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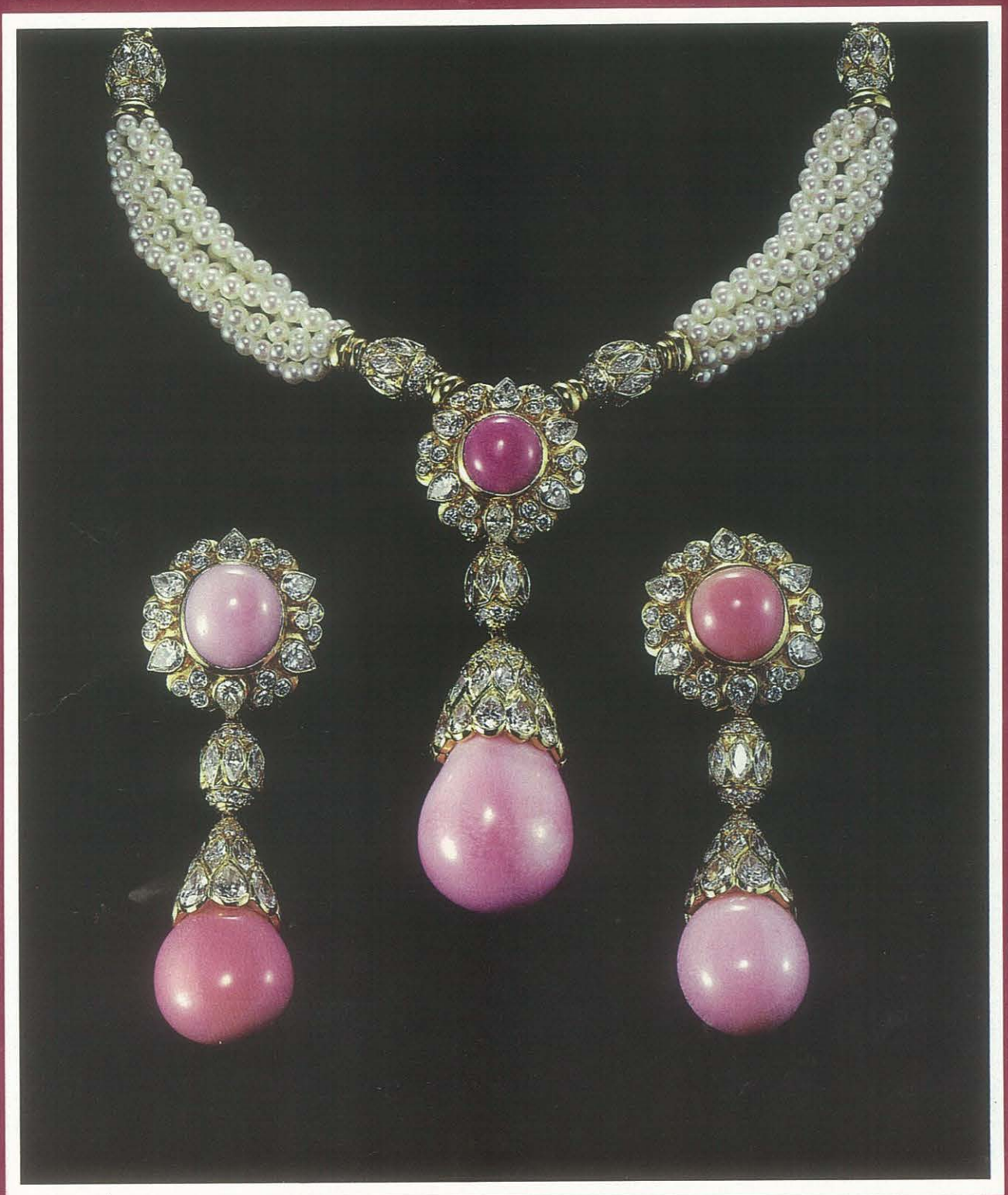

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THE HISTORY AND GEMOLOGY OF QUEEN CONCH "PEARLS"

By Emmanuel Fritsch and Elise B. Misiorowski

Conch "pearls" are calcareous concretions produced by the Queen conch mollusk, Strombus gigas, *which is found in various areas of the Caribbean. Although conch "pearls" occur in a range of colors, the pink are usually the most desirable. "Pearls" over 10 ct are rare, but they have been observed as large as 45 ct. They sometimes exhibit a porcelain-like luster and an unusual characteristic called flame structure, which made pink conch "pearls" quite popular in jewelry at the turn of the last century. This article reviews the history of the conch "pearl," discusses* S. gigas *and its fisheries, and examines the gemological properties and other characteristics of this attractive material.*

ABOUT THE AUTHORS

Dr. Fritsch is research scientist, and Ms. Misiorowski is research librarian, at the Gemological Institute of America, Santa Monica, California.

Acknowledgments: This article would not have been possible without the help of Susan Hendrickson, of the Black Hills Institute of Geological Research, who loaned GIA 150 conch "pearls" for study and provided both rare bibliographic and first-hand information. Dr. Edwin Iversen, of the University of Miami, provided information on the biology of the shellfish. Deborah Day, archivist at the Scripps Institute, gave us access to the private correspondence of La Place Bostwick. We wish to thank Laurence Krashes and Goldbarg Parstabar, of Harry Winston, Inc., for the loan of jewelry. Bonnie Everett and Dee Williams provided useful information. Chuck Fryer did the X-ray diffraction work. Jaime Gabay kindly gave us a conch "pearl" for this project.

Conch "pearls," calcareous concretions produced by the Queen conch mollusk, *Strombus gigas*, often have a very attractive pink color that may be enhanced by a characteristic silky-looking "flame structure" (figure 1). As described by Stevenson and Kunz (1908, p. 279), many specimens "present a peculiar wavy appearance and a sheen somewhat like watered silk, a result of the reflections produced by the fibrous stellated structure." In addition, some conch "pearls" show a smooth, shiny porcelain-like luster that makes them very attractive. Because they are nonnacreous, they cannot be considered true pearls; consequently, the term *pearl*, commonly used in the trade to describe this material, appears here in quotation marks. The name of the mollusk should be pronounced "conk" and both spellings, *conch* and *conk*, are found in the literature.

Although they are truly rare gems, which are found only in the waters of the Caribbean and Bermuda and which seldom occur in a quality and size suitable for jewelry, conch "pearls" are occasionally seen in period jewelry, particularly in the Art Nouveau style. Large unmounted conch "pearls" of high quality have sold for significant prices. An oval 17-ct pink conch "pearl" went for just under US$12,000 at a Paris auction in 1984 (Federman, 1987). Last year, a 6.41-ct fine, dark pink, unmounted conch "pearl" was sold at auction for US$4,400 (Christie's London, June 24, 1987,).

Recently, Susan Hendrickson, of the Black Hills Institute of Geological Research, loaned GIA a large private collection of about 150 conch "pearls." This remarkable group, the result of 10 years of patient gathering, shows the ranges of size, color, and shape in which conch "pearls" can occur. The purpose of this article is to compile the scattered historical references to conch "pearls," review current knowledge of *S. gigas* and its fisheries, and examine the gemological and other properties of this little-known gem material.

Figure 1. This group of exceptional pink conch "pearls" includes some of the finest that were studied for this article. The largest, an unusually fine porcelaneous "pearl," weighs 40.14 ct (22 × 21 × 12 mm). In some, the delicate flame structure typical of conch "pearls" is visible with the unaided eye. Specimens courtesy of Susan Hendrickson; photo by Scott Briggs.

A HISTORICAL LOOK AT CONCH "PEARLS" AND SHELL IN JEWELRY

In antiquity, the conch shell was regarded by the Incas and many early cultures as a symbolic mouthpiece of the gods. "Perhaps it was because, when held to the ear, the voice of the sea god murmured through it" (Dickinson, 1968, p. 7). Although there is no specific reference in the literature to "pearls" obtained from *S. gigas* before the mid-1800s, it is reasonable to believe that they were found and used in jewelry, along with nacreous pearls.

The earliest mention of conch "pearls," specifically from the *S. gigas* mollusk, can be found in the 1839 *Catalogue of the Collection of Pearls & Precious Stones Formed by Henry Philip Hope, Esq.* and referred to in Stevenson and Kunz (1908, p. 464). Among the 148 pearls listed are two conch "pearls": "an oval conch pearl, pink in general color and somewhat whitish at the ends, . . . and another conch pearl . . . button shaped, yellowish-white with a slight shade of pink." Streeter (1886) also mentions this collection and goes on to say that conch "pearls" were quite popular during the 1850s and 1860s, to the point that supply could not keep up with demand.

During Queen Victoria's reign (1837–1901), the shell of the conch was imported into Europe for use in the manufacture of porcelain, to be carved as cameos, and for collecting as a curio. Italian cameo carvers preferred the *S. gigas* shell because of its delicate pink tints (Streeter, 1886). Actually, during the 19th century, conch "pearls" were often referred to as "pink pearls." Alexandra, consort to Edward, Prince of Wales, and daughter-in-law to Queen Victoria, was partial to pearls of all kinds. Edward and Alexandra were the leaders of upper-class society during the late 1800s and early 1900s; the trends that they set in fashion and jewelry came to be known as the Edwardian style. Edwardian jewelry incorporated a lavish profusion of pearls and diamonds usually set in platinum.

One example of an Edwardian piece that incorporates a conch "pearl" (figure 2) can be seen at the Walters Art Gallery in Baltimore, Maryland. This 23.5-ct conch "pearl," at the time one of the largest known, was purchased around 1900 from George F. Kunz at Tiffany & Co. in New York, where he was employed as staff gemologist (Mitchell, 1984, p. 179). Bought by Henry Walters as a gift for his niece Laura Delano, it was eventually presented by her to the Walters Art Gallery.

While the larger conch "pearls" were popular with the upper class at the turn of the century, their smaller counterparts were well suited for use

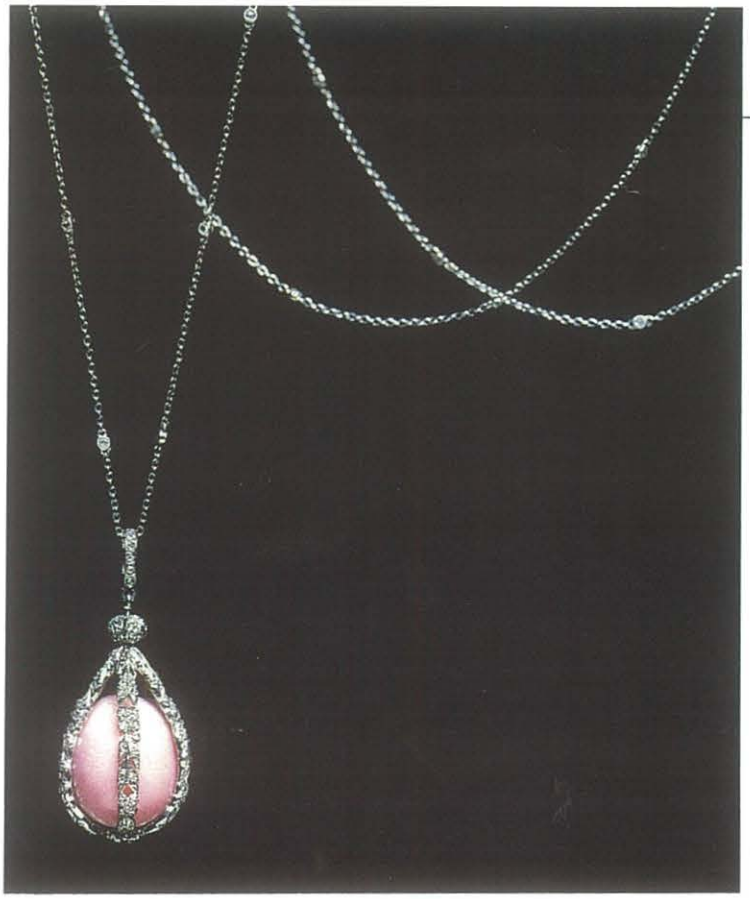


Figure 2. Large conch "pearls" were well suited to the lavishness of Edwardian jewelry. In this Edwardian piece (circa 1900), the 23.5-ct conch "pearl" is set in a hinged platinum cage of prongs with a foliate design. The top can be turned to release the prongs so that the "pearl" can be removed. Courtesy of the Walters Art Gallery.

in the Art Nouveau jewels popular among the rising middle class and artistic avant-garde during the same period. Conch "pearls" lent themselves well to the naturalistic motifs that were common in Art Nouveau jewelry (Misiorowski and Dirlam, 1986). As Art Nouveau jewels often incorporated a mixture of fine gems and metals with inexpensive materials, such as glass and horn, the smaller conch "pearls" were ideal for use as buds in floral designs (figure 3). Jewels of this sort are seen at auction occasionally.

Following the upheaval of World War I, interest in conch "pearls" waned. The Art Deco style that predominated after the war manifested itself in stark geometrics that mirrored the disillusionment of the time and the preoccupation with streamlined modernity. We can find no evidence of the use of conch "pearls" in Art Deco jewelry. Not until the current decade have conch "pearls" regained favor as unique and unusual gems in jewelry. In the last two years, the competition for buying in the Dominican Republic has sharply increased (S. Hendrickson, pers. comm., 1987).

Recently, Harry Winston, Inc. created a few pieces of conch "pearl" jewelry intended for its very special clientèle. One magnificent suite of necklace and earrings features six pink conch "pearls," beautifully combined in size, color, and shape (see cover photograph). The necklace incorporates a deep reddish pink button-shaped conch "pearl"; its pendant contains a magnificent 45-ct (180-grain) pear-shaped conch "pearl" that is probably one of the world's largest. Strong flame structure is readily apparent in many of the "pearls" in the suite.

In conjunction with the pink color, the mysterious allure of the flame structure in conch "pearls" has traditionally added to its desirability as a gem. The rarity of the conch "pearl" precludes its extensive use in jewelry; unless a culturing operation is developed, which is unlikely, conch "pearls" will retain their exclusive status.

BIOLOGY OF THE STROMBUS GIGAS MOLLUSK

Only *S. gigas*, a univalve mollusk commonly known as the Queen conch, grows the calcareous concretions known as conch "pearls." However, one must be careful because the term *conch* is sometimes used to describe other kinds of shell (in fact, the science of shells is called conchology). Nevertheless, fishermen and divers can easily distinguish *S. gigas* from other snails by its distinctive "hook" or "claw," the horny curved operculum attached to the animal's foot. All conchs are vegetarians, eating essentially algaes, and the Queen conch is one of the largest of the herbivorous gastropods (Brownell and Stevely, 1981). Unlike most mollusks, the Queen conch snail moves in a unique "hopping" style (Fleming, 1982), pushing very hard on its foot to raise its heavy shell, and then letting itself fall forward, laboriously gaining about half a body length.

The natural habitat of the conch (figure 4) stretches from Bermuda to the Caribbean (Brownell and Stevely, 1981). When L. D. Powles wrote of his experiences as a barrister in the Bahamas (1888), he titled his book *The Land of the Pink Pearl*. The Queen conch is also found along the southeast coast of Florida and the Keys. In 1910, Kunz wrote a slim promotional book for Tiffany & Co. in which he listed conch "pearl" as one of the state stones. This suggests that Florida also may

have been a source for those conch "pearls" used in jewelry at the turn of the century, although Sinkankas (1959, p. 587) states that "prior to 1900, the vogue for [conch] pearls was largely satisfied by specimens captured on the reefs of Eleuthera and Exuma Islands in the Bahamas and the pearls marketed primarily in Nassau." Streeter (1886), Webster (1975), and Farn (1986) also list the Gulf of California as a source of *S. gigas*. While this area might be the home of similar-looking snails, no marine biology publication mentions the presence of *S. gigas* in this location (see, e.g., Abbott, 1954). Most likely, these reports of "Queen conchs" outside their normal geographic range are just cases of confusion caused by the use of ambiguous common names (E. Iversen, pers. comm., 1987).

Although conchs may undergo minor migrations (Hesse, 1979), they usually remain in the same general area over their lifetime. They tend to inhabit stable sandy bottoms, although occasionally they settle in gravel and coral environments. They may be found in only a few centimeters of water or as deep as 75 m, but they most commonly live at a level above 30 m in depth (Brownell and Stevely, 1981).

Reproduction takes place during the warmer months, from March to September (Hesse and Hesse, 1977). After mating, the female produces an egg mass of about 500,000 units, the size and shape of a fat banana, which is camouflaged from predators by a coating of sand. Four to five days later the eggs hatch and a tiny shell-less conch, called at this stage a "veliger," emerges to drift in water for about four or five weeks, subject to currents and extensive predation, until it settles to the bottom and acquires a small white shell. The young conch, now called a "creeker," seeks protection in the sand. Over the next two years, it will grow its spiral shell, at which time it becomes a "roller." At about three years of age, the mollusk begins to build up its shell in a flared lip. At this point, it has reached breeding maturity and is at optimum size for fishing. It also seems that this is when the snails begin to produce "pearls." The "sanga" or "samba" is a fully matured conch, with a very thick, leathery-looking shell. A group of conch shells of various ages from roller to sanga is represented in figure 5; note the development of the lip and the areas of pink coloration.

Figure 3. Smaller conch "pearls" can be seen in the Art Nouveau pieces that were popular with the middle classes at the turn of the century. The Art Nouveau pendant shown here has a geranium motif of pink enameled flowers with conch "pearl" buds and plique-à-jour enameled leaves. Photo courtesy of Christie's Geneva.

STROMBUS GIGAS FISHERIES

S. gigas is fished throughout the Caribbean primarily for its meat. The shellfish are found in large groups of up to several hundred individuals. The fishermen dive from small boats (figure 6) and pluck the mollusk from shallow waters or use

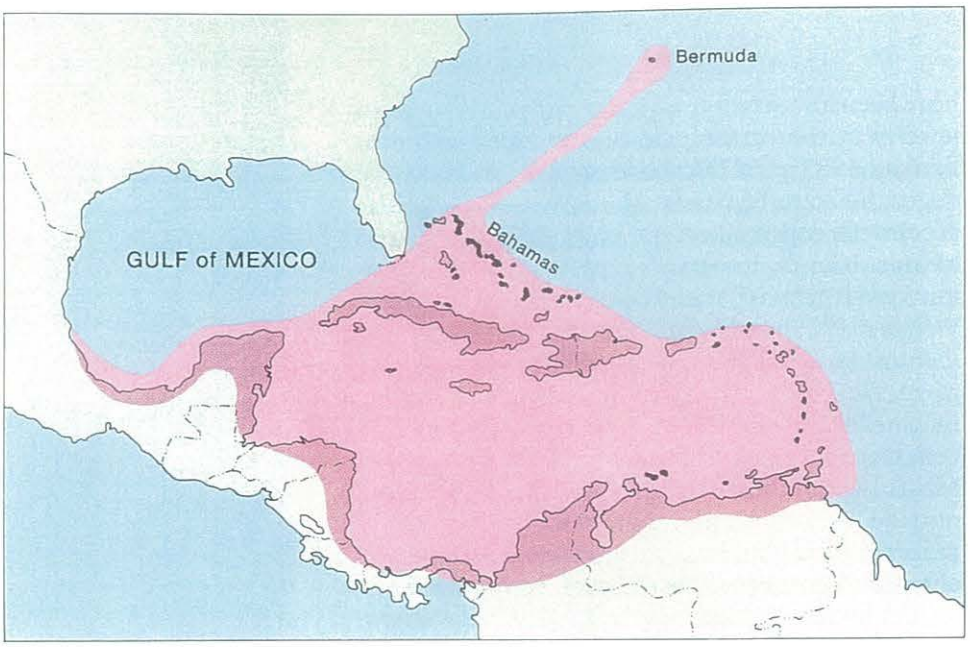


Figure 4. The Strombus gigas *(Queen conch) mollusk is found throughout the waters in the shaded area of this map (After Brownell and Stevely, 1981). Illustration by Jan Newell.*

poles with a hook. The fishermen usually cut the meat out of the shell in the boat. The conch "pearls" are often found at this stage, in a pearl sac within the orange part of the mollusk, which corresponds to the mantle or skirt of the conch (preliminary observations by B. Everett, pers. comm., 1987). They are also recovered when the boat is being cleaned. We have not been able to find any direct documentation on how the "pearl" forms in the conch, but we suspect that it nucle-

Figure 5. These shells are from Strombus gigas *of different ages, from the young "roller" on the left to the oldest "sanga" on the right. Note in the two shells in the center how the lip develops and then, in the two shells on the right, how it thickens as it is eroded over time. Photo by Robert Weldon.*

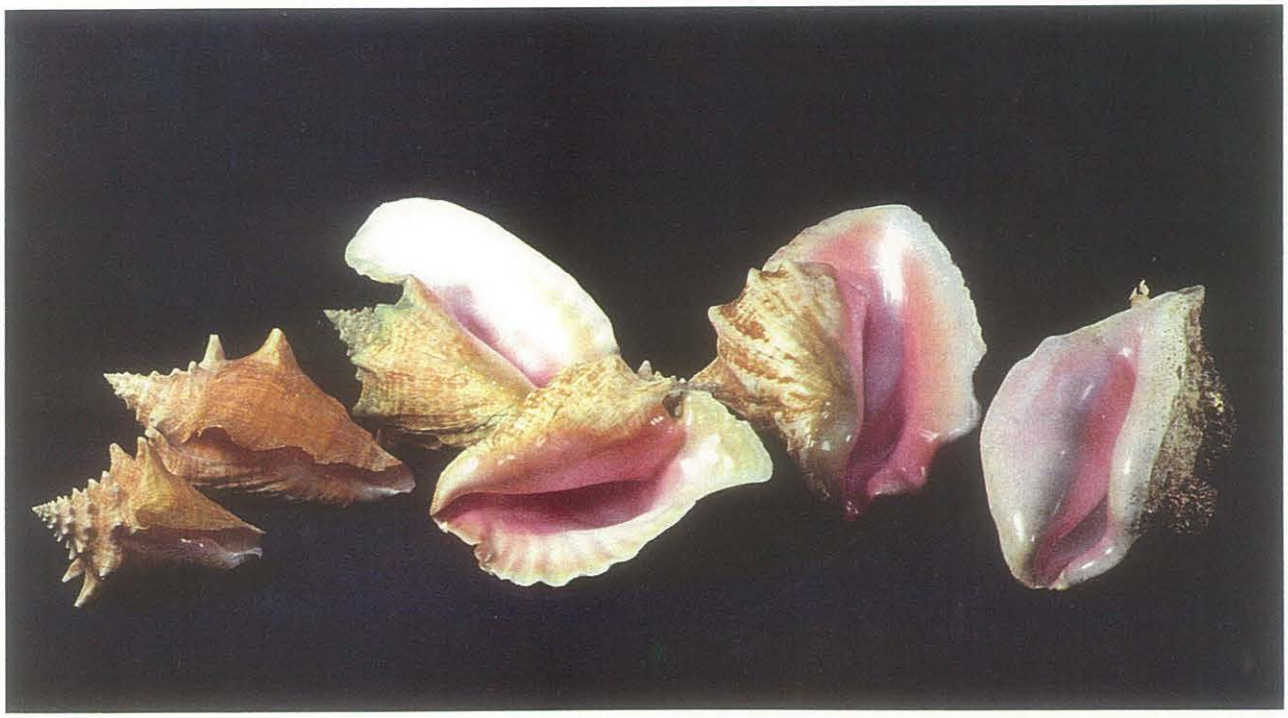


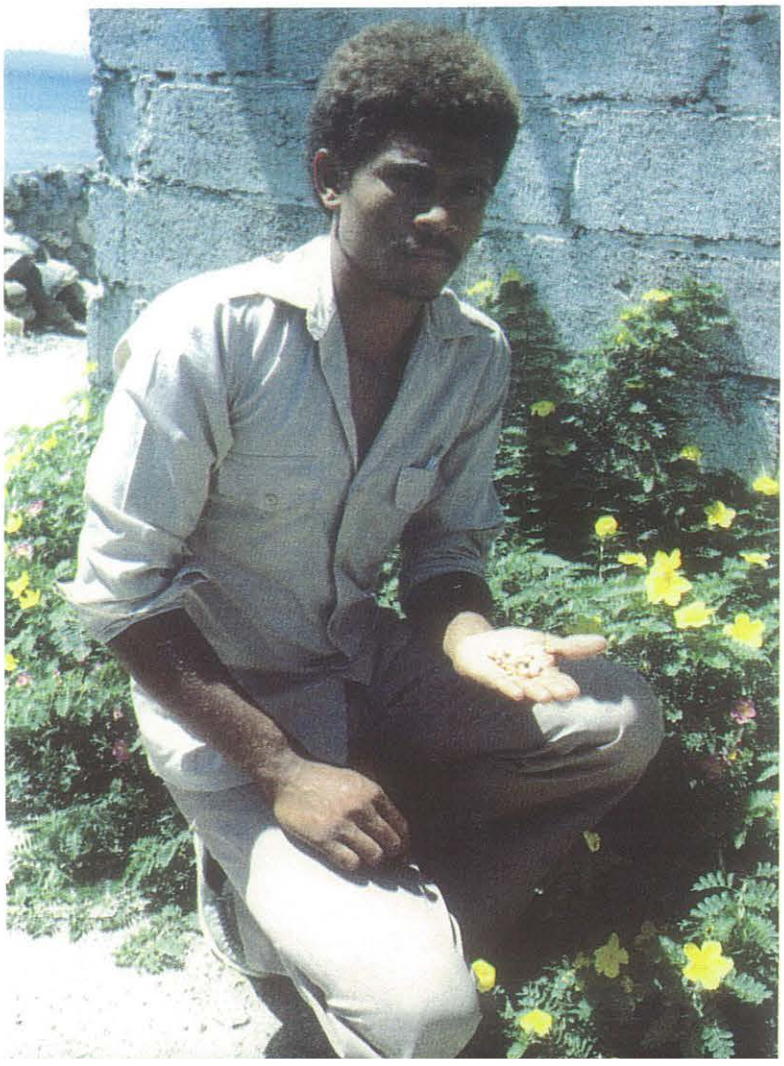
Figure 6. Fishermen from the Dominican Republic and their fishing boat, here dry-docked for maintenance, typify the conditions under which the conch shell is fished. Photo by Susan Hendrickson.

ates due to irritation from a foreign body, in much the same way pearl-like concretions form in other mollusks (Bostwick, 1936; Sweaney and Latendresse, 1984).

The meat, similar to abalone, is usually eaten locally, although during the 1970s it was frozen and exported to the United States. The conch industry benefited greatly from higher prices and improved marketing during this period, but the resulting expansion led to overfishing and the species is now seriously endangered (Hesse and Hesse, 1977; Brownell and Stevely, 1981; Fleming, 1982). Many governments have taken measures to prevent the precipitous decline of *S. gigas*. For example, it is now illegal to fish this mollusk off the coast of Florida. During the period of overfishing, many conch "pearls" (several hundreds, if not thousands) were found, but the recent measures taken to protect the mollusk are likely to reduce this number in the coming years (figure 7). A detailed review of the natural history of the Queen conch and the fishery problems can be found in Randall (1964) and Brownell and Stevely (1981).

One question often raised about conch fishing is how often a "pearl" is found. According to Kunz (1892), there is never more than one conch "pearl" in a shell. This statement has been confirmed by many modern fishermen (S. Hendrickson, pers. comm., 1986). A commercial supplier of conch meat in the Lesser Antilles recently stated that in

Figure 7. Jorge Luis, a Dominican fisherman, displays a handful of conch "pearls" that represent several months of collecting. Photo by Susan Hendrickson.



"approximately 54,000 conchs, only four large (5–10 ct) and a few dozen smaller 'pearls' were found" (Fryer et al., 1985, p. 235). The probability of finding a conch "pearl" is, then, about one in a thousand, which agrees with Streeter's indications in 1886. Ms. Hendrickson (pers. comm., 1986) put the odds even lower—around one in ten thousand to one in fifteen thousand—on the basis of personal observations and discussions with fishermen in the Dominican Republic and the Bahamas. This figure agrees with information provided by Bonnie Everett, who co-owns a fishery in the Turks and Caicos Islands (pers. comm., 1987). Ms. Everett nevertheless points out that there is no way of knowing if a "pearl" has been overlooked. In addition, only about 10% of those found can be considered gem quality. While the degree of scarcity may vary with the fishing grounds, conch "pearls" are, by any standards, very rare.

LA PLACE BOSTWICK AND CONCH "PEARL" CULTURING

The only published account of the successful culturing of conch "pearls" was written by a biological researcher named La Place Bostwick (1936). In 1933, Bostwick applied to the director of the Scripps Institute of Oceanography, requesting permission to work on culturing abalone pearls at their research facilities in La Jolla, California. In his letter, Mr. Bostwick stated that he had "also found the secret of growing round and egg-shaped pearls in the great, pink conch, *Strombus gigas.*"

Bostwick's first attempts at pearl culturing involved some 600 species of freshwater mollusks. In the course of these experiments (as reported in some pages from an undated article published in an unidentified journal that accompanied his Scripps correspondence), he harvested several black cultured pearls from the "Elephant ear" shell.

Working with biological researcher Clarence F. Hoy in Key West, Florida, Bostwick began experimenting with culturing conch "pearls" in the *S. gigas* mollusk. Two photographs and mention in two articles (Bostwick, 1936, and the article of unknown origin referred to above) suggest that the experiments were indeed successful. In 1931, an article in *The Key West Citizen* carried the triumphant title, "After two years work here, experts learn how to grow $50,000 pearls." Bostwick and Hoy, cited in the article as experts, explain the advantages of growing conch "pearls" instead of freshwater pearls. A follow-up article cited Bostwick on the difficulties of the undertaking ("Many Key Westers . . .," 1931). The following year, in a letter to writer Ernest Hemingway, Hoy mentions "Culture Conch Pearls" that Hoy had shown Hemingway previously. Although there is no definitive proof that Bostwick and Hoy were the cultivators, or that the "pearls" were indeed cultured, no evidence has surfaced of any other person cultivating, or attempting to cultivate, conch "pearls" in Key West at that time.

It was apparently at this point that Bostwick applied to the Scripps Institute for space in their laboratories. The correspondence begins in 1933 and suggests, ultimately, that permission was granted and Bostwick moved to La Jolla in the spring of 1934. Between 1934 and 1940, while he confidently awaited the results of his experiments, Bostwick wrote several articles about pearl cultivation, one of which was published in the January 1936 issue of *The Gemmologist*. He also carried on a lively correspondence with a writer, Catherine Meursinge, who was interviewing him for an article about his work with pearl cultivation. This article was eventually published in a Dutch periodical (Meursinge, 1937). There is no evidence, though, that Bostwick ever revealed the secret of his culturing techniques. To one inquiry regarding his methods, he denied drilling the abalone shells to introduce a bead nucleus and further replied: "I . . . hypnotize them [the mollusks] and as the mind has great effect over matter, when they understand that they must grow a pearl, they just get busy and do it. I have a very poor memory and usually FORGET to explain just how the pearls are grown" (letter to Meursinge, 1936).

Both the article by Meursinge and the correspondence leading to it mention repeatedly that a book by Bostwick titled *Pearls and Pearl Bearing Mollusks* was to be published soon by Appleton Century Publishers in New York. However, there is no mention of the book in any correspondence after 1937 and as there is no entry for such a book in the Library of Congress, it is doubtful that it was ever released.

In fact, after 1940, Bostwick himself drops out of sight. The archives at Scripps provide no clue as to the results of his abalone "pearl"–culturing experiments, which may very well have failed. At any rate, the last written record of La Place Bostwick that we were able to discover is a 1940 letter to Catherine Meursinge regarding the turbulent political situation in Europe at the time.

GEMOLOGY OF THE CONCH "PEARL"

For this article, we examined more than 150 conch "pearls," which ranged from 0.2 to over 40 ct (2 to 22 mm). Most of the specimens had been acquired by Ms. Hendrickson directly from conch fishermen in the Caribbean. In all cases, the fishermen confirmed that the "pearls" had come from *S. gigas* specifically, although they were aware that other shells can produce calcareous concretions.

Size. Calcareous concretions from the conch shell are commonly no more than 2–3 mm in diameter, and around 0.2 or 0.3 ct in weight. Only rarely do they occur in sizes and of a quality suitable for use in jewelry (S. Hendrickson, pers. comm., 1986). Although specimens up to 10 ct are found, larger "pearls" are exceptional. Unusually fine, large examples include the 40.14-ct "pearl" shown in figure 1 and the 45-ct pendant in the Harry Winston conch "pearl" necklace mentioned earlier.

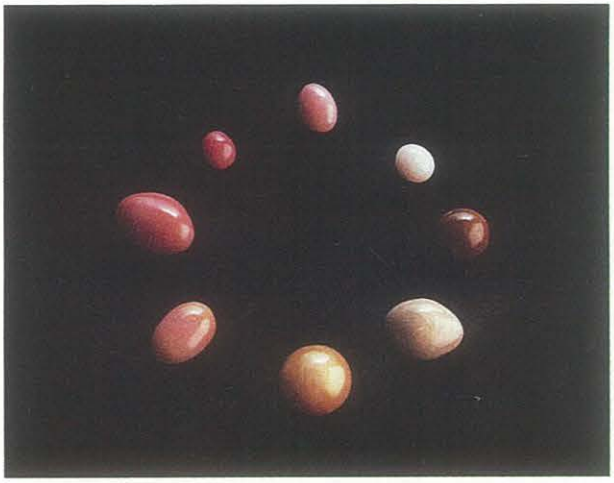
Shape. Conch "pearls" occur in a variety of shapes, ranging from extremely baroque to very symmetrical (figure 8). They are generally somewhat rounded, but only very rarely are they spherical. Quite commonly, conch "pearls" resemble a football or a watermelon in shape. Ms. Hendrickson's collection includes a unique double "pearl." In his 1936 *Gemmologist* article, Bostwick suggested a few rules concerning the shapes of abalone pearls that probably apply as well to conch "pearls": "If a growing pearl is not located in exactly the right part of the anatomy, it will become rough or ill shaped;. . . if it is growing in a region of muscular activity, it will not grow round." He also stated that "if it touches the shell, it will become attached." A few of the samples we studied clearly show an extension, known as a peduncle, that may have been caused by the proximity of the shell.

Symmetry is a key factor in establishing the value of a conch "pearl." Irregular shapes generally do not command prices as high as symmetrical elliptic (football) shapes, particularly among Europeans. Any departure from this "ideal" oval will reduce its desirability. Other details that might have a negative effect on value are an uneven surface, flaws reminiscent of fractures, and surface blemishes. Most oval-shaped "pearls" have white ends that are often tipped with brown protuberances which can be rather unattractive.

Color Range. Conch "pearls" occur in various tones of pink, yellow, brown, and white (figure 9). In the collection provided by Ms. Hendrickson, which

Figure 8. This group of conch "pearls" illustrates the wide variety of shapes in which they occur, from pronounced baroque (brown, 18.62 ct at the bottom) to almost spherical (dark brown, 1.83 ct on the left). Probably the most sought-after shape is a symmetrical elongated ellipse, like a football, approximated by the two pink "pearls" at the upper left (6.49 and 2.48 ct). Specimens courtesy of Susan Hendrickson; photo by Scott Briggs.

Figure 9. Although most people think of them as pink, conch "pearls" may be white (1.44 ct), yellow ("golden," at the bottom, 7.23 ct), brown, or orangy ("salmon"). Specimens courtesy of Susan Hendrickson; photo by Scott Briggs.



primarily represents "pearls" found in the Silver Shoals (a region of shallow waters that is claimed by both the Dominican Republic and the Turks and Caicos Islands), more than half are light brown, sometimes with a gray or yellow modifier. Inasmuch as brownish conch "pearls" are usually discarded by the fishermen, someone who sees only what is commercially available might get the impression that they are uncommon (e.g., Streeter, 1886). However, Ms. Everett maintains that she finds mostly pinks in her conch fishery, so perhaps there is some geographic variability in the proportion of the various colors. A dark brown ("chocolate brown") "pearl" is very unusual. White conch "pearls" also seem to be rather rare, although they are mentioned by Streeter (1886), Kunz (1892, 1894), and Webster (1975). A brownish yellow conch "pearl" is referred to among collectors and dealers as a "golden pearl" (figure 10). The most highly valued hues, however, are pink and orangy-pink, also called "salmon" (Kunz, 1892; Krashes, 1986). In rare instances the color appears to be lavender. Occasionally, the pink color is so intense that the "pearl" is described as red. Among the pink conch "pearls," a medium purplish pink is the preferred hue (see figures 11 and 12); a salmon color is considered to be slightly less desirable.

Figure 10. A rare example of a fine "golden" conch "pearl" (15.56 ct) set in jewelry is this 14K gold ring. Photo courtesy of Manuel and Inge Marcial, Emeralds International Inc., Key West, Florida.

Figure 11. This 2.88-ct pink conch "pearl" of very fine color and unusual oblique flame structure, found off the San Bernardo Islands (Colombia), is set in an 18K gold pendant. Photo courtesy of Manuel and Inge Marcial, Emeralds International Inc., Key West, Florida.

As with other pearls, the color of the conch "pearl" reflects the color of the internal surface of the shell in the region where it grows. Microscopic observation and thin sections suggest that brown is caused by the incorporation of a layer of an opaque, muddy-looking substance close to the surface of the shell. The salmon color seems to occur when a very thin layer of that substance covers a pink zone.

Figure 12. These three pink conch "pearls" represent the range of most desirable colors and flame structure. From left to right: 2.88 ct, 2.24 ct, and 4.04 ct. Specimens courtesy of Susan Hendrickson; photo by Robert Weldon.

Fading. Unfortunately, the attractive color of pink conch "pearls" is not stable. Like the shell itself, these "pearls" fade on prolonged exposure to sunlight to a much lighter pink (figure 13). This characteristic of the shell was noticed early on, as a consequence of its use for cameos (Brown, 1986).

The fading is probably related to the organic origin of the pink color. We obtained the absorption spectrum of a pink conch "pearl" on a Pye-Unicam UV-visible spectrophotometer. A broad absorption band centered around 500 nm is responsible for the pink coloration. Studies using Raman spectroscopy have demonstrated that the intensity of this visible absorption is related to the intensity of certain lines in the Raman spectrum (Délé-Dubois and Merlin, 1981). These lines are characteristic of organic compounds of the carotenoïd family, to which a large number of organic pigments belong. The exact nature of the pigment(s) is not known. Inasmuch as many organic products fade, it is not surprising to observe this phenomenon in the conch "pearl." The fading is probably caused by the decomposition of the product when exposed to the ultraviolet rays of natural daylight. There is no known method by which the color can be restored. Consequently, fine pink conch "pearls" set in jewelry should be reserved for evening or occasional, as opposed to daily, wear. With care, however, the color will remain strong, as the "pearls" in the Edwardian and Art Nouveau pieces demonstrate (again, see figures 2 and 3).

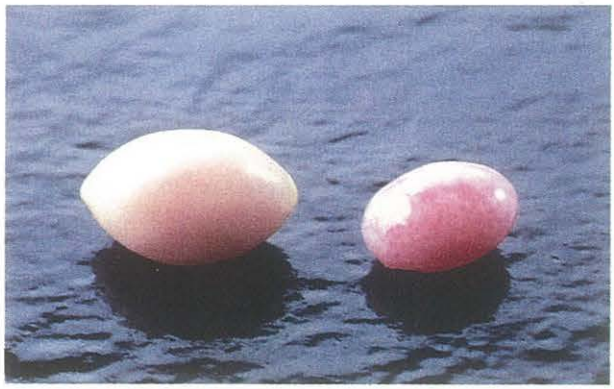


Figure 13. The color of the 3.37-ct faded conch "pearl" on the left originally resembled that of the 1.56-ct "pearl" on the right prior to exposure to sunlight. Note also the whitish protuberances on the faded "pearl"; these are a common characteristic of conch "pearls." The irregular wavy surface of the smaller "pearl" impairs its value. Photo by Robert Weldon.

Refractive Index and Specific Gravity. The refractive indices of 16 conch "pearls," which cover the full range of colors, were determined using the spot reading technique. All fall between 1.50 and 1.53, with an average value of 1.51.

The specific gravity of 12 conch "pearls" was measured using the hydrostatic method. The value obtained seems to correlate with the color. Brown concretions have the lowest values (2.18–2.77), probably because they typically contain cavities, as could be seen when the "pearls" were sawed. Intermediate values (2.82–2.86) were obtained for white and "golden" samples, which may or may not contain cavities. Our experience (both with

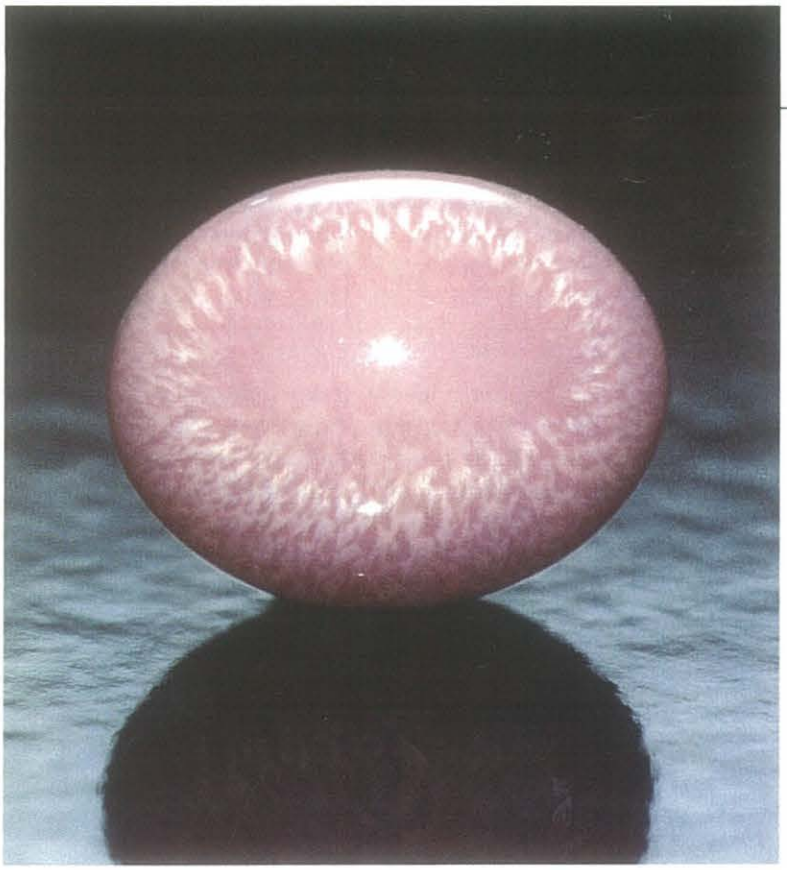


Figure 14. This is a fine example of a conch "pearl" (3.06 ct) of perfect form and good color. Notice how the radial flame structure creates an attractive oval-shaped pseudo-chatoyancy. Specimen courtesy of Susan Hendrickson; photo © Tino Hammid.

sawed "pearls" and as observed with X-radiography) indicates that pink conch "pearls" do not contain cavities; they range in specific gravity from 2.84 to 2.87.

The Flame Structure in Conch "Pearls." One of the most striking characteristics of the conch "pearl" is the flame structure. In some cases, the surface reveals a regular pattern of parallel elongated crystals that imparts a silky sheen to the "pearl" (again, see figure 11). In the very best specimens, the "flames" can be identified by microscopic examination as thin lamellae that are almost parallel to one another and are sometimes perpendicular to the axis of the "pearl," thereby giving rise to a rough chatoyant effect (figure 14). Flame structure has also been observed in portions of the conch shell itself, in the red and black helmet shells (Brown, 1986), and also in the *Tridacna* "pearl" (Liddicoat, 1981).

We have observed flame structure in conch "pearls" only in the pinks (and on the white parts of pink and white pearls), and not all of them exhibit this pattern without magnification (see, e.g., the largest specimen in figure 1). A conch "pearl" in which flame structure is not visible with the unaided eye is called porcelaneous. Therefore, although the presence of flame structure helps to identify a pink concretion as a conch "pearl" (Webster, 1975; Fryer et al., 1982), its absence does not mean the contrary. Flame structure is highly desirable, however, and conch "pearls" in which it is not easily seen carry a lower value than those in which it is prominent.

The structure of the Queen conch shell has been described in great detail by Bolman (1941) and briefly by Brown (1986). Since the "pearl" is formed in the same manner as the shell, one expects to find a similar structure. We cut three thin sections, one in each of two different brown "pearls" (figure 15, left), and one in a pink "pearl" (figure 15, right). Both have basically a concentric organization (see also Fryer et al., 1985), but the layers can vary considerably in structure within the same section. The outermost layer of the pink sample exhibits a somewhat prismatic structure, constructed of rather large crystals (up to 1 mm in width). A similar layer has been found inside a brown "pearl." Other layers have a finely fibrous or a columnar structure, as described by Bolman (1941) for the *S. gigas* shell. All three sections have a very irregular brown core of unknown nature. Brown "pearls" contain intercalated layers of a brown, muddy-looking material that give them their coloration. Because there is apparently very little or no conchiolin layer, X-radiography does not reveal any structure in the "pearl."

Brown (1986, p. 157) explained that the flame structure of the conch shell is "an optical effect that was caused by sharp bending of the shell's fibrous crystals so that their orientation ran almost parallel to the internal surface of the shell." On the thin section of pink conch "pearl" with good flame structure that we studied (figure 15, right), such bending is not obvious. The flame structure seems to be apparent only when mud-like layers are not present under the outermost layer. This allows for better transparency and one sees "deeper" into the pearl. The fibrous or lamellar structure is present in all shells or "pearls" exhibiting flame structure. In polarized light, this outermost layer appears to be constructed of two sets of crystals, one lighted when the other is extinct. This suggests a fixed crystallographic relationship, probably twinning as it is commonly

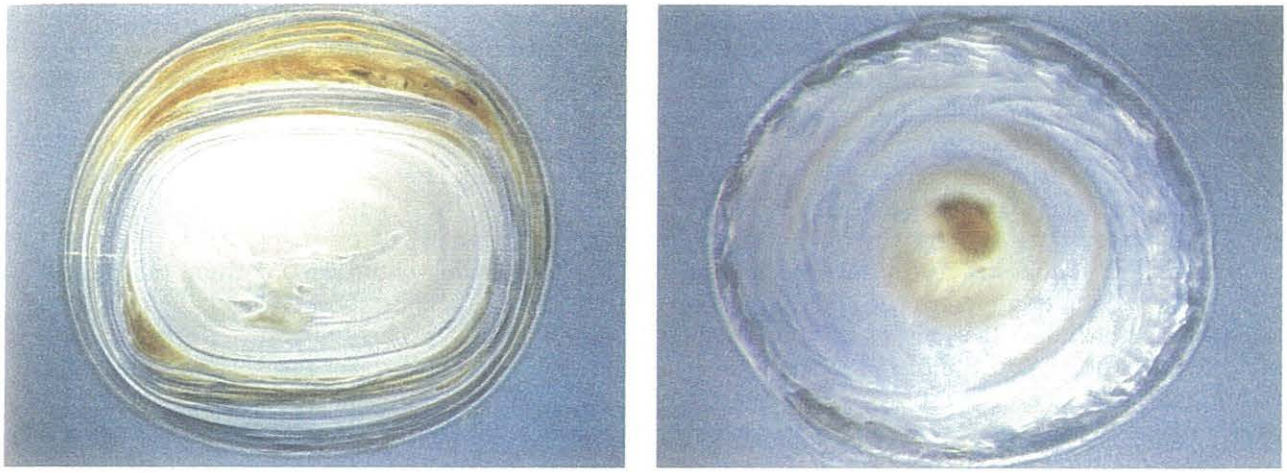


Figure 15. Thin sections (about 100 μm thick) were cut from a brown (left) and a pink (right) conch "pearl." The irregular brown core and the concentric structure are clear in both thin sections. The muddy-looking brown layers in the thin section on the left impart their color to the "pearl." Magnified 12×; photomicrographs by John I. Koivula.

seen in plagioclase. Sabatier (1953) described a calcite twin in some shells that exhibit a similar texture. Microscopic examination of the conch "pearls" also suggests that either one set of crystals is more intensely colored than the other, or that one is fibrous while the other is not.

Unfortunately, the chemical composition of the "pearl" is not clear cut. The average refractive-index value (1.51) is lower than the range for aragonite (1.53–1.68) and within the range for calcite (1.49–1.66). This parallels the observation made on the basis of infrared spectroscopy that the surface of the shell contains some calcite (Compere and Bates, 1973). The specific-gravity values lie between those for calcite (2.71) and aragonite (2.95). If we assume an average for conch "pearls" of around 2.85, as suggested in Webster (1975), they would correspond to a mixture of about 40% calcite with 60% aragonite. Raman spectroscopy (Délé-Dubois and Merlin, 1981) also indicates a mixture of calcite and aragonite. However, X-ray diffraction on several spots of different "pearl" sections, even close to the outer surface, always matched the aragonite pattern. These measurements indicate that conch "pearls" are made up of aragonite as the major constituent, with an unknown amount of calcite and probably water, as well as a few organic products that would allow for the coloration. Therefore, the particular twinning in pure calcite described by Sabatier (1953) is unlikely to be responsible for the flame structure, but the origin of the flame structure is probably to be found in a similar phenomenon of oriented crystal growth.

Hardness and Toughness. We found the conch "pearls" to be of surprisingly high, yet variable, hardness for their composition. Scratch tests using hardness points from two different manufacturers were consistent and resulted in values between 4 and 5 for the two brown "pearls" and between 5 and 6 for two pink ones. This resistance to scratching explains why these "pearls" keep a very high luster even when worn in jewelry. We cannot currently explain why the hardness values are higher than those of both calcite (3) and aragonite (3.5–4).

Jewelers who have drilled and set conch "pearls" have been surprised by their toughness, which can be rated as good. They report it to be much higher than that of oyster pearls (S. Hendrickson, pers. comm., 1986), making conch "pearls" relatively easy to set in jewelry.

SEPARATION FROM OTHER MATERIALS

Pink or orange coral beads are occasionally mistaken for conch "pearls" (Liddicoat, 1981; Farn, 1986). The most famous misidentification is that made by Kunz, and reported by Koivula (1987). As Liddicoat (1981) pointed out, these two materials can be separated on the basis of specific gravity, which is 2.65 for coral and 2.85 on the average for

pink conch "pearls." Also, they differ greatly in surface appearance: Coral shows distinct surface pits as well as banded striations that are much more regular than the flame structure seen on conch "pearls"; coral may also show a characteristic tree-ring structure.

Other conch "pearl" imitations appear to be rare. Pink glass beads (sometimes with a pattern that resembles flame structure) have been used (Farn, 1986). Usually a close examination reveals the presence of bubbles, swirls of color, or other inclusions in the glass sufficient to separate these imitations from the natural material. Streeter (1886, p. 274) relates how an "ingenious American" cut "out of the pink portions of the shell some very creditable imitations." To increase the confusion, those beads were implanted in a conch mollusk, which was found later, of course, to have produced a so-called "pearl." Kunz also mentions these bead imitations in 1894. Recently, a cabochon cut out of the pink part of the shell was submitted to a jeweler (D. Williams, pers. comm., 1987) by a client who indicated that it had been sold to him as a conch "pearl" in Miami some years ago. Ms. Hendrickson (pers. comm., 1987) confirmed that she had seen such imitations being sold in the Dominican Republic recently. This emphasizes that one must always be vigilant, even for old tricks thought to be long forgotten. More common, of course, are the beads cut from conch shell to imitate pink coral (R. Crowningshield, pers. comm., 1987).

THE TERMINOLOGY ISSUE

Pearls are calcareous concretions that are formed from the shell material and grown naturally in a pearl sac of a molluscan animal (Coomans, 1973). This definition implies that conch "pearls" are indeed true pearls, but that calcareous concretions formed by some other animals (*Brachopoda, Vermes, Pisces, Mammalia*) are not. In agreement with this definition, the CIBJO rules recommend that concretions from the conch shell be called "Pink Pearl"; note the capital *P* for *pink* (*Gemstones/Pearls*, 1982). However, most gemology texts emphasize that nacre or orient must be present (Liddicoat, 1981; Webster, 1983). By this definition, inasmuch as it is nonnacreous, a conch "pearl" cannot be considered a true pearl. The recommendations of the Federal Trade Commission do not specify that nacre or orient must be present for the concretion to be called a pearl (USFTC, 1959). The definition included in the recommendations of the Jewelers Vigilance Committee requires the presence of conchiolin, which is difficult to prove, and does not recommend any specific term for conch "pearls" (Preston and Windman, 1986). The policy at the GIA Gem Trade Laboratory, Inc. is to call this material a "calcareous concretion" on its reports.

In the trade, however, common practice is to call the calcareous concretion of the conch shell "conch pearl," probably because this term is more attractive and also because "calcareous concretion" is not specific enough. "Conch pearl" makes it clear that this particular calcareous concretion was produced by a conch mollusk, and does not imply, as in CIBJO nomenclature, that the color must be pink. The CIBJO terminology has engendered some additional confusion. Farn, in his recent book (1986), reports the story of a 93-grain (23.25 ct) "Pink Pearl" found in New Jersey that later became famous as the "Queen Pearl" because it was owned by Empress Eugenie. Although the spelling with a capital *P* indicates a conch "pearl" under CIBJO terminology, the item was actually a freshwater pearl with a pink hue, which should have been called "a pink freshwater pearl" (no capital *P*).

Some confusion might still arise, though, from the appellation "conch pearl." We have discussed here only the calcareous concretions produced by *S. gigas*, from the conch family. Other shells referred to as conchs are known to produce "pearls" (Farn, 1986). Also, pink porcelaneous "pearls" are known from other shells, such as *Turbinella scolymus* (Streeter, 1886).

CONCLUSION

Conch "pearls" are truly rare and fascinating gems, which combine the still-unsolved mystery of their flame structure with their beautiful pink color and exotic origin. Apparently very difficult to culture or to imitate, never treated, they are a true natural gem. Their hardness and toughness make them easy to mount and preserve in jewelry. After years of relative obscurity, they seem to have returned to fashion, probably because more are available, although they are still quite rare. Let us hope that appropriate fishing restrictions will provide a regular supply of these "pearls" for the pleasure of gemologists and gem connoisseurs alike in the generations to come.

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