in proper proportions) are consistent with those of the fillings presently found in diamonds.

The article concludes with the description of an imaginative apparatus that could possibly be used for commercially filling diamonds (in batches up to 100 carats). Many important factors related to the filling procedure are considered, including the requirement that air be evacuated to the fissure roots so that the high-index glass filler may be properly emplaced.

(Comments on this paper by Dr. K. Nassau, and a reply by Dr. Nelson, may be found in *Journal of Gemmology*, Vol. 24, Nos. 3 and 4, 1994, on pp. 183-184 and pp. 281-285, respectively.)

AAL

Subduction diamonds in New South Wales: Implications for exploration in eastern Australia. L. M. Barron, S. R. Lishmund, G. M. Oakes, and B. J. Barron, *Quarterly Notes '94, Geological Survey of New South Wales*, January 1994, pp. 1-23.

New South Wales (eastern Australia) produced perhaps 500,000 carats of diamond from alluvial deposits between 1852 and 1930 (currently, there is no production). The primary source of these diamonds has never been located.

Diamonds from this area have some unusual properties. For example, they are predominantly eclogitic (E-type) in origin, and they have an unusually "heavy" carbon isotopic composition (compared to diamonds from the major producing localities in Western Australia, Africa, and Siberia). This suggests that the two conventional models of diamond genesis do not apply in eastern Australia. These models are: (1) the South African model (also applicable in Siberia, South America, and North America) of kimberlite emplacement in Archean cratons; and (2) the Argyle (Western Australia) model, in which lamproite is emplaced in Proterozoic cratons and mobile belts. Both models require that diamonds form at depths of at least 150 km under high temperatures (about 1050°-1200°C) and pressures (45-55 kb), and that they are later carried to the surface as xenocrysts in kimberlite or lamproite. In eastern Australia, there is no indication that an ancient craton of sufficient thickness (at least 150 km) to permit diamond formation by either of the conventional models ever existed. This is supported by the lack of kimberlite or lamproite occurrences in the area.

Thus, the authors propose the "ES" (Eclogite Subduction) model for the eastern Australian diamond occurrences.

In their model, diamond formation occurs during the active subduction (based on the theory of plate tectonics) of a thick slab of oceanic crust and associated carbon-containing sediments. The subducting slab is up to 1000°C cooler than the surrounding mantle. The slab goes through several stages of increasing metamorphism (e.g., blue schist, coesite, eclogite) until the diamond eclogite stage is reached, and the carbon is converted to diamond. Because of the slab's thickness, and the fact that it has remained relatively cool, diamonds can form when the slab reaches 80–90 km (pressures of 22–25 kb), compared to the 150 km required in the other models. At such relatively shallow depths, magmas other than kimberlite and lamproite are available to bring the diamonds to the surface. In eastern Australia, nephelinites and alkali basalts are common, and they are proposed as the transporting magmas. (Other transportation mechanisms—such as "tectonic excavation"—also are possible.) The ES model may be applicable as well to the formation of diamonds in other localities where diamond occurrences have no apparent connection to ancient cratons (e.g., northern China, Kamchatka Peninsula in Siberia, and Kalimantan [Borneo]).

AAL

Unlocking Indonesia's diamond past. *Diamond International*, January–February 1995, pp. 87, 89, 90, 92.

Diamond mining is believed to have started as early as 600 AD in Indonesia, on the island of Kalimantan (formerly Borneo). The oldest known and most important diamond-producing region is the South East Kalimantan field, near the city of Banjarmasin; both diamonds and gold are found in alluvial deposits that eroded from the Meratus Mountains. Artisanal (traditional) mining techniques have produced gem diamonds up to 167 ct. Recently, mining firms—using modern techniques—have started exploring for diamonds in previously untapped paleochannels, where diamonds may have been deposited in the distant past, and in offshore regions along the Sunda Shelf. This article details the management structures of companies engaged in diamond mining in Indonesia. A sketch map of projects in the South East Kalimantan Diamond Field is also provided.

MLJ

U.S. diamonds may go to U.S. jewelers. R. Shor and R. Weldon, *Jewelers' Circular-Keystone*, Vol. 166, No. 6, June 1995, pp. 72, 74.

Diamonds from the Kelsey Lake kimberlite pipes in Colorado will be marketed as "American diamonds," if the Redaurum Company of Toronto, Canada, and its junior partner, Diamond Co. of Ft. Collins, Colorado, have their way. Although marketing plans are still

indefinite, some jewelry retailers and diamond wholesalers have expressed interest in selling diamonds that are "made in America."

The Kelsey Lake kimberlite body consists of eight relatively small pipes; two of which contain economically feasible quantities of diamonds. Howard Coopersmith, president of Diamond Co., expects the mine to produce one million carats over its estimated 10-year life span; 65% of the samples recovered to date are gem quality, with 25% larger than one carat.

MLJ

GEM LOCALITIES

An evaporite origin of the parent brines of Colombian emeralds: Fluid inclusion and sulphur isotope evidence. G. Giuliani, A. Cheilietz, C. Arboleda, V. Carrillo, F. Rueda, and J.E. Baker, *European Journal of Mineralogy*, Vol. 7, 1995, pp. 151–165.

Fluids trapped in emerald, dolomite, and pyrite from the Colombian emerald deposits are rich in sodium, calcium, and potassium. This chemistry suggests that these brines might originate in evaporites, such as salt domes, as such structures occur nearby. This hypothesis was verified using sulfur isotopic data from pyrite (iron sulfide) that co-precipitated with the emeralds. These results show that sulfur characteristics are the same for all pyrites within the deposit, and different from those of the pyrite found in the enclosing black shale. It is thought that the sulfate-rich brines were reduced to hydrogen sulfide by interaction with strata rich in organic matter.

EF

Time-pressure and temperature constraints on the formation of Colombian emeralds: An $^{40}\text{Ar}/^{39}\text{Ar}$ laser microprobe and fluid inclusion study. A. Cheilietz, G. Féraud, G. Giuliani, and C.T. Rodriguez, *Economic Geology*, Vol. 89, 1994, pp. 361–380.

Two Colombian emerald deposits—Coscuez and Quipama-Muzo—have been dated using $^{40}\text{Ar}/^{39}\text{Ar}$ induction and laser microprobe methods. (Contemporaneous green muscovite was tested and not the emeralds themselves.) The ages found, respectively, were 35 to 38 My and 31.5 to 32.6 My. Microthermometry, Raman spectroscopy, and scanning electron microscopy experiments on fluid inclusions in emeralds from the Coscuez deposit show that the trapped fluids are complex $\text{H}_2\text{O}-\text{NaCl}-\text{CaCl}_2-\text{KCl}-\text{CO}_2-\text{N}_2$ brines. Taking into account various geologic constraints, these findings led the authors to estimate temperature and pressure during emerald deposition of about 1.1 kb and 290° to 360°C.

The heat required for emerald deposition was generated partly by burial, but also partly by the rising of evaporites or salt domes. There is no evidence that nearby intruded magmatic bodies generated the additional heat necessary, as was once proposed. This interaction

with salt-rich bodies would also explain the complex brine chemistry of the fluid in which the emeralds grew. The large amount of pyrite created is due to sulfate reduction. Isotopic evidence demonstrates that the water probably came from within the basin in which the host shales were deposited. The chromium, vanadium, and beryllium necessary for emerald formation most likely came from leaching of the host black shales. Tectonic movements led to fracturation and circulation of basinal fluids, which in turn led to the growth of emerald in veins. Such growth explains the temperature, pressure, and chemistry conditions described by the authors. Indeed, the formation of emeralds is synchronous with a shortening episode during which the Nazca and South American plates converged at an accelerated rate.

The authors compare this unusual genetic mechanism, although at higher temperature, to the maturation, migration, and trapping of oil. *EF*

Flinders Island's "Bay of Diamonds." P. O'Brien, *Australian Gold Gem & Treasure*, Vol. 10, No. 3, 1995, pp. 21, 22, 24-26, 34.

Some colorless gems are incorrectly called "diamonds." Perhaps the most famous of these are "Herkimer diamonds," colorless quartz crystals from New York State. This nontechnical article discusses the mining and collection of "Killiecrankie diamonds," almost-colorless alluvial topaz crystals found around Killiecrankie Bay on Flinders Island, off the northeastern coast of Tasmania.

The topaz crystals occur as "unusually clear, glassy, water-worn pebbles," sometimes blue and infrequently light pink in color. Although today few crystals can still be found on Killiecrankie Bay beach, three groups are successfully mining topaz offshore with dredges. Total production was not reported, but large stones include one weighing 2,925 ct and a "flawless" 955-ct piece.

The topaz probably originated in nearby tin deposits. The author found about half-a-dozen topazes, and some smoky quartz crystals, in an afternoon of "fossicking" (mineral collecting) on the dumps of the Mount Tanner tin mine on Flinders Island. *MLJ*

Gold, iron, copper and jade in the Seminoe Mountains, Wyoming. W. D. Hausel, *International California Mining Journal*, Vol. 64, No.4, 1994, pp. 18-21.

The Seminoe Mountains, in central Wyoming, have been known as a source of silver and gold since 1871. Malachite, chrysocolla, and cuprite are also found in gold-bearing quartz veins around Bradley Peak. Nephrite jade occurs as veins along the northern flank of the mountain range and as "olive"-green pods in a quartz diorite dike (the Sage Creek deposit). Other lapidary materials include a jasperized banded iron formation, resembling petrified wood, from Deweese

Creek north of Bradley Peak, and "Leopard rock," a porphyritic basalt with large white rounded feldspar crystals in a fine-grained black matrix. *MLJ*

A preliminary investigation of peridot from Vietnam. R. C. Kammerling and J. I. Koivula, *Journal of Gemmology*, Vol. 24, No. 5, 1995, pp. 355-361.

Yet another gem material being produced by the fast-growing gem industry in Vietnam is peridot from Lam Dong Province. The authors provide gemological characteristics—including refractive indices, pleochroism, absorption spectrum, specific gravity, and inclusions—for five faceted samples, as well as chemical composition for one sample. The properties are consistent with those for peridot found in other localities. *CMS*

The story of the Sri Lankan pearl. M. M. M. Mahroof, *Journal of Gemmology*, Vol. 24, No. 5, 1995, pp. 337-348.

Although Sri Lanka produces few pearls for the gem trade, antique and remodeled jewelry containing Sri Lankan pearls is still encountered. Thus, knowledge of their history and lore should remain part of the gemologist's repertoire. This article reviews the 2,000-year history of pearling in Sri Lanka, including the significance of pearls in ancient Ceylon, their reputed mystical and medicinal qualities, and their exploitation by a series of conquering civilizations.

The pearl banks were located off the northwest shores of the island in what is now the Gulf of Mannar, most abundantly along rocky shelves in only five to six fathoms of water, where the pearl oysters could flourish. During the 16th century, under the Portuguese, Sri Lankan pearls were traded extensively as far west as Venice, Italy, and as far east as Canton, China. Citations from various manuscripts paint colorful pictures of the Sri Lankan pearl trade at various times in history. In the early 20th century, political, economic, and ecological factors combined to effectively end the pearl trade in Sri Lanka. Only since 1955 has there been any notable activity, with approximately 2,000 persons still pearling in Tuticorin, in the Chidambaran district of Tamil Nadu. Very interesting and informative, this article suffers only from the lack of any photographs. *CMS*

Studies on kosmochlor, jadeite and associated minerals in jade of Myanmar. W. Htein and A. M. Naing, *Journal of Gemmology*, Vol. 24, No. 5, 1995, pp. 315-320.

In proper gemological usage, the term *jade* applies only to nephrite and jadeite. However, it is well known that individual specimens are rarely pure. In this discussion of jadeite from Myanmar, the authors meticulously use the terms *jadeite jade* or *pure jade* versus the term *impure jade* for polymineralic material. The most common admixture is jadeite and kosmochlor, with a

continuous series from essentially pure jadeite to 85% kosmochlor. The latter mineral is also well known to gemologists as a major constituent in Maw-sit-sit, also from Myanmar.

The authors present an excellent overview of this complex topic, including chemical analyses and X-ray diffraction data that emphasize the difficulty that faces gemologists in the identification of jade and jade-like green specimens. Minerals found as components in the specimens studied include jadeite, kosmochlor (once called ureyite), edenite, richterite, tremolite, chromite, magnesiochromite, and enstatite. This is an important paper that should be read carefully by gemologists involved in the trade and identification of jades.

CMS

JEWELRY HISTORY

Gold and silver from ancient China—the Pierre Uldry collection on show at the Museum Rietberg Zurich. F. Louis, *Arts of Asia*, Vol. 24, No. 5, 1994, pp. 88–96.

This article contains much valuable information on early Chinese culture and the role that precious-metal jewelry and personal ornaments played in it. The Pierre Uldry collection (which was on display at the Rietberg from October 1994 to March 1995) includes over 320 objects of unique historic value, and amply depicts many Chinese uses for gold and silver. The incredible detail of this metalwork is captured in beautiful photographs by Brigitte Kammerer and Isabelle Wettstein.

Unlike other areas of Chinese art, precious metalware and jewelry are only now beginning to be appreciated for their contribution to the long history of Chinese crafts. Until about 15 years ago, gold and silver jewelry was included in only a few of the collections that focused on Chinese art. Rarely have precious metalware and jewelry been collected inside China, due to the cultural concept of art being interwoven with the Confucian ideals of scholarly learning and simplicity: The monetary value of the materials prevented gold and silver wares from being considered a collectable art form.

The collection features many jewelry-making processes, such as pierced work, granulation, and filigree. In more modern periods, various polished, transparent gemstones were applied to the ornate gold wares; usually they conspicuously protruded from the metal surface. A catalog of the collection is available from the Museum Rietberg Zurich, Gablerstrasse 15, CH-8002 Zurich, Switzerland.

JEC

JEWELRY RETAILING

At auctions, record highs. R. Bates, *National Jeweler*, Vol. 39, No. 10, May 16, 1995, p. 2B.

Spirited bidding, big purchases, and two record sales of

fancy-color diamonds highlighted April's round of New York "Magnificent Jewelry Auctions." At Christie's, a 13.49-ct fancy, deep-blue internally flawless diamond set in a ring sold for \$7.4 million, a record price of \$550,000 per carat. The buyer was Sam Abrahms, who paid \$9.9 million for a blue diamond at Sotheby's in October 1994. At the auction, Christie's brought in a total of \$34.8 million, with 75% of the pieces sold by lot, and 82% sold by dollar value. This Magnificent Jewelry sale was up \$20.3 million from the same sale last year, according to François Curiel, international director of jewelry at Christie's.

Sotheby's sale brought in \$30.2 million, with 78% of the pieces sold by lot and 68% by value. This was the sixth highest total ever for a Sotheby's auction in New York, according to John Block, executive vice president of Sotheby's.

Other highlights included the purchase by prominent London diamond-dealer Laurence Graff of a magnificent 7.78-ct fancy blue diamond set in a ring, for \$2.5 million at Sotheby's; at Christie's, Saudi Arabian Sheik Ahmed Fitaihi paid \$5.6 million for a 69.79-ct rectangular-cut, D-color, internally flawless diamond.

MD

PRECIOUS METALS

Gold sales continue to rise—discount stores post biggest gains, WGC says. M. Goley, *National Jeweler*, Vol. 39, No. 3, February 1, 1995, p. 6

According to the World Gold Council (WGC), gold jewelry sales increased for the 12th consecutive quarter as of December 1994, with a third-quarter sales increase of 3.2% in dollar volume and 5.4% in units as compared to 1993 levels. Gold jewelry sales totaled nearly \$5.7 billion through the third quarter of 1994, a 4% increase over 1993. Unit volume exceeded 62 million, up 5.9%. These levels were below retail sales overall, which were up 6.2% for the comparable period.

Gold jewelry sales were up across all channels of retail distribution for the year to date, according to the WGC. Discount stores continue to outpace other retail outlets, posting a 14.9% dollar increase over the prior year. This follows a 28% increase in 1993 results versus 1992. Chain jewelry stores came in slightly below the category average, with a 3.2% increase over 1993. Independent jewelers, department stores, and catalog showrooms—up 3%, 2.6%, and 2.2%, respectively—all performed below the category average.

Compared with 1993, sales of gold chains increased 3.4%; earrings and charms were up 5.9% and 6.4%, respectively; bracelets posted a 5.2% increase in dollar volume; and sales of gold rings, excluding wedding rings, were up 5.5%. Gold wedding rings continued to remain virtually flat, up a marginal 1.1% over 1993.

MD

SYNTHETICS AND SIMULANTS

An examination of Swarovgreen. E. Fritsch, R. C. Kammerling, and J. I. Koivula, *Australian Gemmologist*, Vol. 19, No. 1, 1995, pp. 15–18.

Of the three most famous colored gems—ruby, emerald, and sapphire—emerald is the most expensive to synthesize. Because flame-fusion techniques are not considered effective for hydrous, beryllium-bearing (toxic) materials, flux or hydrothermal techniques must be used. Therefore, simulants are used in place of synthetics when the look of emerald is desired in an inexpensive product. Historically, such simulants have included green sapphire (“oriental emerald”) and green glass. Swarovgreen is a new glass developed as an emerald simulant by D. Swarovski and Company, of Wattens, Tyrol, Austria.

On the basis of their examination of seven faceted stones and one polished block of “rough,” the authors determined these properties for Swarovgreen: color—medium-dark bluish green; diaphaneity—transparent; R.I.—1.608–1.612; optic character—singly refractive, with very little or no strain; fluorescence—weak to faint yellowish green to greenish yellow to long-wave UV radiation, weak green to short-wave UV radiation; Chelsea filter reaction—none; S.G.—about 2.90; hardness—about 6¼ (Mohs); and dispersion—about 0.030 (the last according to manufacturer’s claims). The absorption spectrum showed a doublet at 442 and 448 nm; a triplet at 466, 472, and 488 nm; and a broad band centered at about 590 nm. Although the rough block contained gas bubbles, no inclusions were seen in the faceted stones (the manufacturer says that it discards all included stones).

Energy-dispersive X-ray fluorescence (EDXRF) spectroscopy revealed the presence of Al, Si, Ca, Cu, and Pr (praseodymium); the latter two elements are responsible for the color. An ultraviolet-visible absorption spectrum revealed a large absorption in the near-infrared region of the spectrum, centered at about 780 nm, in addition to the peaks and band seen with a spectroscope. X-ray powder diffraction showed no evidence of crystal structure; and none would be expected in a glass. (Note that although figure 4 is called out in the text in reference to X-ray diffraction, it actually refers to the EDXRF spectrum.)

The authors conclude that, although the color and lack of inclusions could cause Swarovgreen to be mistaken for emerald from Zambia or Pakistan, the other gemological properties are distinctive. *MLJ*

Some observations on a gem-quality synthetic yellow diamond produced in the region of Vladimir (Russia). F. Sosso, *Journal of Gemmology*, Vol. 24, No. 5, 1995, pp. 363–368.

Observations on a single brownish yellow synthetic diamond, produced in Russia, are reported in this arti-

cle. A simple pattern of two intersecting grain lines, which corresponds to the distribution of color zoning in this sample, differs from that described in previous reports on Russian synthetic diamonds. SEM-EDS analysis of included areas revealed iron, nickel, and—surprisingly—cesium (possibly a contaminant). The authors report no attraction to a simple magnet (but do not describe the exact type used). The characteristic most useful in identification was zoned luminescence (both to ultraviolet radiation and to electrons), which has been reported elsewhere for synthetic diamonds. Infrared spectroscopy revealed a mixed Ib + IaA nitrogen type, similar to that previously found in Russian synthetic diamonds. *CMS*

MISCELLANEOUS

William Earl Hidden, 1853–1918: Mineralogist, geologist, and entrepreneur. M. I. Jacobson, *Mineral News*, Vol. 10, No. 11, November 1994, pp. 6–9.

The emerald-green variety of spodumene, hiddenite, is named after W. E. Hidden, an enthusiastic collector at the turn of the century. Mr. Hidden became interested in minerals during the 1870s building boom in New York City, filling his parents’ house with all manner of rocks collected from bedrock excavations; he was a friend of George F. Kunz, who apparently supported himself for a few years by selling mineral collections to universities and individuals, including inventor Thomas A. Edison. It was a request for platinum for light bulb filaments from Mr. Edison that sent Mr. Hidden off to explore the southern Appalachian mountains for five months. During this investigation, Mr. Hidden met J. Adlai Stephenson, who was searching for gem deposits in North Carolina.

In April 1879, Mr. Stephenson gave some unknown green crystals to Mr. Hidden for investigation. Mr. Hidden passed these along to J. L. Smith, of Louisville, Kentucky, for identification. In September of that year, Mr. Hidden and Mr. Stephenson visited the G. W. Warren farm, near Stony Point, North Carolina, reportedly the source of these stones, and of some emeralds as well. After leasing the farm for six months, Hidden bought it (for \$1,800) in 1880. In 1881, Mr. Smith described the unknown crystals as a variety of spodumene, which he named hiddenite (although it was actually discovered by Mr. Stephenson).

Mr. Hidden formed the Emerald and Hiddenite Mining Company and moved to North Carolina. He personally supervised mining at the Warren farm until about 1888, when the mine was sold.

Hiddenite mining at the Warren farm ended soon after Mr. Hidden sold the mine. Despite his many projects, he achieved neither prosperity nor utter ruin: “Hidden fared about average, neither rich nor truly poor (which is probably still true of most geologists today).” *MLJ*