Gems & Gemology

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ABOUT THE COVER: The jadeite necklace and earrings illustrated here give some indication of the beauty and mystery of this material. The identification of jade and some of its simulants is comprehensively examined in the article by Jill Hobbs. The motifs that the Chinese have used for centuries to carve jade—for example, these earrings have been formed in the shape of a pi, *a symbol of heaven—are reviewed in the article by Evelyn Tucker. The natural green jadeite beads are 30 inches (75 cm) long; the largest bead is 9.5 mm in diameter. The natural green jadeite earrings are 25 mm in diameter. Courtesy of the Crystalite Corporation. Photograph ©1981 Harold and Erica Van Pelt—Photographers, Los Angeles, CA.*

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MANUSCRIPT SUBMISSIONS

Gems & Gemology welcomes the submission of articles on all aspects of the field. Please see the Suggestions for Authors for preparing manuscripts in the Summer 1981 issue of the journal or contact the Managing Editor for a copy. Letters on articles published in *Gems & Gemology* and other relevant matters are also welcome.

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THE GEMS & GEMOLOGY MOST VALUABLE ARTICLE AWARD

RICHARD T. LIDDICOAT, Jr. Editor-in-Chief

The response to the ballot included with the Winter 1981 subscriber copies of *Gems & Gemology* was very gratifying. Almost 500 people took the time to review their 1981 issues of the journal and register their votes for the three articles they found most interesting and potentially useful, that is, of the greatest value to their pursuits in gemology. It is a credit to the authors that the voting was so competitive: all articles received several votes, and a number of people returned their ballots with no votes and the explanatory note that they felt that it was impossible to choose only three articles from the many excellent papers available.

Three articles did, however, receive a greater proportion of the votes cast—and the special recognition of our subscribers. I am pleased to announce that the winners of the first annual GIA Award for the most valuable article published in *Gems & Gemology* are, in order from first through third in the balloting:

- Jill M. Hobbs, for the article "A Simple Approach to Detecting Diamond Simulants" (Spring 1981)
- Kurt Nassau, for the article "Heat Treating Ruby and Sapphire: Technical Aspects" (Fall 1981)
- Peter C. Keller, for the article "Emeralds of Colombia" (Summer 1981)

In honor of their achievements, Ms. Hobbs, Dr. Nassau, and Dr. Keller will receive certificates and cash awards of $500, $300, and $100, respectively. We on the editorial staff know the many weekends and evenings that all three authors devoted to their articles, and congratulate them on the success of their efforts. Brief biographies of the authors appear on the following page.

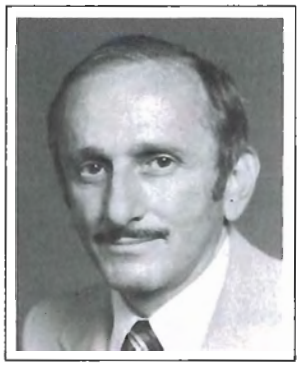
At this time, I would like to thank those of you who participated in the balloting and especially those who took the time to include comments. We appreciate the overwhelming vote of support for the new *Gems & Gemology*. Your specific suggestions and concerns are being taken into consideration (including those of the gentleman who asked that we please not change anything). For the time being, we will continue to strive to publish a wide variety of articles and items in our regular sections to appeal to the broad range of interests of our readers.

THE WINNERS

JILL M. HOBBS

Before assuming her present position as assistant manager of GIA's Home Study Department, Jill Hobbs taught Colored Stones/Gem Identification for four years in the GIA Resident Program. Ms. Hobbs is a popular lecturer in gemology, and her articles have appeared in several trade publications. Gem identification is a special interest of hers, as evidenced both by the award-winning article on diamond simulants and the article on identifying jade and its simulants that appears in this issue of *Gems & Gemology*.

Ms. Hobbs is a native of Washington State. She is a graduate gemologist and received her B.A. from the University of California at Los Angeles.



KURT NASSAU

Dr. Nassau's work at the Materials Laboratory of Bell Telephone Laboratories includes active involvement in research on crystal growth and chemistry research of laser materials, semiconductors, and the like. Currently, Dr. Nassau is studying quenched and conventional glasses and crystals for electronic and fiber optic applications. In addition to being a prolific writer (he has authored one book, three book chapters, and over 250 articles), he belongs to several professional societies and serves on the board of governors of GIA.

Dr. Nassau was born in Austria. He received his B.Sc. from the University of Bristol, England, and his Ph.D. in physical chemistry from the University of Pittsburgh, Pennsylvania.

PETER C. KELLER

Dr. Keller joined GIA as director of education in August of 1980, after serving four years as curator of mineralogy and geology at the Los Angeles County Museum of Natural History. He complements his responsibilities for the various educational programs at GIA with membership in several professional societies, an adjunct professorship in geology at the University of Southern California, and membership on the board of trustees of the Los Angeles County Museum of Natural History. He has written several articles and served as associate producer on the movie "Gems of the Americas."

A native of Allentown, Pennsylvania, Dr. Keller received his B.A. from George Washington University in Washington, DC, and his M.A. and Ph.D. in mineralogy from The University of Texas at Austin.

THE JADE ENIGMA

By Jill M. Hobbs

Jade is one of the most misunderstood gemstones. It is actually two separate materials: jadeite and nephrite. Together, these materials have more simulants than most other gems. Thus, it is important to know the various simulants, and to understand how to separate them from jade. This article examines the key identifying properties of green jade (jadeite and nephrite) and contrasts them with the properties of the 10 most common green jade simulants. Simple visual techniques are emphasized as well as the appropriate gemological tests.

ABOUT THE AUTHOR

Ms. Hobbs is a gemologist and assistant manager of the Home Study Department, Gemological Institute of America, Santa Monica, CA.

Acknowledgments: The author is indebted to Chuck Fryer for his invaluable advice and information, and to Peter Keller for his help in the research and direction of this article. Special thanks also go to Susan Kingsbury for the line drawings and to Evelyn Tucker for the design of these drawings. The photographs in figures 4, 5, 6, 8, 9, 10, 11, 12, and 14 were provided by Tino Hammid of GIA Gem Media. Other photo credits appear with the individual figures.

It is easy to understand why jade has been considered a "piece of heaven" for centuries. The rich color and soft texture of fine jade have made it a favorite of gem connoisseurs everywhere. It is also easy to understand why many materials have been represented as jade. It is curious, however, that the names for jade are still a subject of controversy and that so much misinformation, myth, and superstition surrounds this gem, especially the treasured green material (see figure 1).

This article will try to remove some of the confusion that often accompanies the purchase of jade jewelry or carvings. By introducing the common trade names and misnomers for green jade and its simulants, and by explaining how these materials can be separated from one another, the following text will serve as a guide to the gemology of jade.

WHAT IS JADE?

Civilizations of all ages have prized this material. In his widely read book on jade, Gump (1962) captures the spell of this gemstone:

> The Central Asians placed a huge slab of jade before the tomb of Tamerlane to make it inviolate. The pre-Columbians made sacrificial knives from it. Aladdin expressed wonder at the fabulous trees of the jade in the underground cavern. The Russians carved a whole sarcophagus, for Czar Alexander III, of jade. In both New Zealand and New Calcedonia a jade mere or war club was the chief's symbol of authority. Fathers in the Loyalty Islands once bartered their daughters for jade. China built a civilization around the stone.

All races and ages that encountered jade valued it. Prehistoric civilizations recognized jade for its toughness. In China, in the Swiss Lake area in Europe, and in Central America (especially Guatemala and Mexico), prehistoric cultures used jade for functional articles. In the Swiss

Figure 1. An attractive example of green jadeite used in jewelry (the jadeite measures 6.3 × 5.6 × 0.4 cm). A wide variety of simulants attempt to duplicate the unique beauty and appearance of jadeite. It is enigmatic that although jadeite (and nephrite, which is also known as jade) have been worked and admired by many civilizations, the true nature of the material is still misunderstood, and its simulants are often misidentified as the original. Brooch courtesy of Mason-Kay, Inc.

Lake area in particular, archaeologists have documented that early dwellers used jade for axe heads, scrapers, and instruments of war; they eventually treasured it for aesthetic and symbolic value as well (Foshag, 1957).

Curiously, the scientific nature of jade was not fully understood until the 19th century, when Professor A. Damour proved that the gemstone that is commonly called jade is actually two separate and distinct materials: jadeite and nephrite. The former is usually the more valued of the two for jewelry and carvings, because fine-quality jadeite is an intense medium green, whereas even the best nephrite tends to be a darker, more blackish green. Interestingly, the distinction was made in another culture long before Damour published his scientific findings. When the intense-green jadeite began to enter China from Burma in the middle of the 18th century, the Chinese called it *fei-ts'ui* instead of *yu*, which had been the standard name for jade (Hardinge, 1953). In addition, while most early writings purportedly described nephrite, a few of them were said to describe material that would fall under the modern mineralogical classification of jadeite (Foshag, 1957).

Although A. G. Werner, in 1788, was the first to apply the mineralogical name *nephrite*, Damour was the first to determine the chemical composition of this material. In his 1846 publication, Damour established that nephrite is a compact variety of the amphibole minerals tremolite and actinolite. Then, in 1863, Damour reported the very important discovery that jadeite is a separate and distinct species. A member of the pyroxene group of minerals, jadeite is very different from nephrite in both chemistry and internal structure (see box). Thus, it has different properties and a different appearance.

These findings revolutionized jade nomenclature, and they should have simplified the identification, evaluation, and marketing of jadeite and nephrite. Yet jade remains an enigma to most buyers. The tradition of myth and misinformation continues today. In addition to the accepted trade names for jade (see table 1), many misleading terms such as "Mexican jade," "Japanese jade," "jasper jade," and "Transvaal jade" are used to market gem materials other than jadeite and nephrite (table 2). With so many materials touted as jade, the buyer must be aware of the names of these simulants as well as their key identifying characteristics.

This article examines both the identification of jadeite or nephrite and the separation of these

THE QUESTION OF JADE NOMENCLATURE

The term *jade* encompasses two tough, compact, fine-grained materials: jadeite and nephrite. The definition of these two materials is difficult, at best.

Strictly speaking, jadeite is a distinct monoclinic mineral belonging to the pyroxene group and having an ideal chemical composition of $NaAl[SiO_3]_2$. However, jadeite may be an intimate intergrowth of jadeite with at least one of two closely related pyroxenes: acmite $[NaFe[SiO_3]_2]$, or diopside $[CaMg[SiO_3]_2]$. The three minerals can form a continuous isomorphic substitution series. The variations in the properties of jadeite are therefore dependent on the proportions of each pyroxene present.

If enough diopside is present that the material's chemical composition is intermediate between diopside and jadeite, the material is sometimes called diopside-jadeite. The optical and physical properties of this material are normally so close to those of pure jadeite that a distinction is impractical. However, if the material's chemical composition is intermediate between acmite and jadeite—or acmite, diopside, and jadeite—its properties and appearance are distinct from pure jadeite and it is commonly known as chloromelanite. This material is typically blackish green to nearly black; the presence of a significant amount of iron produces a slightly higher refractive index and specific gravity as well.

The definition of nephrite is even more controversial. Mineralogy texts have traditionally listed nephrite as a variety of actinolite, a monoclinic member of the amphibole group. As in the case of jadeite, however, actinolite is very closely related chemically and structurally to other members of its group. Actinolite $[Ca[Mg,Fe]_3[SiO_3]_4]$ is so closely related to tremolite $[CaMg_3[SiO_3]_4]$ that their optical and physical properties may be indistinguishable. The magnesium in tremolite is commonly replaced by iron, and the two minerals do, in fact, grade into one another. The color of the material, however, indicates the amount of iron present: the iron in actinolite imparts a green to grayish-green color, whereas the iron-poor tremolite is normally white to gray. The fact that nephrite is, in reality, a variety of two mineral species recently led the International Mineralogical Association (I.M.A.) to discredit nephrite as a valid mineralogical variety.

In defining both jadeite and nephrite, texture is as important as mineralogical composition. The material must be tough, compact, and fine-grained. In the case of nephrite, it must also consist of interlocking fibers. If the fibers are not interlocking, but simply parallel or subparallel, the material lacks the necessary toughness and therefore cannot be considered nephrite. This author defines jade as any member of the pyroxene or amphibole group that possesses the necessary textural characteristics to impart toughness, as well as the commonly accepted refractive index and specific gravity of jadeite or nephrite.

Note how different this late-19th century jadeite vase is from the jadeite illustrated in figure 1. This difference in appearance reflects variations in chemical make-up. Such variations in materials classified both mineralogically and gemologically as jadeite contribute greatly to the nomenclature problem. Vase courtesy of Crystalite Corp. Photo ©1981 Harold & Erica Van Pelt.

TABLE 1. Common trade names for green jade.

Type of jade	Trade name	Standard color/appearance
Jadeite	Apple	Intense, medium yellowish green.
	Chicken or Tomb	Iron oxidized causing a yellowish or brown color.
	Emerald Gem Imperial	Intense, medium green resembling fine emerald. Considered by most to be top quality.
	Kingfisher (Chinese word, *fei-ts'ui*)	Intense, medium green. The Chinese named the material after the brilliant green plumage of the bird by the same name.
	Moss in the Snow	White jadeite with green streaks that are called streamers.
	Yunan or Yunnan	Intense, medium green, nearly opaque. When cut in thin sections, it appears translucent.
Nephrite	Axe[a]	In reference to the use of jade as a tool.
	B.C. jade Canadian	Dark green to blackish green.
	Kidney[a]	In reference to the belief that jade would cure kidney trouble if worn.
	Maori stone	Dark green material from New Zealand, often carved into items of adornment; mainly prehistoric.
	New Zealand New Zealand greenstone Spinach jade	Medium to dark grayish green.
	Siberian	Medium green, fine quality.
	Taiwanese	Medium green, fine quality.

[a]*This name is now obsolete.*

TABLE 2. Misleading terms for jade simulants.

Simulant	Misleading term
Calcite	Oriental alabaster (trade name)
dyed	"Mexican jade"
Chalcedony	
Chrysoprase	"Queensland jade"
dyed jasper	"Swiss jade"
Jasper	"Jasper jade" "Oregon jade"
Glass (partially devitrified) also known as Imori or limori stone	"Metajade"
Idocrase	"Vesuvianite jade"
Californite	"American jade" "California jade"
Malachite	"Silver Peak jadeite"
Microcline, amazonite	"Amazon jade" "Colorado jade"
Pectolite	"Alaska jade" "Pectolite jade"
Prehnite	"Japanese jade"
Pseudophite	"Styrian jade"
Quartz	
Aventurine	"Regal jade" "Indian jade" "Imperial yu"
Serpentine (Antigorite)	"Korean jade"
Bowenite	"Soochow jade" (may also refer to talc) "New jade"
Verd-antique (mixed with marble)	Verdite (trade name)
Talc	"Fukien jade"
also known as steatite or "soapstone"	"Honan jade" "Manchurian jade" "Shanghai jade"
TI grossularite	"Transvaal jade" "South African jade" "Garnet jade" "White jade"

two forms of jade from their 10 most common simulants (see table 3 for a list of other materials occasionally used to simulate jade). For the purposes of this article, jadeite and nephrite will be cited individually when appropriate and together under the term *jade* when the discussion applies to both.

THE IDENTIFICATION OF GREEN JADE

With practice and an understanding of the techniques involved, jadeite and nephrite can be readily separated both from each other and from their simulants. The best method is first to look at the material, since your eyes can reveal a great deal about a gemstone's composition and properties, and then to perform those gemological tests that will effectively lead to an identification.

Visual examination of a jade-appearing material may yield significant identifying clues such as texture, surface luster, and fracture, as well as characteristic inclusions, evidence of dye, the presence of phenomena, and possibly other distinguishing characteristics. All these visual characteristics contribute to the typical appearance of

a gemstone, thus allowing the gemologist with a well-trained eye to limit the range of possibilities quickly after an initial examination of the material.

But even experts support the suppositions they make after a visual examination with standard gemological tests. The two tests that provide the most diagnostic results are those that use the refractometer and the spectroscope. Specific gravity determinations and hardness points may also provide useful supplemental data.

The rare cases that require additional instrumentation usually involve mixtures of materials or materials that contain impurities. If green jade and its simulants mix with other minerals such that their appearance and properties deviate noticeably from normal, an identification often can be obtained by X-ray diffraction.

The recommended approach to the identification of jade is summarized in the property chart. After jadeite and nephrite, the 10 most problematic green jade simulants are listed from top to bottom in order of descending refractive index. From left to right, the properties are arranged according to the steps to be followed in the suggested approach; that is, visual characteristics are listed first, followed by properties that are determined by standard gemological tests. Distinctive absorption patterns are illustrated separately, in the section on spectroscopy.

TABLE 3. Other jade simulants.

Aragonite (may be dyed)
Agalmatolite (pagodite), also known as pagoda stone
Beryl, green nontransparent
Fluorite
Malachite
Maw-sit-sit (mixture of ureyite and natrolite, and possibly albite)
Microcline, amazonite
Opal, prase
Pinite
Pectolite
Plastic
Pseudophite (chlorite group)
Pyrophyllite
Serpentine mixed with zoisite
Sillimanite (fibrolite)
Smaragdite (near actinolite in composition)
Smithsonite, also known as bonamite

VISUAL CHARACTERISTICS

To a discerning eye, jade is different in appearance from its simulants. The ancient Chinese philosopher Confucius (551–479 B.C.) recognized the unique visual traits of jade when he likened them to worldly virtues:

> Its polish and brilliancy represent the white of purity, its perfect compactness and extreme hardness represent the sureness of intelligence; its angles, which do not cut, although they seem sharp, represent justice; the pure and prolonged sound which it gives forth when one strikes it represents music. Its color represents loyalty; its interior flaws, always showing themselves through the transparency, call to mind sincerity; its iridescent brightness represents heaven. . . .

The alluring appearance of fine jade is created by certain optical and physical properties, some of which can be detected by an experienced eye. The visual factors that contribute to jade's unique appearance are the stone's texture, surface luster, fracture surface, inclusions, and distinctive surface features. While the net visual effect is not enough to identify the gem material conclusively, it renders clues that are invaluable in the identification process.

Texture. This relates to the "perfect compactness" of jade noted by Confucius. It is that quality of jade which makes it the toughest of gem materials. The toughness of a gem material is not the same as its hardness: toughness is the resistance to breaking, chipping, or cracking, while hardness is the resistance to scratching or abrading.

Toughness helps to explain why, when a major earthquake struck Southern California recently and shook various art objects off the shelves of a store in Santa Barbara, most of the jade pieces did not break (GIA, 1980). Jade is not an extremely hard material: jadeite is listed as 6½–7 on the Mohs scale of hardness and nephrite as 6–6½. The toughness of jade, however, is unsurpassed, and of the two jades, nephrite is somewhat tougher. Prehistoric peoples recognized this attribute of nephrite as evidenced by its use in early tools and functional implements.

The toughness of a material is related to its internal structure, which is different for nephrite and jadeite. The internal structure, in turn, is often reflected in the texture of the stone. Thus, by looking at texture, the difference between jadeite and nephrite—and between these stones and their simulants—may become apparent.

PROPERTY CHART: GREEN JADE AND SIMULANTS

Gem Material	Visual Characteristics: Texture	Surface Luster	Fracture Surface	Inclusions/Dye	Other Distinguishing Features	Gemological Properties: Refractive Index	Specific Gravity	Hardness
Jadeite	Interlocking granular structure	Vitreous-greasy	Granular, possibly splintery	May be dyed	Grainy, or dimpled surface; color mottling	1.660–1.680[a] + 0.10[b] Spot: 1.66	3.34 +0.11[b]	6½–7
Nephrite (Actinolite/tremolite)	Interwoven fibrous structure	Greasy-vitreous	Splintery, possibly granular	May have black inclusions (chromite, diopside), may show brown iron oxidation; rarely dyed	Chatoyancy	1.606–1.632[a] Spot: 1.61–1.62	2.95 ± 0.05	6–6½
TI Grossularite	Not apparent	Vitreous	Conchoidal	Usually dotted with black inclusions (magnetite, chromite)		1.720–1.730[c] Spot: 1.72	3.47 + 0.03 − 0.32[c]	7
Idocrase Californite	Not apparent	Vitreous, possibly resinous	Uneven to subconchoidal			1.713–1.718[a] Spot: 1.71	3.40 ± 0.10	6½
Zoisite Saussurite	May appear somewhat fibrous	Vitreous	Uneven to subconchoidal		Often variegated colors	1.691–1.704[a] Spot: 1.68–1.71 (1.52–1.57)[d]	2.95–3.40 2.60–2.75[d]	6½–7
Prehnite		Vitreous-waxy	Uneven to conchoidal		Usually pale yellowish green	1.616–1.649[a] Spot: 1.63 Bire blink: 0.020–0.033	2.88 ± 0.06	6–6½
Serpentine (Antigorite) Bowenite	May appear somewhat fibrous	Subresinous, greasy, pearly, resinous, waxy	Splintery to conchoidal	May have black, chromite inclusions, may be dyed	Color mottling may be present	1.560–1.570 (−0.07)[a] Spot: 1.56	2.57 ± 0.06	2½–4 5–6
Talc Steatite or "Soapstone"	May appear somewhat fibrous	Pearly-greasy	Uneven	May be dyed	Soapy feeling	1.540–1.590[a] Spot: 1.55	2.75 + 0.05 − 0.20	1–2½
Quartz Aventurine Dyed	Appears crystalline	Vitreous	Conchoidal	Chromium mica platelets (fuchsite) May have dye in fractures	Aventurescence	1.544–1.553[a] Spot: 1.54, 1.55	2.66 ± 0.01	7
Chalcedony Chrysoprase	Not apparent	Vitreous-greasy	Conchoidal	May be dyed	Even color	1.535–1.539[a] Spot: 1.53	2.60 ± 0.05	7
"Metajade" Glass	Not apparent	Vitreous	Uneven to splintery to conchoidal	Fern-like structure, gas bubbles	Warm to touch	1.510	2.65	5½–6
Calcite	Appears crystalline	Vitreous	Uneven to splintery	May be dyed	Cleavage may be noted (3 distinct directions)	1.486–1.658[a] Bire blink: 0.172	2.70 ± 0.01	3

[a] *Doubly refractive.*
[b] *Increase due to diopside and acmite impurities, e.g., chloromelanite.*
[c] *Hydrogrossular as low as 1.690.*
[d] *Two different readings possible.*

Figure 2. A thin section of jadeite shows many interlocking granular crystals. Magnified 100×. Photograph courtesy of the Smithsonian Institution, NMNH 94303.

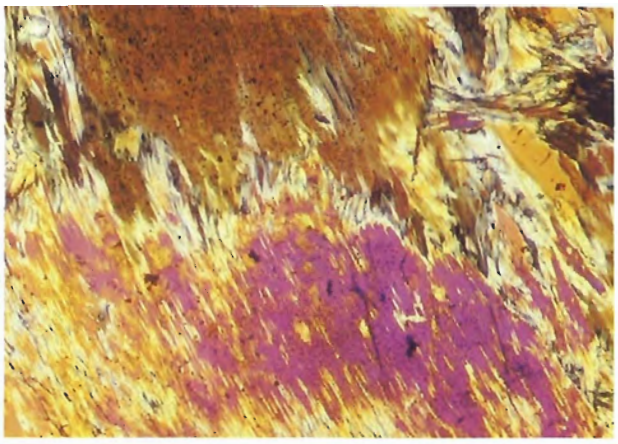


Figure 3. A thin section of nephrite shows interwoven, fibrous crystals. Magnified 100×. Photograph courtesy of the Smithsonian Institution, NMNH R6775.

Jadeite and nephrite are aggregates; that is, they are made up of a number of individual crystals. Aggregates are usually distinguished by the size of the individual crystals, but in the case of jadeite and nephrite it is the nature of the individual components that is distinctive. Magnification of a thin section from each of the materials provides a dramatic comparison: in jadeite (figure 2), the crystals appear as separate entities even though they are intergrown; whereas in nephrite (figure 3), the crystals take on a rope-like, fibrous appearance and seem to be inextricably woven together. This difference in structure is reflected in the visual appearance of the two materials: jadeite normally looks granular while nephrite looks fibrous.

None of the jade simulants has the tightly bound structure of either jadeite or nephrite, although aventurine quartz and calcite often appear to have the same degree of crystallinity as jadeite. None of the common jade simulants possesses a texture similar to that of nephrite; nephrite's interwoven structure qualifies it for a unique rating of exceptional toughness. Of all the jade simulants, saussurite, talc (also called steatite), and a few types of serpentine may appear fibrous.

Surface Luster. When Confucius notes that jade's "polish and brilliancy represent the whole of its purity," he touches on the significance of the stone's surface appearance, especially its ability to take a high polish. Luster is the appearance of a material's surface in reflected light, as determined by the quality and quantity of light reflected. For example, a beam of sunlight will show a much sharper reflection off a freshly waxed car than off a car in need of wax. In order to evaluate luster on a polished gemstone surface, simply note the sharpness of the image that the light source creates and the brightness of the area surrounding that image.

The refractive index of the stone and the quality of its surface (which is determined by the polish) are the two main factors that affect how much light is reflected. Texture may also affect luster. In the case of jade, it is almost impossible to achieve an optically flat, planar surface upon polishing because the random orientation of minute crystals causes undercutting during the sanding operation. As a result, the quality of light reflected from the surface is affected, so that the surface of most polished jadeite and nephrite has a slightly "greasy" luster. Because of its structure, polished dark-green nephrite usually has a greasier appearance than jadeite. Even the best-polished nephrite often looks as though someone left fingerprints on it, or smudged its shine. As evidenced in figure 4, the reflection of the light source is dim, and the area surrounding the reflection is blurry.

The luster of a gemstone often varies from one sample to the next, and there are no sharp divisions between types of luster. Yet, the jade simulants can be grouped into basic luster categories. Aventurine quartz, glass, and calcite are, like some jadeite, usually vitreous (the most common type of luster on transparent gemstones, like the surface of most window glass in reflected light; see figure 5). These materials reflect much of the light off their surfaces.

Figure 4. Nephrite usually exhibits a greasy surface luster.

The surface luster of grossularite, chalcedony (cryptocrystalline quartz), saussurite, idocrase, prehnite, and serpentine may range from vitreous to greasy, but usually it lies somewhere in between. Talc generally has the poorest luster of all. At best it is greasy; but because of talc's extreme softness and inability to take a good polish, it is usually waxy or pearly.

Fracture Surface. A break in any direction other than along a cleavage plane is called a fracture, and the surface of that break differs in appearance depending on the nature of the material. Crystalline aggregates such as jadeite and nephrite may show the same type of fracture, but usually they differ. A granular fracture is characteristic of jadeite (figure 6). The surface of a granular fracture looks like that of a lump of sugar; that is, it shows the fine, individual crystals of the material.

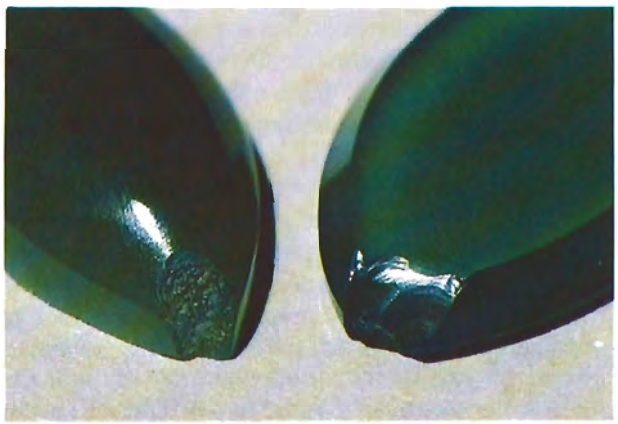
Jade, though, may also exhibit a splintery fracture, which looks like the surface of a broken piece of wood. The splintery, or fibrous, appearance of a fracture is most often seen on nephrite, reflecting its fibrous structure. A splintery fracture is characteristic not only of jade, but also of common jade substitutes such as serpentine, "metajade" glass, and calcite.

A conchoidal fracture may be as helpful as a granular fracture when separating jade from its substitutes. A conchoidal fracture has curved ridges similar to the outside markings on a shell (again, see figure 6). While a granular fracture may suggest jade, a conchoidal fracture usually suggests a jade simulant. As indicated in the property chart, many jade simulants show conchoidal fractures on a broken surface.

Figure 5. Jadeite usually exhibits a vitreous surface luster.

Several of the jade substitutes exhibit an uneven fracture surface, that is, a break that does not have any regular pattern although it often appears jagged. Because it is nondescript and may be seen in many of the jade simulants (and possibly jade), an uneven fracture is not as helpful in jade identification as a granular or a conchoidal fracture.

Figure 6. A granular fracture on a broken surface is often characteristic of jade (in this case nephrite, illustrated on the left). Many jade simulants (such as dyed chalcedony, illustrated here on the right) show a conchoidal fracture on a broken surface.



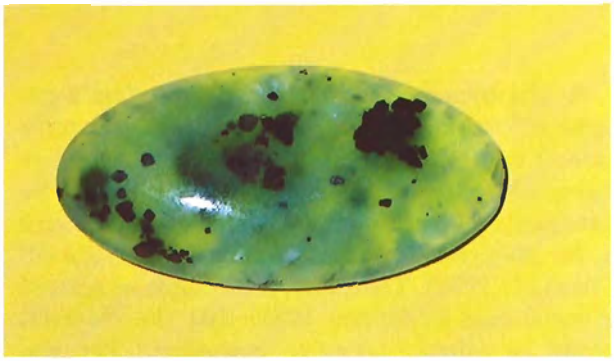


Figure 7. Black inclusions, such as the chromite in serpentine shown here, may suggest that the stone is a jade simulant.

Figure 9. "Metajade" glass often shows a fern-leaf pattern under magnification. Here, magnified 5×.

Inclusions/Dye. Jade and its substitutes often contain the same types of inclusions. When combined with the color and typical appearance of the stone, though, the inclusions may aid in the identification of the material. For example, grossularite and serpentine (figure 7), as well as nephrite, often contain black chromite inclusions. Yet, if the chromite inclusions are scattered throughout a medium bluish-green, semitranslucent to opaque material, the gemologist suspects grossularite (or hydrogrossular, i.e., grossularite with a high water content). The types of nephrite and serpentine that most often contain chromite are generally a darker green (Bergsten, 1964). Do not assume, however, that all black inclusions are chromite; often, they are magnetite or diopside.

Some inclusions in jade simulants can serve to identify the material. Round green platelets that are so densely packed that they give the gemstone color strongly suggest aventurine quartz. The platelets are fuchsite, a green chromium mica, and prove that the material is not jade. These disc-like inclusions, pictured in figure 8, can be detected with the unaided eye if the material is examined under good lighting.

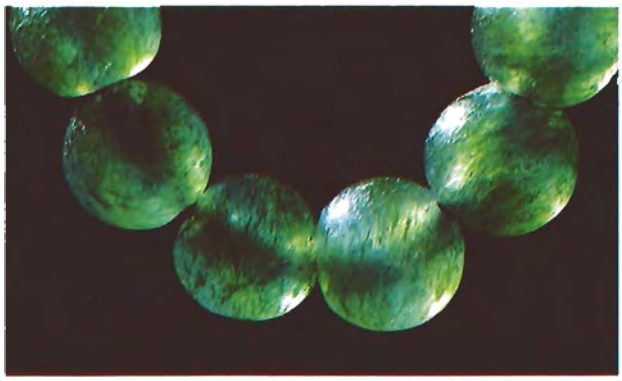
"Metajade" glass, also called Imori or Iimori stone, is an excellent imitation that is made by Iimori Laboratory in Japan. This material can be detected by its inclusions as well as by its other optical and physical properties. Because the material is partially crystallized, it exhibits a fern-leaf pattern that is easily seen under magnification, as illustrated in figure 9 (Crowningshield, 1973). Patterns such as these, which are the result of devitrification (the partial change from an amorphous to a crystalline structure), suggest glass. Gas bubbles may also be present.

Dyed green quartzite can also be mistaken for jadeite. Green dye hides the "non-gemmy" quality of this massive, metamorphosed sandstone, and may provide a believable jadeite color. The dye can be detected under magnification in the form of heavy concentrations of color in the breaks or fractures that usually occur throughout the stone (figure 10).

Green organic dyes have also been used to im-

Figure 8. Green chromium mica (fuchsite) inclusions, as shown in these 8-mm beads, suggest aventurine quartz.

Figure 10. Green dye is evident in the fractures, or cracks, of these 8-mm quartz beads.



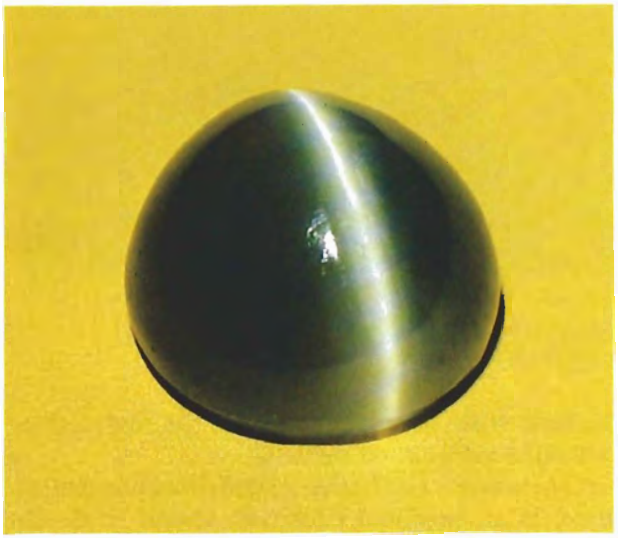


Figure 11. Actinolite, a major constituent of nephrite, often exhibits chatoyancy. Stone (9.4 × 5.9 mm) courtesy of Robert E. Kane.

part color to jadeite, serpentine, calcite, talc, and—in rare instances—nephrite (Liddicoat, 1965). The ease with which the dye is detected depends on the nature of the material and the dye used. In the case of jadeite, the granular structure of the stone may cause the uneven distribution of the dye and thus a heavier concentration in some areas. Concentrations of dye may be detected under the microscope, but the gemologist must be careful not to confuse this characteristic with the color mottling of untreated jadeite. Positive proof of green dye in jadeite and serpentine can be determined with the spectroscope, which will be discussed later. Magnification is usually sufficient to detect dye in calcite and talc.

Other Distinguishing Features. As previously noted under surface luster, the structure of jadeite may cause undercutting during the sanding process, which results in a grainy or dimpled surface appearance. This dimpled surface, the result of minute, randomly oriented crystals, is not found in the common jade simulants.

Phenomena, or unusual optical effects, may also help in the identification of a jadeite simulant. The fuchsite inclusions in aventurine quartz set up a glittery effect as the stone is turned in light. Aventurine quartz is the only jadeite simulant that exhibits this effect, known as aventurescence.

A chatoyant material known as "cat's-eye nephrite" surfaces occasionally in the jewelry trade. It belongs to the tremolite-actinolite series of amphiboles, of which nephrite is a variety. The chatoyancy is due "to the fibrous structure and to the preferred orientation of tremolite fibers" (Tan et al., 1978). Therefore, it has been suggested by some (see Anderson, 1980) that the material should be called "cat's-eye tremolite." Yet, the material is more apt to be actinolite than tremolite (figure 11). Using X-ray diffraction, Fryer confirmed that a sample of the cat's-eye nephrite was in fact cat's-eye actinolite (Crowningshield, 1972). In any event, either tremolite or actinolite cat's-eye is more appropriate than "cat's-eye nephrite," because the chatoyancy is due to the reflection of light off parallel fibers, and by definition nephrite consists of randomly oriented, interlocking fibers. Regardless of the nomenclature question, chatoyancy is important in identification because it is most common in the tremolite-actinolite series and is rarely seen in the jade simulants.

A true jade *aficionado* may develop a sense for the feel of jade. In an article on the "Art of Feeling Jade" (1961), it was stated that jade fishers of Khotan, who wade the rivers in search of jade, find it by the touch of the foot. Also, Chu Hsi, the last Empress Dowager of China, was said to have trained her fingers to recognize jade and some of its different quality grades. The family of Richard Gump, a renowned jade dealer, claim that he was able to identify jade by feel after losing his eyesight in later years. In addition, when jadeite was first introduced into China, the Chinese apparently knew "it wasn't the same (as nephrite) as soon as they handled it, it didn't feel the same" (Gump, 1962).

Identification of jade by feel is extremely difficult. In centuries past, there were not as many recognized jade simulants, or methods to distinguish jadeite from nephrite. The feel of jade, therefore, is best left as a questionable means of detection.

While we are on the subject of tactile sensations, it is interesting to note that glass and plastic are warm to the touch, while crystalline materials are cold. Thus, all jade and jade simulants other than glass and plastic should feel cold to the touch initially. Also, talc can be easily identified by its slippery, or soapy, feel. It is often called "soapstone" for this reason.

In short, a visual examination of a gem material can limit the field of possibilities. It can help to separate nephrite and jadeite. Gump (1962) attempts to pinpoint the difference in the appearance of most green nephrite and jadeite:

> For the brightness and clarity of jadeite's tones contrast sharply with the soapy, almost aged-looking hues of most pieces of nephrite. Jadeite comes closer to being, and sometimes is, translucent. In general, one might say that the colors of jadeite turn toward vividness and translucency, while the hues of nephrite are greasier, denser, and heavier.

Visual characteristics can provide some valuable indications to the identification of jadeite and nephrite, but they usually lead only to suppositions that should be backed by positive gemological tests. Several key tests in the separation of jadeite from nephrite and the two jade materials from their simulants are described below.

GEMOLOGICAL TESTS

Standard tests used to verify the identity of jade-appearing materials include refractive index readings, specific gravity determinations, and spectroscopic analysis. Less frequently, careful hardness tests are conducted. Sophisticated laboratories may also use X-ray diffraction to analyze jade-appearing specimens.

Refractive Index Readings. The refractometer is one of the most helpful instruments in the separation of jade from its simulants. Almost all of the jade simulants have refractive indices well above or below that of jadeite and nephrite. The only difficulty lies in using the refractometer on the surface that is usually accessible.

Normally, that is, with faceted gemstones, a flat facet of the stone in question is placed directly on the refractometer hemicylinder with a small amount of liquid. Since jadeite, nephrite, and their simulants are generally cut with rounded or curved surfaces, a "spot" or "distant vision method" must be used to read the refractive index. The spot technique requires that a portion of the curved surface be placed or held on the refractometer with a small drop of liquid, the size of which is reduced until the image that is seen without the eyepiece magnifier is only two or three scale increments. By reducing the stone's image to a very small spot, the gemologist can obtain a meaningful refractive index that should serve to separate jade from most of its simulants. (Note: in taking a spot reading, it is only possible to judge the refractive index accurately to the hundredths place, e.g., 1.66.)

Figure 12. Dyed calcite such as this may look like jadeite, and its refractive index may be confused with that of jadeite. The birefringence blink technique is suggested for this material.

Using the spot technique and a little ingenuity, one of the GIA lab experts was able to take a refractive index reading on a large jade carving. An associate held a light source to the refractometer porthole as the gemologist held the refractometer hemicylinder on the gemstone surface rather than the gemstone on the hemicylinder.

Jadeite and nephrite are easily separated from one another by their refractive indices. Although both are doubly refractive, it is rare to see the full spread of refractive indices listed on the property chart because both are crystalline aggregates. Also, only one refractive index is easily resolved with the spot technique. The refractive index obtained, however, is usually sufficient to distinguish the two materials, since jadeite's reading tends to be around 1.66 and nephrite's is around 1.61.

The jade simulants can be divided into three groups on the basis of refractive index: (1) those with refractive indices higher than that of jade, (2) those with refractive indices lower than that of jade, and (3) those with refractive indices that could be confused with jade (see figure 12).

Grossularite, idocrase, and saussurite have refractive indices that are usually higher than that of jadeite. Saussurite's refractive index (R.I.) may

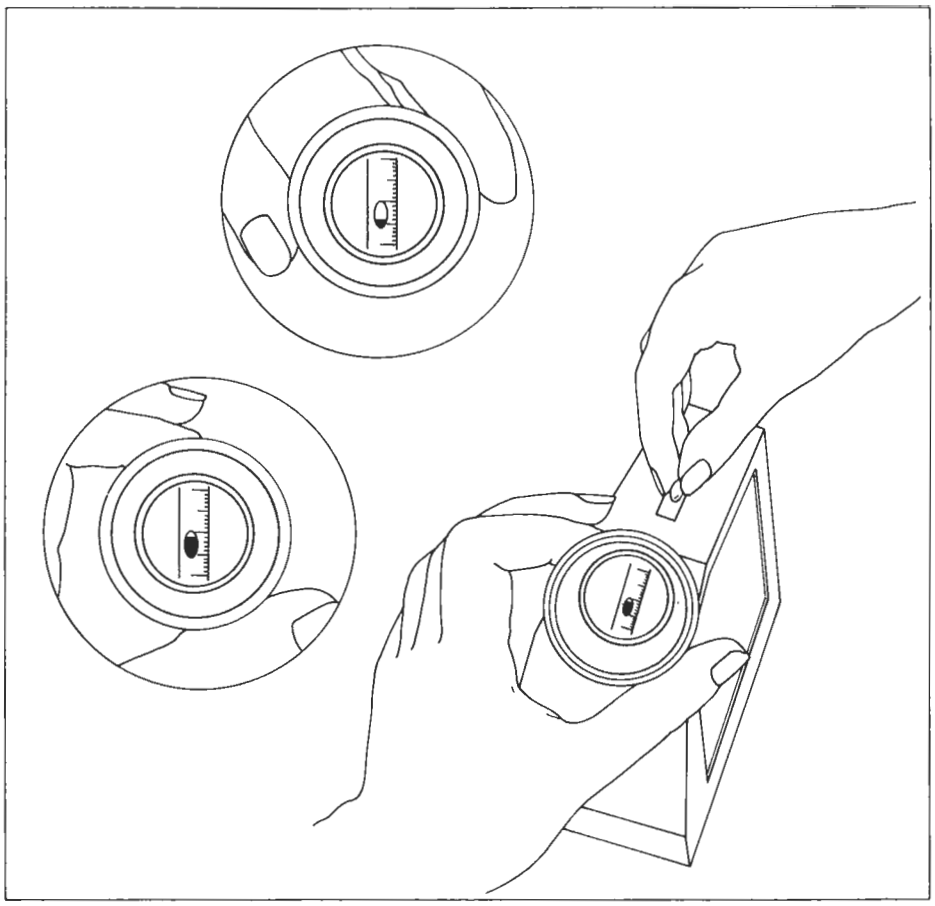


Figure 13. The birefringence blink technique involves rotating a polaroid plate in front of the refractometer (magnifier removed). If the stone is placed in the approximate direction of maximum birefringence, the R.I. shadow will jump within the spot image. Birefringence is estimated as the amount of movement seen. As illustrated in the two circular diagrams, prehnite will show a maximum birefringence of 0.030 as the polaroid plate is turned.

vary because it is a rock. If it mixes with feldspar or serpentine, its R.I. may be as low as 1.55; more often, saussurite shows a much higher R.I., around 1.68–1.70, due to the presence of idocrase or zoisite. Such a reading is too high for pure jadeite, but could indicate chloromelanite, which is a very dark green to almost opaque type of jadeite (again, see box). Saussurite can be separated from chloromelanite by spectroscopic analysis, X-ray diffraction, or possibly the presence in saussurite of two widely different refractive indices (which reflects the presence of different minerals).

Most jade simulants fall into the second category, that is, materials that have lower refractive indices than jadeite or nephrite. Quartz, chalcedony (cryptocrystalline quartz), serpentine, talc, and most types of glass or plastic used as simulants can be easily separated from jadeite with the use of the refractometer.

Using the regular spot refractive index technique, the gemologist might mistake calcite and prehnite for jade. Both of these materials can, however, be identified by employing the "birefringence blink" technique. Birefringence is a measurement of the difference between two refractive indices in a doubly refractive material. Although jadeite and nephrite are doubly refractive, they rarely show any birefringence; whereas prehnite may show a birefringence of 0.020 to 0.033, and calcite one of 0.172. The birefringence blink technique uses the standard spot-reading procedure, which requires white light and no magnification. A slightly larger amount of liquid may be needed. Rotate a polaroid plate in front of the refractometer eyepiece and note the extent to which the shadowed lines (which represent refractive index) jump inside the spot, or stone image (figure 13). Provided that the stone is lying in the direction of the greatest birefringence, there is a slight but noticeable shadow movement in prehnite, and in calcite shadows appear to leap between the different refractive indices and may even blink from red to green.

Specific Gravity Determinations. Specific gravity (S.G.) determinations are not as conclusive as refractive index readings because (1) many of the jade simulants have specific gravities close to

those of jadeite and nephrite, and (2) the measurements are not constant in most of the jade simulants because they often mix with other minerals. Specific gravity is defined as the ratio of the weight of a substance to the weight of an equal volume of water at 4°C. Specific gravity can be estimated by the use of heavy liquids, and precise measurements are obtained on a hydrostatic balance.

The specific gravity liquid that is most useful in separating jadeite from nephrite and from most other jade simulants is methylene iodide (3.32 liquid). When nephrite or most jade simulants are immersed just slightly under the surface of the liquid, they will bob to the top, while jadeite will remain suspended or sink very slowly to the bottom.

For large pieces, an accurate specific-gravity measurement can be obtained on a balance that has been adapted for hydrostatic measurements. The material is weighed first in air and then in water to determine the weight lost in water. The specific gravity is found by dividing the material's weight in air by the loss of weight in water.

On property charts, the specific gravity of jadeite is usually listed near 3.34, although it may vary depending on the presence of impurities. Chloromelanite may have a specific gravity as high as 3.45, and a rock-like form of jadeite that has a high albite content may be as low as 2.90 (Foshag, 1957). If we take this range into account, nephrite and three of the common jade simulants have S.G. values that could be confused with jadeite: grossularite, zoisite, and idocrase. However, all of these gemstones could be identified by their refractive index readings. All the other common jade simulants have S.G. values far lower than that of jadeite.

The specific gravity of nephrite usually ranges between 2.90 and 3.00. Nine of the 10 jade simulants discussed here have specific gravity values that are significantly different from nephrite: those of grossularite, zoisite, and idocrase are normally higher, and those of quartz, chalcedony, "metajade" glass, bowenite, talc, and calcite are normally lower. Only prehnite could be confused with nephrite on the basis of specific gravity, in which case the refractometer would make the distinction.

In short, specific gravity should be used as a supplemental test in the separation of jade from jade simulants. Jadeite, and many jade-like materials, may contain impurities that will cause the specific gravity to vary. Also, specific-gravity determinations can be helpful only if the results are noticeably higher or lower than that of jadeite or nephrite. Two other tests provide more consistent results: refractive index readings (as discussed above) will positively identify jadeite and nephrite, and spectroscopic analysis (as described below) can provide conclusive proof of jadeite.

Spectroscopic Analysis. The spectroscope may provide positive identification of jadeite, although it is not helpful with nephrite (which usually does not show absorption lines in the spectroscope). Jadeite and some of its simulants show absorption that correlates with the presence of certain coloring agents, so their absorption patterns are distinctive. For example, pure jadeite is white; the various colors in which jadeite appears are due to the presence of such impurities as iron, manganese, and/or chromium. Green jadeite owes its coloration primarily to chromium, even though some iron may also be present. The higher the chromium content in jadeite, the stronger and more distinct the absorption pattern is in the red part of the spectrum. Some of the jade simulants also have characteristic absorption patterns that, when used in conjunction with refractive index readings, definitely identify these materials (figure 14).

The spectroscope is helpful in that both cut and rough, as well as mounted or loose, materials can be tested. In order to assure accurate results, the maximum amount of light must be sent through the material, and the slit of the spectroscope must be adjusted correctly. Since jadeite and its simulants are normally translucent to opaque, the transmitted light that passes through the material may not be sufficient for the absorption pattern to be seen by the spectroscope. Reflected light will usually resolve the absorption lines on a more opaque material. When using reflected light, make sure that the spectroscope picks up the maximum amount of light reflected from the stone (figure 15).

To achieve optimum results, the slit of the spectroscope must be opened the correct amount. Specifically, the more light absorbed by the stone, the more the slit must be opened to pick up absorption lines. However, the slit should not be opened beyond the first point at which the absorption pattern is seen or else too much light

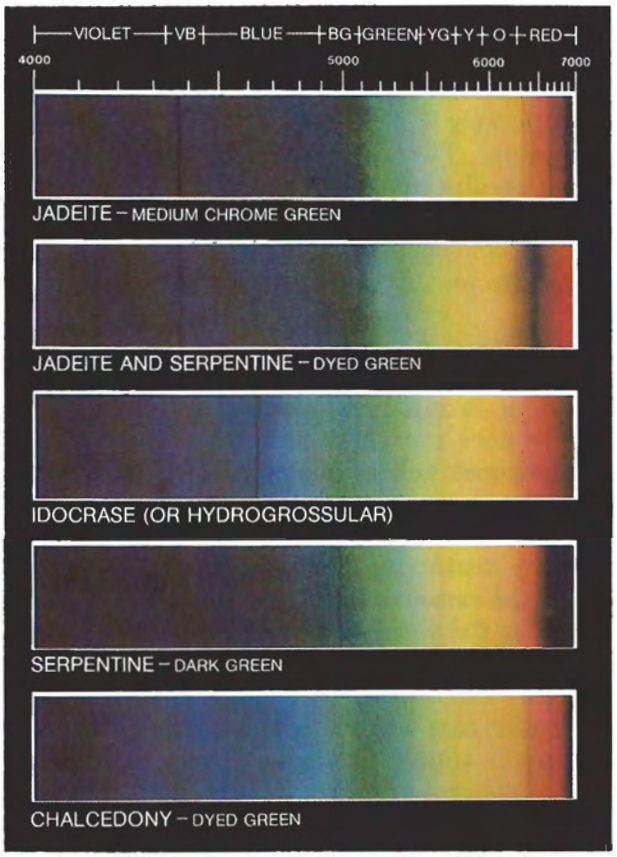


Figure 14. Green jadeite and some of its simulants have identifying absorption patterns. Water-color spectra by Misha Merrill.

will enter and the lines will not appear distinctly. Special attention must also be paid to the position of the drawtube to obtain proper color resolution (see the caption to figure 15).

Two color areas of the spectrum are particularly important to the identification of jadeite: the violet and the red. In the violet end of the spectrum, jadeite often shows a line around 4370 Å that appears in only one of its simulants (again, see figure 14). It is most easily seen in jadeite that is pale green; in darker green material, the line may be obscured by general absorption in the violet-blue area. If difficulties are encountered, Anderson (1980) suggests that a flask of copper sulphate be placed in front of the light source in order to eliminate the glare from the red and yellow sections of the spectrum. Prehnite is the only gemstone that may show an absorption line in the same area (4380 Å). Green jadeite, however, normally has additional lines in the red that prehnite does not have.

A band seen near 4640 Å in the blue area of the spectrum signifies idocrase (or hydrogrossular, which is a type of grossularite that grades into idocrase). Broad absorption in the violet-blue region that cuts off in the area between 4800 and 5200 Å indicates serpentine. Bowenite, the hardest variety of serpentine, may even show a line around 5000 Å (Liddicoat, 1981). If idocrase or zoisite is present in saussurite, this material may show a line around 4600 Å.

The red area of the spectroscope is also important in the identification of jadeite. Spectral absorption in the red may indicate dye in jade, serpentine, or chalcedony; may signal a triplet; or may indicate the presence of chromium, a primary coloring agent in some green gem materials.

Medium-green jadeite characteristically shows three distinct bands in the red, near 6300, 6600, and 6900 Å (Anderson, 1980). These bands usually have absorption shading in between them, and the shading darkens near 7000 Å. Lighter tones of green jadeite usually will not exhibit all three lines; instead, they will exhibit one or two lines (usually 6600 and 6900 Å) and dark shading near 7000 Å.

Dyed green chalcedony, and rare chrome-colored chalcedony, may exhibit somewhat similar narrow bands in the red, but there is no subtle shading between the bands as in jadeite. Refractive index will also suffice to separate these materials.

A piece of "metajade" glass was tested by the GIA Gem Trade Laboratory and found to have a spectrum "identical to that of a naturally colored green jadeite" (Liddicoat, 1975). Most pieces of "metajade" do not show this spectrum and are easily identified by their visual characteristics, refractive index, and specific gravity; the latter two values are considerably lower for "metajade" glass than for jadeite.

A broad band in the red, extending from approximately 6300 to 6700 Å, is proof of dye in green jadeite. The novice spectroscopist often cannot tell the difference between the broad dye band and the shaded bands of untreated jadeite. However, if the spectra are compared side by side, it is apparent that a light area exists between the high numeric edge of the dye band and 7000 Å. In an untreated piece of green jadeite, the immediate area near 7000 Å is quite dark.

The broad band in the red area also proves dye in serpentine, once the material has been identi-

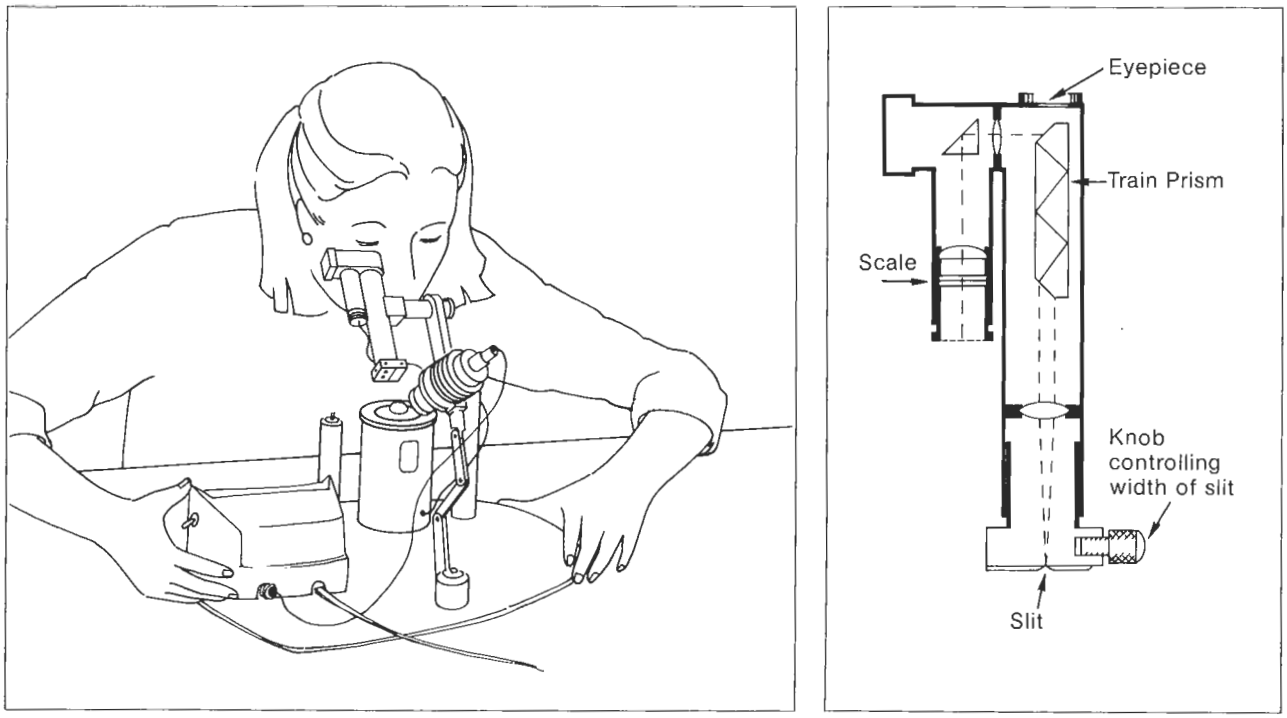


Figure 15. Reflected light is most often used to resolve absorption lines on translucent-to-opaque materials such as jade and its simulants. The spectroscope and light source should be positioned so that the maximum amount of light reflected from the specimen is seen by the spectroscope. The slit and drawtube of the spectroscope must then be adjusted properly in order to obtain the most distinct absorption lines. The slit should not be opened beyond the first point at which the absorption pattern is seen. When looking for absorption in the violet region, push the drawtube up until the lines are in focus; for absorption in the red region, pull the drawtube down until the lines are distinct. In general, follow the drawtube role, Blue (violet)–Up, Red–Down, perhaps best remembered by the acronym BURD.

fied by refractive index. The band appears in green jadeite triplets as well, because of the dye in the cement layer.

Many gem materials that are colored by chromium show absorption lines in the red area of the spectrum. Aventurine quartz may show lines in the red because of the presence of chrome mica. Even though aventurine's lines, near 6500 and 6800 Å, are close to that of jadeite, the overall absorption pattern is different. Like other jade simulants that show lines in the red, aventurine quartz can be verified by refractive index and specific gravity. Characteristic inclusions, as discussed above, are also helpful in the identification of this material.

In short, the spectroscope is a key test in the identification of jadeite. It can provide quick, positive proof of green jadeite, dyed green jadeite, and many green jade simulants if the spectroscope results are analyzed in conjunction with refractive index readings.

Hardness Tests. Hardness tests are rarely used in gemology because, if improperly done, they can easily mar or even break a gem material. Moreover, other gemological tests are just as quick and are usually more useful in identification. Although hardness tests should never be performed on transparent gemstones, the tests may have some application in the case of a translucent to opaque material such as jade.

Hardness is the ability of one material to scratch another. The hardness of gem materials is rated from 1 to 10 on a scale developed by Mohs (it is a relative scale in that the numbers do not represent equal increments of hardness). A set of hardness points is most commonly used for this test. Each of the small metal tubes in the set usually holds a piece of a mineral of known hardness that has been ground to a point and centered into one end of the tube. Common minerals include diamond, synthetic corundum, topaz, quartz, and feldspar.

The material should be observed under the microscope while a hardness point is drawn firmly across an extremely small, inconspicuous area. Then, the test surface should be wiped and examined to see whether the point has powdered itself or actually scratched the test surface. Always start with a low hardness point and then try increasingly harder points until a scratch is made.

Jadeite cannot be separated from nephrite using this test because their relative hardness values are too close. Hardness tests would only help separate materials that have a hardness value that is significantly lower than jade, such as serpentine, calcite, and talc. The other common simulants are of the same hardness as, or slightly harder than, jade. Although most serpentine is between 2½ and 4 on the hardness scale, the variety bowenite may have a hardness value as high as 6. Because the hardness of jade is between 6 and 7, bowenite cannot be separated from jade on the basis of a hardness test.

Calcite has a hardness of 3 on the Mohs scale, which makes it easy to distinguish from jade. However, other gemological tests, such as for birefringence, are recommended in the identification of calcite.

Perhaps the best application of the hardness test lies with the identification of talc. Since talc has a hardness of 1–2½, even a fingernail (which has a hardness of 2½ or lower) will cut into it. Its low hardness may also be evidenced by a low luster and by surface scratches resulting from wear or contact with other materials.

When using hardness points to separate jadeite from its simulants, you should remember that many jade-like materials contain impurities that have hardness values different from the main mass. Therefore, it is advisable to avoid testing areas that differ in color or texture from the basic material.

In short, hardness tests will determine that a gem material is too soft to be jadeite. They will not identify the material, and the results help in the detection of only a few jade simulants.

X-ray Diffraction. The most precise test in jade identification involves X-ray diffraction by the powder method. Not only can this test identify most crystalline materials, but it can also detect variations in their mineralogical compositions. Unfortunately, X-ray diffraction is feasible only for sophisticated laboratories. It takes more time than other gemological procedures, requires costly equipment, and a skilled laboratory technician must set up the test and interpret the results.

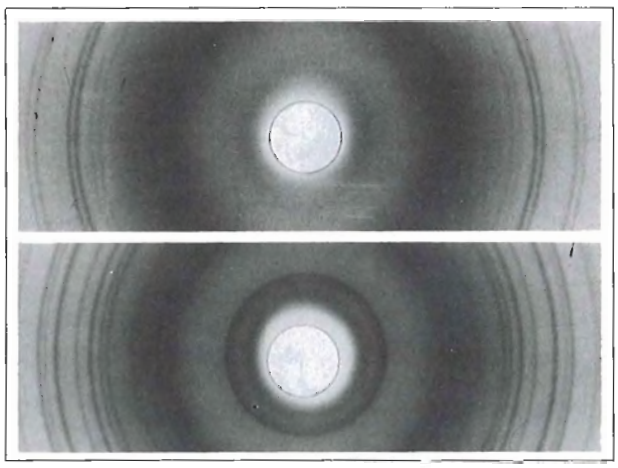


Figure 16. An X-ray diffraction pattern will identify jadeite from nephrite and both from their simulants. Top, jadeite; bottom, nephrite.

The powder method works best in gemstone analysis because only a small amount of material is required. Chuck Fryer (personal communication) has devised a technique in which a very minute scraping from the girdle is sufficient for the test. The crystalline particles can be picked up and cemented to a very fine glass spindle. The spindle is mounted in the center of a cylindrical camera that has a small hole that will allow X-rays to pass through to the material. A filmstrip fits snugly around the inside wall, and when X-rays strike the material, the atomic planes of that material show up by reflection of the X-rays as a certain diffraction pattern that is recorded on the filmstrip (figure 16). The diffraction pattern on the filmstrip appears as curved lines, the spacing and intensity of which are characteristic for the specific crystalline substance (Hurlbut and Switzer, 1979). By applying mathematical formulas, or by comparing the filmstrip patterns against standard patterns of known materials, most gem materials can be positively identified. This is true for jade and jade simulants as well as for any other single-crystal mineral.

CONCLUSION

Much of the enigma surrounding the identification of jade is based on the long-time propagation of misnomers, misinformation, and tenuous no-

menclature. This confusion can be greatly reduced if the correct information is circulated among buyers and sellers alike.

Visual characteristics provide the first indication that a gem material may or may not be jade. The granular texture of jadeite and the fibrous texture of nephrite are often distinctive, just as the surface luster of these materials may be. A granular fracture, too, indicates a crystalline aggregate such as jadeite. Certain other features, such as a dimpled surface, may also suggest the unique structure of jadeite.

Since visual characteristics are rarely sufficient proof, assumptions made from visual inspection need to be supported by appropriate gemological tests. Refractive index readings and absorption spectra lines provide the most accurate information. Specific gravity measurements and hardness tests should be considered as supplemental data. If any problems arise in the testing of jadeite, nephrite, or any of the jade simulants, the material can be sent to a laboratory for X-ray diffraction analysis.

Thus, the identification of jade requires an awareness of its appearance, skill in instrumentation, and sound deductive reasoning. The nomenclature may change in the future as these minerals are more clearly defined and separated, but good gem identification skills will always be needed to separate jade from its simulants.

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JADE FORMS FROM ANCIENT CHINA

By Evelyn Tucker

The attraction of jade is two-fold: the nature of the material and the way it is used. The color, texture, and feel of jade are easily appreciated, but the symbolism of the motifs in which it is carved is an enigma to many of the stone's admirers. This article briefly examines some of the symbols used in jade carved in China, including an introduction to the religions on which much of this symbolism is based. By mastering these basic symbols and the philosophy behind them, collector and seller alike can gain greater understanding of the cultural and philosophical meaning of the art involved in a particular piece.

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Jade has delighted the senses since it was first discovered. Like the early admirers of jade, today's collector is initially attracted to the appearance and feel of the stone; he is drawn to its color and texture, its smoothness and soft appearance. Soon, however, this attraction broadens into an interest in the material itself, in its history and uses.

Anthropologists and historians hypothesize that early people valued jade because they could, though slowly and laboriously, shape it into implements that were stronger and more durable than anything man had before he learned to forge metals (Hansford, 1968). Of all the stones that can be worked to suit the needs of man, jade is the most intractable. The same toughness that made jade implements so durable also made them difficult to fashion. As a result, early people simply ground their jade into convenient shapes. Later artisans maintained this tradition by following the contours of jade pebbles and boulders even when carving articles of great intricacy and sophistication (figure 1).

Although it is by no means common, jade is found in a number of areas of the world (most notably North and South America and Asia), and has been used and valued by a number of civilizations. The Chinese, however, perfected jade carving to a level unmatched by any other culture. Jade has played an integral role in their traditions since the beginning of recorded history (Whitlock and Ehrmann, 1949). No other gemstone is as closely tied to a major culture, as intricately interwoven with an aesthetic tradition. Although many people have wondered why jade so captivated the Chinese, no one has ever conclusively resolved this question. Perhaps part of the answer is that jade is well suited to the philosophies and religions of China; it seems to fit the Chinese cultural temperament.

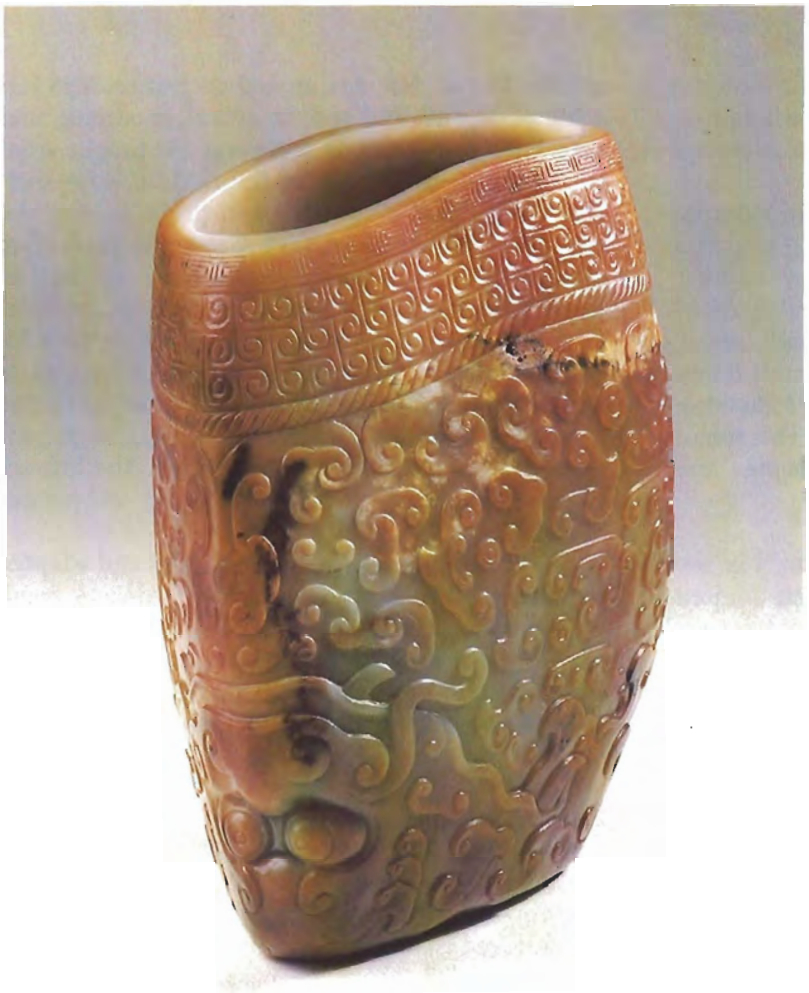

Figure 1. In planning and executing this piece, the artist used the outer "rind" and original contours of the water-worn pebble to produce a work of subtlety and sophistication. Jades seldom have dates on them, but this one has an inscription crediting it with "having spent a thousand autumns in the Khotan river," which is followed by the date 1785 A.D., the imperial signature, and one of Emperor Chien-lung's seals (d'Argencé, 1972). Nephrite, Ch'ing dynasty (18th century A.D.), Chien-lung period, H. 5½ in. Courtesy of the Asian Art Museum of San Francisco, The Avery Brundage Collection.

THE PHILOSOPHICAL AND RELIGIOUS FOUNDATIONS OF CHINESE ART

Chinese philosophy, religion, and art are so closely interwoven that an appreciation of Chinese art requires at least a cursory examination of the philosophy and religions of this nation.

This survey covers only the three major religious and philosophical movements of ancient China. It is understood that any attempt to condense the art of a culture as ancient and sophisticated as that of China in a short essay only illustrates Western man's ethnocentricity. This overview, however, provides a few brush strokes of background for the discussion of motifs used in jade carvings from China.

The World View of Eastern Thought. Comparisons reveal that art from the Eastern hemisphere differs greatly from art of the Western hemisphere. Differences in religion and symbolism come to mind, yet there is a more subtle and pervasive difference frequently overlooked or unappreciated by the Western intellect: in the culture, art, and philosophy of the West, man is at the center; in the East, man is one small part of a much greater whole.

Early Western man viewed the world from his perspective only: the earth was flat and the center of the universe. He even modeled his gods after himself. In his self-importance, he saw nature as his adversary and constantly sought to conquer it through brute force and strength of will.

The oriental approach is exactly the opposite. Especially in China, with its long history of Taoist teachings (as discussed below), man sought to em-

ulate nature by observing its ways and following its example. As a result, no other culture is as successful in capturing the spirit of nature in its art (figure 2).

And what was man's place in the oriental scheme of things? Richard Gump (1962) suggests that you can answer this question by looking closely at a Chinese painting: "Where is man? There, that tiny figure sitting on that small bridge, in the midst of that vast landscape which represents the universe." This world view is incorporated in some way into all three of the major religions of China: Taoism, Buddhism, and Confucianism.

Taoism. Taoism (pronounced *"dow-ism"*) is the oldest extant religion in China. It is an ancient form of nature worship. *Tao* in Chinese means "the way," "the road." Taoism is a way of intuition, of creativity, of searching for harmony with the forces of nature. Its most famous teacher, Lao Tzu, is thought to have lived about 500 years before Christ. The *Tao te Ching*, a book of enigmatic poetry still studied by Taoist scholars today, is attributed to him.

With time, Taoism developed in a new direction. The older nature deities were overshadowed by a host of new divinities—spirits, ghosts, demons, and immortals—some of them borrowed from the new faith, Buddhism. All were eventually incorporated into a kind of folk religion tinged with magic.

Taoism was a primary force in the development of art in China. On one level, craftsmen and artists, using materials provided by nature, were often more successful working through intuition and experience rather than through rational analysis. On another level, scholars found their deepest insights in Taoist perceptions of nature and the nature of creativity. The search for an understanding of nature, and for a way of becoming part of the greater whole, a way of uniting with Tao, is the foundation of the Chinese artistic tradition.

Buddhism. Buddhism came to China from India at about the time of Christ. Initially it had little impact on Chinese culture, but by the second or third century A.D., it had reached its first peak of popularity. Buddhism has been a significant force in Chinese culture ever since (Willetts, 1958).

The historical Buddha was born in the sixth century B.C., probably in the region of India that is now Nepal. He was an Indian prince who left a life of wealth and ease to travel, meditate, and search for the causes of suffering. He taught what has come to be known as the middle way—neither the pursuit of desires and pleasure, nor the pursuit of pain and hardship. Gradually Buddhism evolved into a religion based on the premise that life is suffering which ends only in death, and that all life is caught up in an endless chain of reincarnation, traveling from birth through life, death, rebirth, and so on. This cycle continues until one reaches Nirvana, which has been described variously as the extinction of all desires, the knowledge of supreme reality, the state of perfect blessedness.

Over time Buddhism was adopted and adapted by the Chinese. And Buddhist subjects were wrought in a characteristically Chinese style. Thus we see Buddha, or any of a number of other Buddhist figures, in Chinese dress, adopting Chinese poses, and surrounded by Chinese landscapes.

Confucianism. Confucius, a Chinese scholar and teacher, was also born in the sixth century B.C. Although he was a contemporary of Lao Tzu, his teachings differed radically from those of Taoism. He believed that cultivated men, trained in ethics and aesthetics, were the best hope for a stable government. He taught that respect for one's elders, for the wisdom of early rulers, and for ritual observance would promote the welfare of humanity. These ancient Chinese teachings, which he and his disciples codified and collected into several volumes, have been a shaping force in Chinese culture for 2,500 years.

Confucius's tolerant, scholarly, well-mannered approach to life exercised a profound influence on Chinese art. His philosophy of the Golden Mean, developed in his work the *Chung Yung*, or *Doc-*

Figure 2. This carving is an outstanding example of the Chinese use of color and symbolism in jade. The peach is a symbol of immortality; the bats denote happiness; the butterflies, immortality; and the silkworm, industriousness. Jadeite, 19th century, 4⅞ in. by 4 in. Courtesy of the Crystalite Corporation. Photograph © 1981 Harold & Erica Van Pelt—Photographers, Los Angeles, CA.

Figure 3. Two t'ao t'iehs (monster masks) appear on the front of this covered urn. Both masks are split by the ridge running down the front of the piece. The upper mask is highly stylized, so that only the eyes are easily recognizable. The lower t'ao t'ieh is more conventional: its eyes, eyebrows, and flaring nostrils are clear. Nephrite, late 19th century, H. 13⅜ in. Courtesy of the Los Angeles County Museum of Natural History. Photograph by Tino Hammid, GIA Gem Media.

trine of the Mean, advocated a love of learning and knowledge so that one might become a "superior man." Moderation in everything was central to his philosophy. The Chinese artist followed the doctrine of the mean. The philosophy of neither too much nor too little led him to seek a perfect balance in his use of detail, proportions, textures, and colors.

Confucianism also affected Chinese art by fostering an appreciation of the culture's ancestral heritage. Because Confucius and his followers taught respect for one's elders, for tradition, and for the wisdom of the ancestors, many early artistic motifs were used long after their original meanings were lost. In some instances, these are among the most pervasive forms in Chinese art. The *t'ao t'ieh* is one such form.

T'AO T'IEH

Of all the emblems ever used in Chinese art, the most constant in form and most widely used is a compound, mask-like design known as the t'ao t'ieh (figure 3). It is both one of the oldest and one of the least understood of the ancient motifs (Nott, 1947).

We do know that Sung dynasty (960–1279 A.D.) art critics labeled this already ancient emblem the t'ao t'ieh, or "glutton," inferring that it was orginally meant as a symbol of greed or lust and used as a warning against these vices. Their theory, however, is no longer taken seriously as an explanation for the origin of the t'ao t'ieh. For one thing, it is inconceivable that the Chinese would have insulted their ancestors, their minor deities, or their guests at official banquets by

warning them against eating or drinking too much (Burling and Burling, 1953).

Described as a "gluttonous ogre with a fang projecting on each side," the mask might be a representation of "the all-devouring storm god of the Chinese, with a background of clouds" (Laufer, 1946). Laufer supports this theory with his observation that "the t'ao t'ieh always appears on a background of meanders emblematic of atmospheric phenomena. . . ." However, he also cites another expert (Hirth), who proposes that the early t'ao t'ieh was based on the features of the Tibetan mastiff. This is possible since the Chinese domesticated the dog in ancient times and held it in high esteem.

The t'ao t'ieh has also been identified as a dragon, but Pope-Hennessey (1923) points out that since the t'ao t'ieh and the dragon sometimes appear side by side on the same object, this explanation is unlikely. Instead, she suggests that the t'ao t'ieh was derived from the face of a tiger. This theory is more plausible than most, since the tiger is an ancient and ominous figure in Chinese art. It is also consistent with the appearance of the t'ao t'ieh and dragon on the same carving, since Chinese mythology has traditionally grouped the tiger and the dragon together. The tiger symbolizes the West and autumn; and the dragon, the East and spring. The winds were said to follow the tiger; and the rains, the dragon (Nott, 1947). It has also been suggested that the t'ao t'ieh is a diagram which ancient Chinese healers used when diagnosing and discussing pain with their patients (Nott, 1947).

Because of its antiquity, the t'ao t'ieh is probably Taoist in origin. Since it can be made up of any collection of natural forms grouped symmetrically to suggest a mask, it is perfectly suited to the Taoist perception of patterns within patterns in nature and the universe. As such, it is a wonderfully versatile decorative device whose long life stems, at least in part, from its ability to be modified and used in a variety of ways without becoming repetitious. It can be strong, bold, and dominant, or faintly and delicately suggested. Today, the t'ao t'ieh is used as an emblem of cultural origin, an elegant testimony to an ancient aesthetic heritage.

THE PI

Although much has been written, little is understood about the origin and meaning of the *pi* (pronounced "bee"), a flat, circular disk with a hole in the center. Early forms were plain and roughly finished. As the art of carving progressed, however, the pi was first covered with relief designs, and later carved as ornate, highly stylized sculpture (figure 4).

Undoubtedly Taoist in origin, the pi has been used in ritual worship since the beginning of recorded history. In writing about the pi, jade authorities have suggested that it stood for everything from a musical instrument to the flywheel of a drill (Willetts, 1958). The most popularly accepted interpretation, however, is that the pi represents heaven. *The Book of Rites* (Chou dynasty, 1122–256 B.C.) lists it as the first of the six ritual jades: "With a sky-blue pi, worship is paid to Heaven."

Gump proposes that the pi stands for, among other things, the sun disk, or the sun shining through the vault of heaven, or heaven itself. As he suggests, we have only to put ourselves in the place of the early Chinese looking up into the sky to understand this explanation. That the ancient graph for sun was written as ⊙ further corroborates this theory (Willetts, 1958). Whatever its origin, for thousands of years the pi has been used as a symbol of heaven and is so used today.

THE DRAGON

Created in ancient Babylonia, mankind's most pervasive mythical invention moved, both literally and figuratively, in opposite directions, toward the West to become a symbol of evil, and toward the East to become a symbol of beneficence. Today it is known the world over as the dragon (Leach and Fried, 1972).

Actually, as is the case with other ancient symbols, the true origin of the dragon is open to conjecture. That it is mankind's most common mythical animal, one that is found in almost all cultures, has produced endless rounds of speculation and little agreement among authorities. Perhaps it is a Jungian archetype, an element of the subconscious common to all men regardless of culture. Or perhaps, as suggested above, it had one birthplace in mythology and spread as travel and trade increased throughout the world. A combination of these two theories probably explains the dragon's pervasiveness. Even if it had one birthplace, the dragon myth could hardly have spread and taken hold unless it satisfied some basic need in the human psyche.

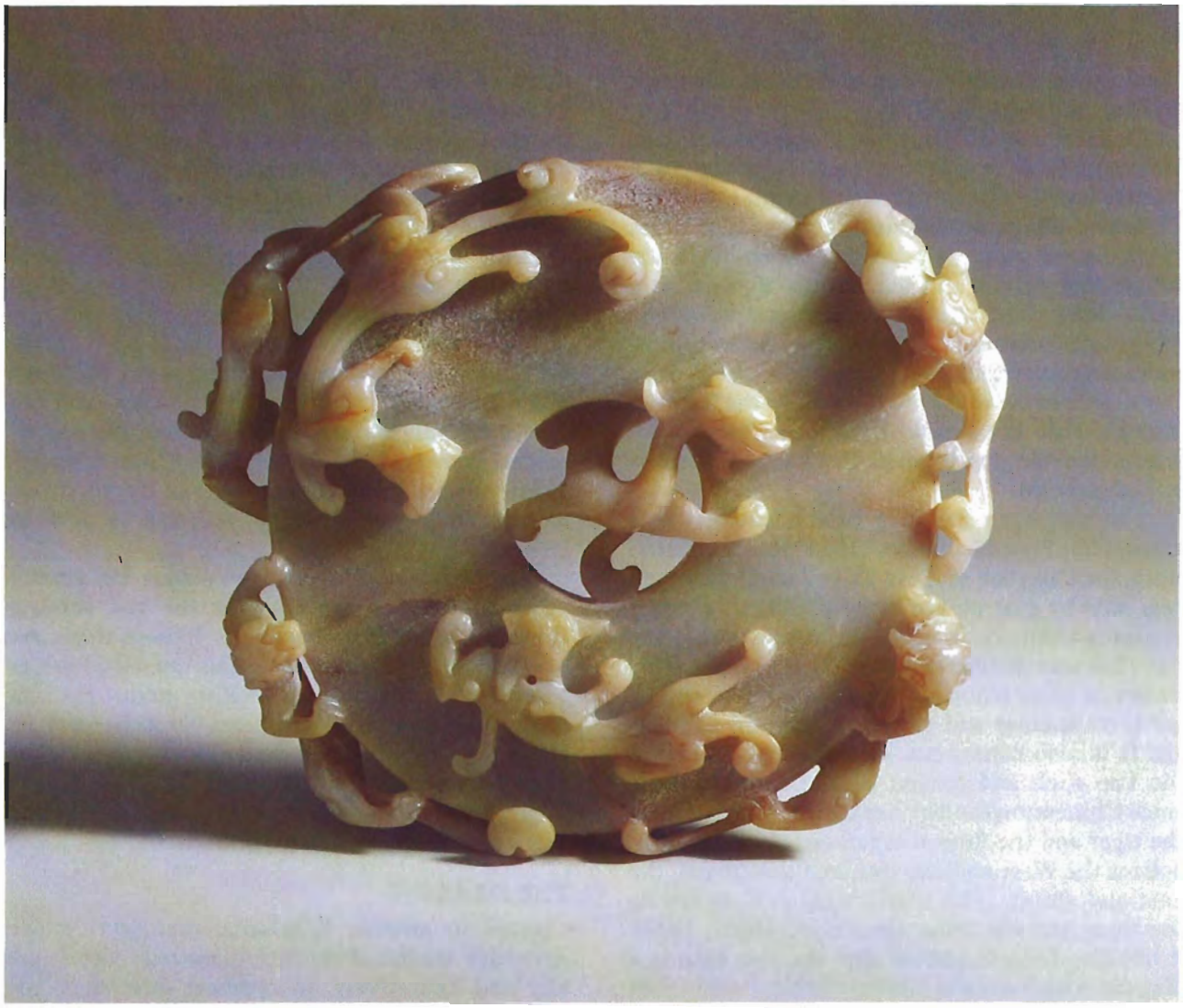

Figure 4. Nine lithe, almost cat-like, ch'ih dragons scamper around and through this pi. The lack of scales and claws, the sinewy body, and the playful stance characterize this type of dragon. Nephrite, late medieval or early Ming period (14th–16th century A.D.), Diam. 5½ in. Courtesy of the Asian Art Museum of San Francisco, The Avery Brundage Collection.

Less esoteric scholars remind us of the existence of prehistoric dinosaur bones and suggest that there is an obvious connection between early dragon myths and the discovery of the first of these bones (Leach and Fried, 1972). Such discoveries may or may not have produced the dragon myth, but they undoubtedly contributed to its proliferation.

In discussing the origin and development of the dragon myth in China, scholars frequently mention the snake worship of India, citing the Indian influence on Chinese culture, most notably the influx of Buddhism at about the time of Christ. According to Nott (1947), in Chinese translations of Buddhist writings the Indian term *naga* ("snake") is frequently rendered *lung* ("dragon"). However, the dragon existed before Buddhism came to China and probably before Buddhism began; thus, while snake worship might have influenced the development of the dragon myth, it is unlikely to have been its source.

There are many different kinds of dragons in Chinese mythology. All are benevolent creatures associated with nature and the elements. They control the wind and, more importantly, the rain that nourishes the crops.

The least fearsome are the chi'ih, or immature, dragons. These are usually portrayed as

Figure 5. A fire-breathing dragon is carved in high relief on this vessel. Jadeite, late 19th century (?), H. 5 in. Courtesy of the Crystalite Corporation. Photograph © 1981 Harold & Erica Van Pelt—Photographers.

clinging, lizard-like, or in some instances almost cat-like, reptiles with clawless feet and a split tail (again, see figure 4). The chi'ih dragon is particularly beneficial, said to have guardianship over mortals (Nott, 1947).

Water dragons are characterized by sinewy, fish-like bodies, also with long split tails. In Chinese mythology, they have dominion over the oceans and rivers (Nott, 1947). It has been suggested that the dragon was modeled after the alligator (Gump, 1962); the scales on the water dragon support this theory.

Regardless of its origin, the development of the dragon myth in China was remarkable. In no other culture do we find the profusion of types and styles of dragons (figure 5), and nowhere is the dragon as important as it is to the Chinese. Because this myth has existed for such a long time and is so closely associated with nature and the elements, the dragon of Chinese mythology is probably Taoist in origin.

THE FO DOG

Although in its conventional form it resembles a pekingese more than anything else, the dog of Fo is actually a Buddhist lion (figure 6). Since fo dogs (pronounced "foo," as in "food") came to China with Buddhism, they are not seen in Chinese art earlier than the Han dynasty (207 B.C.–220 A.D.).

In Buddhism, the lion is the defender of the law and the guardian of sacred buildings. Far from being intimidating, fo dogs are usually portrayed

Figure 6. Two elaborate antlered dragons hold loose rings on the side, and a fo dog snarls from the top of this incense burner. A low-relief free-form carving decorates the front. Nephrite, Date (?), H. 6-7/10 in. Courtesy Los Angeles County Museum of Natural History. Photograph by Tino Hammid, GIA Gem Media.

as small, playful lions and are frequently shown with a brocaded ball that represents the Jewel of the Law. In their capacity as guardians, they are often placed at the entrances of buildings or on the corners of roofs. Fo dogs may be standing or sitting, with their heads up or elegantly curved back, jaws open, and manes and brows represented by spirals.

JADE MOUNTAINS

The largest and most famous jade mountains were carved during the reign of Ch'ien-lung; who ruled China from 1736 to 1795. The empire was secure under Ch'ien-lung; trade flourished, the economy was strong, China was wealthy. Not only was Ch'ien-lung an able statesman and ruler, he was also a creative thinker and a patron of all artistic endeavors. His reign was an age of creative freedom and artistic accomplishment.

During the reign of Ch'ien-lung, jade carving reached "an apex of perfection and refinement never touched before or since" (Burwell, 1948), as figures 1 and 3 illustrate. In a field where agreement among authorities is conspicuously absent, all are unanimous that as a group Ch'ien-lung jades are the finest jade carvings ever produced. Consequently, there is a tendency to label all fine jade carvings as Ch'ien-lung even though they may have been produced before or after that period.

Jade mountains are mentioned in Chinese literature as early as the Yuan dynasty (1260–1368 A.D.). According to d'Argencé (1972), though, none has been dated with any certainty prior to the Ch'ing dynasty (1644–1912 A.D.).

Religious motifs predominate in jade carvings, and throughout most of China's history carvers freely chose the religious themes they used. As a result, different pieces from one workshop might be inspired by any of China's religions. Most jade

Figure 7. Although highly ornate, the trees and clouds on this jade mountain harmonize with the contours of the original stone and illustrate the oriental desire to emulate nature. The lone human figure symbolizes man's place in the overall scheme of the universe. Nephrite, date (?), W. 24 in. Courtesy of the Crystalite Corporation. Photograph © 1981 Harold & Erica Van Pelt—Photographers, Los Angeles, CA.

mountains are naturalistic renderings of scenes from Buddhism, Confucianism, or Taoism. The Taoist love of nature is, however, an underlying theme in all jade mountains regardless of their overt subject matter (figure 7). Jade mountains embody the Chinese respect for nature and the Taoist desire to seek refuge in the tranquility of the country.

THREE TAOIST SYMBOLS: THE BAT, THE BUTTERFLY, AND THE PEACH

The Taoist love of nature and the Chinese love of symbols combined to transform a number of unlikely animals and plants into auspicious emblems used in small carvings or as decorative motifs on larger pieces.

Figure 8. Five bats symbolize happiness and the five blessings: old age, health, wealth, love of virtue, and a natural death. The two larger and three smaller bats might also represent the family and a wish for domestic happiness. Nephrite, late Ming–early Ch'ing period (17th century A.D.), W. 4 in. Courtesy of the Asian Art Museum of San Francisco, The Avery Brundage Collection.

In most countries, the bat is maligned and unloved, but in China it is a symbol of happiness and long life. The Chinese are renowned punsters, and at times their puns have become well-established symbols and art motifs (d'Argencé, 1972). This is the case with the bat; its use to signify happiness was not derived from the natural characteristics of the little marauder but from the Chinese word for happiness, *fu-i,* which when pronounced with a slightly different emphasis denotes a bat. When depicted in groups of five, the bat symbolizes the five happinesses or blessings: old age, health, wealth, love of virtue, and a natural death (see figure 8 and refer back to figure 2).

The Chinese wedding ceremony includes the prescription that the bride and bridegroom each drink three cups of wine in succession (Nott, 1962). The vessels used in the ceremony are frequently decorated with such auspicious symbols as bats, butterflies, and peaches. In this instance, the bat is associated with matrimony; it is a common motif on wedding presents and symbolizes the wish for a long and happy marriage.

The butterfly is a symbol of immortality (again, see figure 2). In ancient times, jade butterflies were buried with the dead in the hope that the deceased would awaken to an afterlife in the same way that a butterfly emerges from its cocoon after a period of dormancy (Nott, 1962). Gradually the butterfly has evolved into a symbol of longevity. When used in pairs, butterflies symbolize happiness in marriage.

The peach, another symbol of immortality (figure 2), has origins that are even more obscure. According to early Taoist mythology, the peach was a talisman in the quest for everlasting life. Legend has it that Ho Hsien Ku, the only female of the eight Taoist immortals, ate one of the peaches of immortality and so achieved eternal bliss (Nott, 1962). Other religious figures are also frequently depicted holding or carrying peaches.

Unlike many other cultures, the Chinese were remarkably tolerant of religious differences. While there was religious persecution from time to time, for the most part the three dominant religions of China co-existed peacefully, even borrowing sym-

Figure 9. Small, slightly flattened peaches are frequently carved for use as pendants. They symbolize the wish for a long and happy life. Jadeite, Modern, H. 2 in. Photograph by Tino Hammid, GIA Gem Media.

bols from one another. For example, the Buddhist saint Kuan Yin is often depicted with the Taoist peach of immortality. Today, small, slightly flattened, almost heart-shaped peaches, carved singly or in bunches, are worn as pendants to symbolize the wish for a long and happy life (figure 9).

JADE CARVING TODAY

Jade carving is an ancient art. Not only were the Chinese carving jade before the fall of Troy (approximately 1184 B.C.), but they were also using some of the same motifs then that they use now. For example, some of the more comprehensive collections of early carvings contain examples of pi's, t'ao t'iehs, and dragons from the late Shang (1766–1122 B.C.) and early Chou (1122–256 B.C.) dynasties.

Today, in an age characterized by space travel, micro chips, and computers, the Chinese are still carving jade. A large community of hardstone carvers following the Chinese tradition flourishes in Hong Kong. Smaller carving centers are scattered throughout the Far East. In the United States, some individual carvers are making names for themselves on both the East and West Coasts. The People's Republic of China produces hardstone carvings both for export and for their domestic market. Recent reports indicate that they are attempting to further revitalize their carving industry by offering tax incentives and other inducements to Hong Kong carvers who set up shops and teach in mainland China (Don Kay, personal communication).

Modern tools and methods have changed the jade carver's art. Carvings that once would have taken years can now be finished in weeks or months. The great potential for jade carving lies in blending the old and the new. A skilled and artistic carver who combines contemporary tools with the artistic heritage developed in China over the last 4,000 years can create a work of art to rival any produced in the history of jade carving.

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SOME OBSERVATIONS ON THE TREATMENT OF LAVENDER JADEITE

By John I. Koivula

The separation of naturally colored lavender jadeite from color-treated material is a problem that has long plagued gemologists. One theory is that the dying agents being used are of an organic nature. If this is true, they should break down at elevated temperatures and lose their coloring ability. Naturally colored lavender jadeite, however, should retain its color and not bleach on heating. To investigate this theory, the author sawed 42 different specimens of lavender jadeite in half. One half of each specimen was heated while the other half was retained as a color control. Those stones that bleached on heating showed a strong orange fluorescence to long-wave ultraviolet radiation before heating and a moderate bluish-purple X-ray fluorescence both before and after heating. The control halves of those stones that retained their color when heated to as high as 1000°C fluoresced a very weak brownish red when exposed to long-wave ultraviolet radiation and a strong reddish purple to pink when exposed to X-ray radiation both before and after heating.

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The problem of detecting color treatment or enhancement in lavender jadeite has plagued gemology for many years. Gemological laboratories receive a regular stream of rings, pendants, bracelets, and the like from various trade sources who ask that they determine whether the color is natural or treated. Thus far, the laboratories have had to respond that there are no known tests to detect color treatment in some lavender jades, so that the precise nature of the coloration in the gems in question must remain a mystery.

To study color in lavender jadeite, the researcher must first establish whether the sample specimens are of treated or natural color. However, the lack of a method to separate treated from naturally colored lavender jadeite has made it virtually impossible to obtain the control subjects of known color origin that would be required to carry out an accurate study of the problem.

One theory voiced repeatedly in the trade is that the dye(s) being used to enhance the color are organic in nature, at least one suspect being blueberry juice. If we assume that this theory has some merit and we apply the knowledge that organic compounds will break down at temperatures as low as 200°C to 300°C, it should be possible to detect organic dye treatments simply by heating the subject. Although this would have to be considered a destructive test and, as such, could not be used as a routine gemological procedure, it might be an effective method of obtaining study specimens of known coloration and thus could aid the search for other, nondestructive, methods of identifying color treatment.

In fact, during the routine identification of lavender jadeite over a period of several years, the author noted that some gems fluoresced bright orange when exposed to long-wave ultraviolet radiation while others did not. Intrigued by this variation in the long-wave fluorescence, the author tested 42 small specimens of lavender jadeite

Figure 2. The two color types of lavender jadeite noted by the author. The color-treated stone is on the left (GIA collection no. 3654), and the "natural" type with stable color is on the right (GIA collection no. 528).

from various sources. Of the original 42 samples, 28 showed a strong orange fluorescence to long-wave ultraviolet radiation, while the remaining 14 showed only a very weak brownish-red reaction to the long-wave lamp. A careful microscopic examination of all the test subjects revealed the existence of an unidentified coloring agent that could be seen concentrated in some of the tiny surface fractures of those jadeites that glowed orange to long-wave ultraviolet radiation (figure 1), but not in any of the others. Heat treatment of these specimens offered the opportunity to confirm these observations regarding the identification of the treated material.

HEATING TO OBTAIN CONTROL SAMPLES

To establish both control and study groups, the 42 different samples of various shades and tones of lavender jadeite discussed above were sawed in half with a thin-bladed diamond trim saw. The saw was lubricated and cooled with distilled water rather than a cutting oil to avoid introducing any organic contaminants into the somewhat porous surfaces of the samples. The specimens were then washed in clean distilled water and allowed to dry at room temperature. They were subsequently sorted by color into two basic groups: (A) those that showed a pinkish-purple color, like the stone on the left in figure 2; and (B) those that showed a bluish-purple color, like the stone on the right in figure 2. Using a Blue M Electric Company Lab-Heat muffle furnace (manufactured in Blue Island, Illinois) with a temperature range of 0°C to 1000°C, the author heated one sawed half of each of the 42 test specimens individually (for a total of 42 heating sessions) and retained the other half at room temperature as a control sample.

Figure 1. Dye concentrated in the tiny surface cracks of color-treated lavender jadeite. Oblique illumination, magnified 45×.

The heating atmosphere was air, and the temperature for heating ranged from a low of 220°C to the furnace maximum of 1000°C. The heating time ran from 30 minutes to eight hours. (The variation in temperature and heating time resulted from initial efforts to determine the amount of time and heat required to bleach the dyed material.) All 28 of the jadeites in the pinkish-purple color group (figure 2, left) lost this color when subjected to temperatures ranging from 220°C to 400°C for 30 minutes. The color that remained was a pale brownish to grayish white. This heat-induced color change is vividly illustrated in figure 3, which shows a sliced cabochon with the control half on the left and the heated half on the right.

No color change was detected in the 14 subjects in bluish-purple color group B after heating. The shortest run for this group was four hours and

Figure 3. An example of heat bleaching. The unheated control half is on the left, and the heat-bleached half of the same stone is on the right (GIA collection no. 3661).

Figure 4. The strong orange long-wave fluorescence of a color-treated lavender jadeite (GIA collection no. 3654).

the longest was eight, at a miximum temperature of 1000°C. It was concluded that these stones had not been organically dyed. Once the subjects were divided by color and reaction to heat into the two basic groups, they were then subjected to the more useful and practical nondestructive gemological tests of ultraviolet and X-ray fluorescence.

ULTRAVIOLET FLUORESCENCE

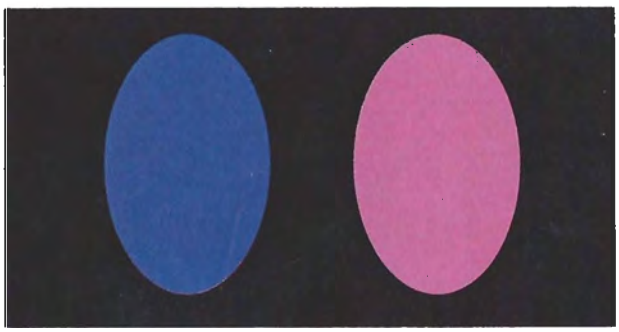
The 28 jadeites that had a pinkish-purple color before heating and lost their lavender color on heating showed a very interesting fluorescence to long-wave ultraviolet radiation. Before heating, the subjects exhibited a strong to very strong, bright orange fluorescence (figure 4). After heating, when the lavender color had been burned out, the strong orange fluorescence was gone as well, and the remaining fluorescence was a very weak brownish red. The short-wave fluorescence, both before and after heating, was a weak brownish orange to brownish red. The author studied the absorption spectrum of the strong orange long-wave fluorescence using a hand-held prism spectroscope, and found that only the yellow-green, yellow, orange, and red were passed, and all of the violet-blue and green were absorbed. The method used to examine the fluorescence spectrum for this study was rather crude. Perhaps if ultraviolet spectrophotometry were done, the points of absorption would be diagnostic of a particular organic dye.

Those 14 jadeites that showed a bluish-purple color initially and retained their color on heating showed a very weak brownish-red fluorescence to the long-wave and short-wave lamps both before and after heating.

X-RAY FLUORESCENCE

Using an X-ray fluorescence unit powered by 88 kilovolts, the author subjected all of the test specimens to X-rays both before and after heating. Those jadeites that bleached when exposed to the heat showed a moderate bluish-purple X-ray fluorescence both before and after heating (figure 5, left). The jadeites that retained their body color during heating showed a strong reddish purple to pink X-ray fluorescence (figure 5, right). In this

Figure 5. Artist's rendition of the X-ray fluorescence of the two types of lavender jadeite discussed here. On the left is the bluish purple of the heat-bleaching, treated stone. On the right is the "natural" type, showing a reddish-purple to pink fluorescence color.



case, the absorption spectrum of the reddish-purple to pink X-ray fluorescence color of the latter group was studied. This examination revealed a broad absorption band from 4900 Å to 5300 Å, a general overall haziness, and that the red was passed very strongly.

If the two types of lavender jadeite are placed side by side in the X-ray chamber, the difference in fluorescence is quite evident and the two stones can be easily separated. However, the small size of the circular X-ray fluorescence chamber well, which measures only 30 mm in diameter on its floor and 30 mm in depth, makes it virtually impossible to test large objects such as carvings by the X-ray fluorescence method.

CONCLUSION

Of the 42 specimens of lavender jadeite examined for this study, 28 bleached when exposed to heat in excess of 220°C for a maximum of 30 minutes. These same stones had a notable pinkish-purple color in their original state and fluoresced bright orange to long-wave ultraviolet radiation before they were exposed to the heat. All 28 stones also revealed dye in tiny cracks when examined under the microscope, and fluoresced a distinctive bluish purple when exposed to X-ray radiation.

In contrast, the remained 14 specimens did not bleach when heated to extreme temperatures (as high as 1000°C) and for as long as eight hours. In addition, these stones showed a bluish-purple color and a weak, brownish-red fluorescence to long-wave ultraviolet radiation both before and after exposure to heat. No dye was apparent when they were viewed under the microscope, and they fluoresced a distinctive reddish purple to pink in the X-ray unit. Although it is not feasible to heat every specimen to determine whether it is dyed, the results reported here suggest that a lavender jadeite that fluoresces strong orange to long-wave ultraviolet radiation is dyed, presumably with an organic compound. This conclusion can be confirmed if the orange-fluorescing stone reveals dye in its cracks when viewed under the microscope. If a stone with a color of unknown origin is exposed to X-ray fluorescence in conjunction with a lavender jadeite that is known to be dyed, and the unknown glows a distinct reddish purple to pink (as compared to the bluish purple of the treated stone), this writer feels that the unknown stone is *not* organically treated and the color may be natural.

At this time, we still have tackled only part of the problem, since it cannot be stated unequivocally that a stone that does not respond as described to long-wave ultraviolet or X-ray radiation is untreated. An inorganic dye or some other process may still be involved. However, the use of a combination of ultraviolet radiation, X-ray fluorescence, and microscopy (see table 1) should enable the gemologist to confirm that treatment has been used to enhance color in many cases.

TABLE 1. A comparison of "natural" color and treated lavender jadeite.

Type of lavender jadeite	Bleaches with heat?	Reaction to ultraviolet radiation	Reaction to X-ray fluorescence	Microscopy
"Natural" color	No	Long-wave, before and after heating: very weak brownish red Short-wave, before and after heating: very weak brownish red	Strong reddish purple to pink both before and after heating	No evidence of color concentration in surface cracks
Treated (dyed) color	Yes	Long-wave, before heating: strong to very strong orange Long-wave, after heating: very weak brownish red Short-wave, before and after heating: weak brownish orange to brownish red	Moderate bluish purple both before and after heating	Evidence of color concentration (dye) visible in micro surface cracks

NOTES
· AND ·
NEW TECHNIQUES

CULTURED 3/4 BLISTER PEARLS

By Robert Crowningshield

More information is now available on the cultured 3/4 blister pearls that were recently introduced into the marketplace. Cultivated with both salt water and fresh-water nuclei, the material is attractive and durable. This article describes the method of culturing these "pearls" as well as the differences between this material and 3/4 South Sea cultured pearls or assembled cultured blister pearls (Mabe pearls).

Gerald V. Rogers, the precious-stone specialist who introduced the cultured 3/4 blister pearls mentioned in the Summer 1981 issue of this journal (p. 104) to the trade, has provided additional information on this material and given us the opportunity to examine several hundred of these "pearls" in the New York Gem Trade Laboratory. The following description is based on the information given by Mr. Rogers and on the observations of the author and his colleagues in the laboratory.

The cultured 3/4 blister pearls are cultivated with both large salt-water nuclei and smaller fresh-water nuclei. They appear in a wide range of subtly attractive colors and various degrees of luster (figure 1), and average 8 mm (fresh water) to 15 mm (salt water) in size. Mr. Rogers describes these as cultured 3/4 pearls. Indeed, they do look like large, slightly baroque 3/4 South Sea cultured pearls. The difference is evident, though, in the exposed mother-of-pearl nucleus at the base of the blister pearl (figure 2), which reveals its formation on the shell of its host. We also observed that the blister pearl had been worked (polished to preserve roundness) and not sawed as is the case with the 3/4 South Sea cultured pearls. The line drawn on the stone in figure 3 marks the area from the widest part to the base where most cultured 3/4 blister pearls are worked.

According to Mr. Rogers, the large nuclei in the cultured 3/4 blister pearls are made of salt-water pearl shell (probably *Pinctada maxima*). There is usually very little conchiolin around the bead if it is salt water in origin, which suggests a compatibility not shown when the bead is of fresh-water pearl shell.

The fisheries for this new material are in the Philippines. The product is the result of experiments forced on the fishery owner when his Japanese cultured-pearl technicians were recalled to Japan. Without these technicians, sac pearl culturing was not feasible. Experiments were conducted to find the location within the large shells in which the rejection rate would be minimal and nacre thickness acceptable after two years. That

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Mr. Crowningshield is Vice President–Director of the Gem Trade Laboratory, Inc., New York, Gem Identification Department.

Acknowledgments: The author is indebted to Mr. Paul Heubert of Inter-Ocean Trade Co., New York, for introducing him to Mr. Gerald V. Rogers, who provided much of the information for this article. Ms. Renée Moore, of New York, is responsible for the fine color photographs in this article.

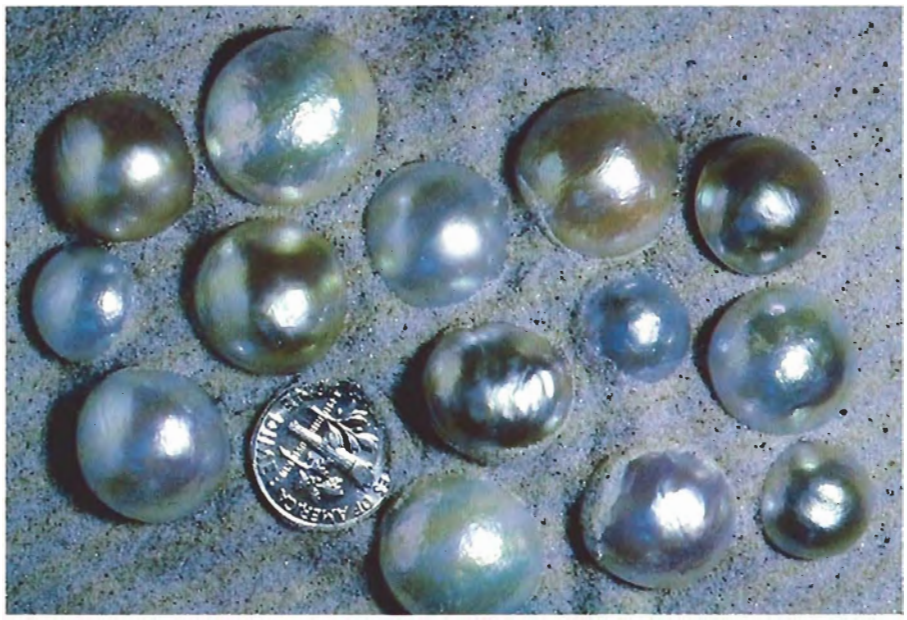

Figure 1. Cultured 3/4 blister pearls appear in assorted hues, as illustrated here.

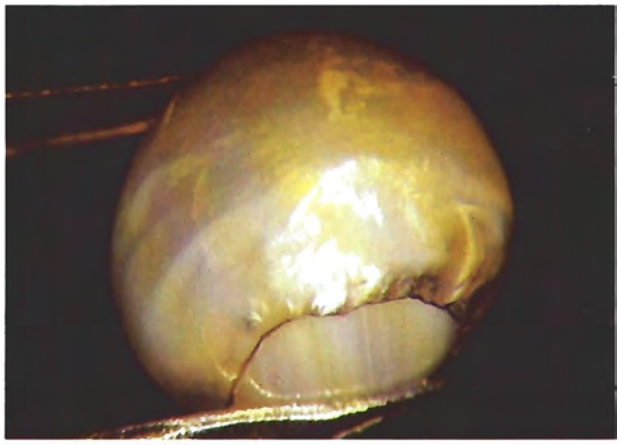

Figure 2. A cultured 3/4 blister pearl. Note the exposed nucleus at the base.

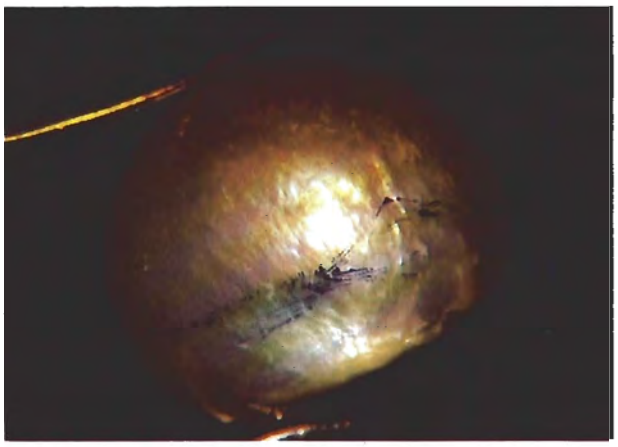

Figure 3. This line delineates the area where most cultured 3/4 blister pearls are worked.

area within the shell has been found and has led to visible characteristics that are very useful in identifying this material when the mother-of-pearl is hidden by a setting (figure 4). Figure 5 shows a large cultured blister pearl with typical grooves that appear to merge near the girdle. This is seen in a high percentage of the new pearls, but rarely in a full cultured pearl.

The differences between the cultured 3/4 blister pearl and assembled cultured blister pearls (known as Mabe pearls) are easily detected. The X-radiograph of a 3/4 blister in figure 6 clearly shows the solid nucleus and relatively heavy nacre of this product. The Mabe, on the other hand, has four parts (see figure 7): an egg-shell-thin nacre, a bead of mother-of-pearl, a filler of some-

Figure 4. A cultured 3/4 blister pearl set so that the nucleus is hidden.

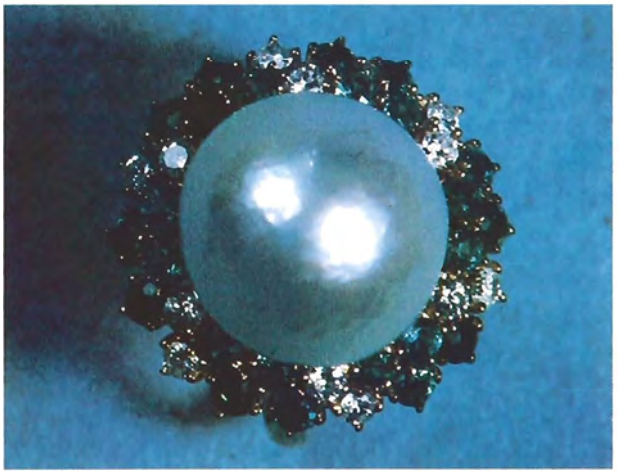

Figure 5. These grooves, which appear to merge near the girdle, are typical of a cultured 3/4 blister pearl.

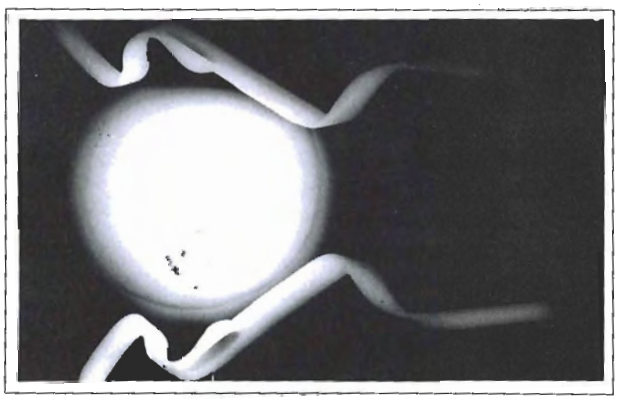

Figure 6. X-radiograph of a cultured 3/4 blister pearl.

Figure 7. This section of an assembled cultured blister pearl (called a Mabe) clearly shows the four parts of which this product is composed.

Figure 8. A damaged Mabe pearl.

thing that looks like Canada balsam, and a base of mother-of-pearl. It may also have a colored lacquer coating inside the dome. For the most part, Mabes are cultivated in Japan in a mollusc that is not used for culturing pearls and is known scientifically as *Pteria penguin.* They have also been cultivated in *Pinctada maxima* in Australia. The fragility of Mabe pearls, especially in rings, is known to most jewelers (figure 8). This is because the balsam-like filler offers little support to the nacre, a failing the solid nucleus of the cultured 3/4 blister pearl should avoid.

The resurgence of interest in pearls and cultured pearls, together with the increasing scarcity of fine cultured pearls, would appear to be happy circumstances to welcome into the trade this attractive and durable product, which is now readily available in the marketplace.

THE NATURAL FORMATION AND OCCURRENCE OF GREEN QUARTZ

By Thomas R. Paradise

Amethyst may develop into the more common citrine and rarer green quartz naturally under certain geologic conditions. On the California-Nevada border, just north of Reno, amethyst, citrine, and green quartz do occur together in clusters of crystals in detritus. These crystals, found lying loose in rocky and sandy rubble, appear to have eroded from cavities and vesicles in the inaccessible cliffs above. The quartz was deposited in these spaces by the slow accumulation of silica from migrating solutions. Low-grade radiation over a geologic time span was responsible for the alteration of the ferric and ferrous quartz into its amethystine color. Secondary, high-temperature, extruding volcanic bodies are believed to be responsible for the subsequent color change to citrine or green quartz.

Figure 1. Amethyst (3.77 cts.), green quartz (4.99 cts.), and citrine (5.74 cts.) faceted from rough material found at the same location along the California-Nevada border. Photograph by Tino Hammid, GIA Gem Media.

It has been known for some time that amethyst from specific locations may turn green rather than the expected, and more common, citrine-yellow when subjected to controlled induced heating. For the most part, gem-quality green quartz (also known in the industry as prasiolite or "greened amethyst") is produced by exposing amethyst to high temperatures for a specific period of time. Amethyst from the Montezuma area of Brazil is noted for its purple color alteration to green when subjected to these temperature conditions (Webster, 1978). According to Nassau (1980), exposure of amethyst to temperatures ranging from 140°C to 380°C for one hour is sufficient to artificially alter the purple to green or yellow. Although this induced heating develops the unusual green color in Brazilian amethyst, in very rare cases nature has supplied the required impurities, radiation, and high temperatures to create green quartz without man's aid.

In 1979, the author and two colleagues examined one such occurrence on the Nevada-California border, where ideal conditions have produced amethyst, citrine, and green quartz (see figure 1) in close proximity. An area of approximately 3 km² was studied, with uncovered crystals ranging in size from 3 to 55 mm in length. Iron impurities in the silicon dioxide in conjunction with an optimal radiation dosage were required to produce amethystine purple. Through subsequent heating and the resulting disruption of the purple color center, the characteristic yellow of citrine and the less common green quartz were produced.

GEOLOGY OF THE AREA

The quartzes were discovered in pebbly talus below steep basalt-andesite cliffs, approximately one-half kilometer to the east of Interstate Highway 395, 33 km (19 miles) north of Reno, Nevada. The amethyst, citrine, and green quartz specimens were found by the author in a detrital area that followed the base of the cliffs for approximately 3 km and no farther from the cliff face than the highway. The quartz appeared as crystal

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Mr. Paradise is a geological consultant, gemologist, and registered jeweler with Gleim Jewelers, Palo Alto, CA.

Acknowledgments: The author gives special thanks to Laurel Thompson for her great professional advice, to Donald Laufer for his fine work on faceting the gems illustrated in this article, and to Mr. Arthur Gleim for his encouragement and example.

clusters, single crystals, and portions of crystals, with no quartz found in situ. Exploration of the area indicated that the quartz had formed in the inaccessible basalt-andesite cliffs. A large talus slope and alluvial fans extend from the base of the cliff to the roadway; here, within a few hundred meters of the cliff base, the detrital crystals were unearthed. The host rock material, which consisted primarily of basalt with andesite, is actually metavolcanic. The prefix *meta* denotes a material that has been changed by subsequent events; in this case, the extruded material was later altered by further heating. This basalt-andesite mass is filled with lenses of brecciated and pyroclastic material, as well as with the numerous vesicles and amygdules that are ideal for the secondary silica deposition required for the formation of quartz (Stinson, 1960). The origin of the host basalt-andesite dates back approximately 140 million years (Jurassic period), coinciding with the early formation of the Sierran mountain core (Hill, 1975).

The quartz was deposited after the cooling and microcrystallization of the basalt-andesite. During the solidification of the lava (the basalt-andesite in its fluid state), trapped gases slowly accumulated and ascended, producing the vesicles, bubbles, and vug areas that are easily observed from the cliff base. As aqueous solutions migrated through the porous basaltic rock, they became enriched with soluble elements such as silica, which is soluble at very high temperatures or in an alkaline environment, that were slowly deposited from the saturated fluids onto the cavity walls (Sinkankas, 1959). Chalcedony, the cryptocrystalline variety of quartz, was deposited initially. As the siliceous solutions became less saturated, slower, more controlled crystallization occurred. The larger crystals developed very gradually from the ferrous and ferric siliceous solutions deposited on the chalcedony, with subsequent lengthy low-grade radiation exposure providing the energy required for the formation of the amethyst color center (Nassau, 1980). Low-grade radiation is a common natural occurrence during times of volcanic activity.

After the formation of the crystalline quartz and its alteration to amethyst, the area underwent a period of major metamorphism. Approximately 30 million years ago (Oligocene epoch), the basalt-andesite was overlaid and bordered by a major volcanic extrusion of rhyolite (Bateman, 1960), which appears to have produced temperatures of sufficient degree and duration to force the radiation-induced amethyst color center into an unstable state, whereby the color was altered from amethystine purple to either the brownish yellow typical of citrine or the far less common green.

The hot extrusion caused the underlying basalt material to alter in the areas closest to the rhyolite. The degree of such metamorphism is relative to the degree of heat, so that the higher the temperature is, the greater the bleaching of the amethyst should be. If this theory is correct, it should then follow that the crystals discovered nearest the extruding rhyolite mass will exhibit the greatest incidence of conversion of amethyst to citrine and green quartz. In keeping with this hypothesis, we observed that the amethyst crystals found farthest from the zone of metamorphism were a deeper purple than those found closest to the contact zone (see figure 2). Similarly, the greatest concentration of green quartz was unearthed nearest the rhyolite. Interestingly, we found little correlation between intensity of color and proximity to the rhyolite extrusion for the citrine. No variation in the transparency or flawlessness of any crystals was noted with location.

COLORATION

It is the iron impurity in silica that causes the purplish color of amethyst. According to Nassau (1980), "the iron merely provides the defect which permits the special amethyst color to occur." This purple coloration is due to a hole color center in amethyst. The iron impurity substitution in the silica structure is required for the hole center to occur. The hole-type color center forms where an absent electron causes the color. Thus, the word *hole* describes this electron absence.

Simply stated, the iron impurity in quartz causes amethyst color after the material is exposed to radiation. Heat destabilizes the color center and consequently produces citrine when ferric iron (Fe^{3+}) is present or green quartz when there is ferrous iron (Fe^{2+}), as explained in Nassau (1980). It is possible that the rhyolite extrusion provided the heat to produce these color alterations.

GEMOLOGY OF THE GREEN QUARTZ

The author examined approximately 45 specimens of amethyst, citrine, and green quartz. They

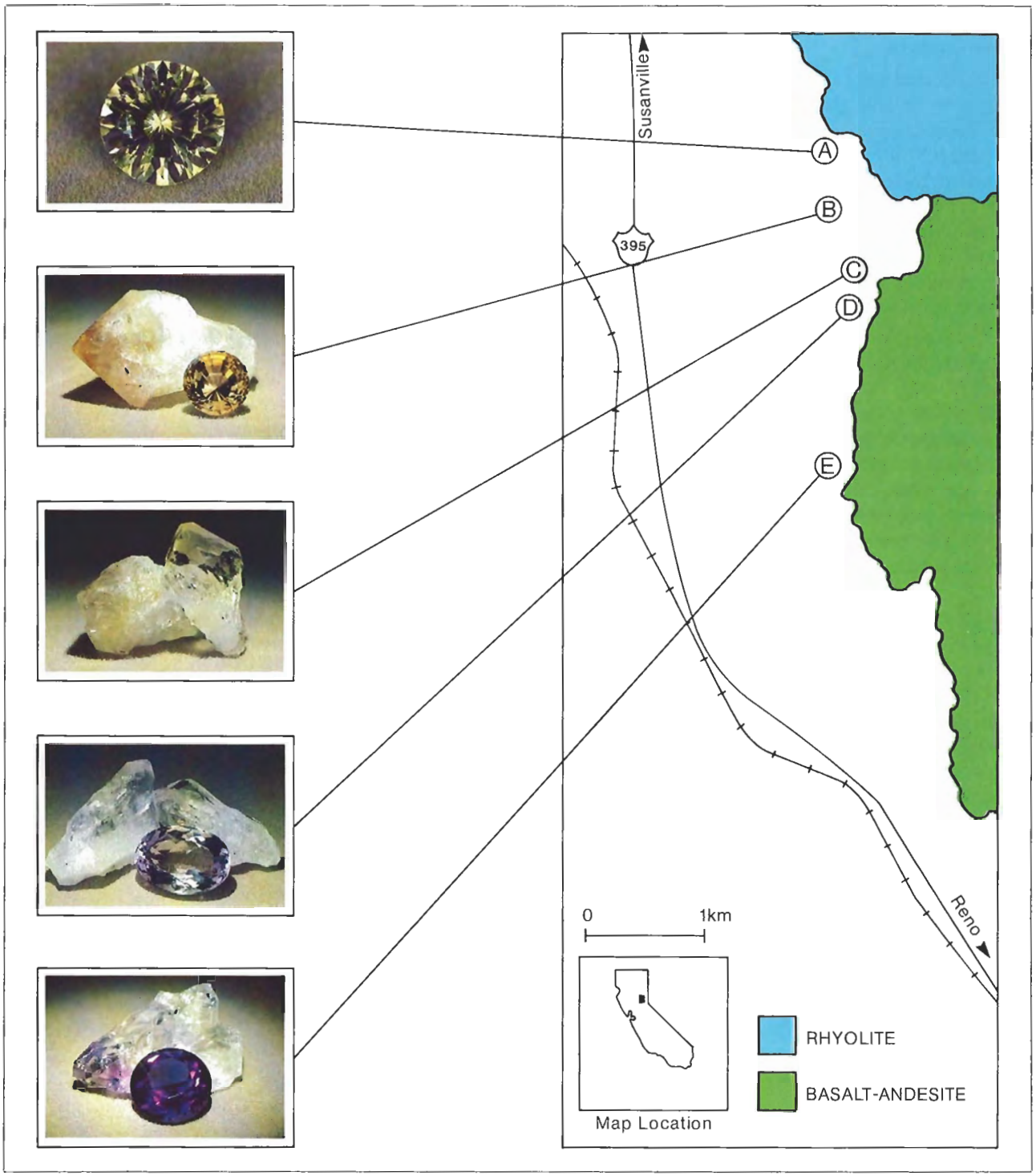

Figure 2. This map and the accompanying photographs illustrate representative discovery sites for the green quartz, citrine, light amethyst, and dark amethyst in relation to the host basalt and extruding rhyolite. The distribution of the discovery sites lends support to the hypothesis that the alteration in color of the amethyst to green quartz is directly related to the heat provided by the rhyolite extrusion. A = faceted green quartz, 4.99 cts.; B = faceted citrine (5.74 cts.) with rough; C = light green quartz rough (note that the green color is enhanced with faceting); D = faceted light amethyst (19.30 cts.) with rough; E = faceted dark amethyst (3.77 cts.) with rough. Photographs by Tino Hammid, GIA Gem Media. Map drawn by Susan Kingsbury, GIA Gem Media.

all exhibited the characteristic properties of quartz, with the green variety showing a weak iron spectrum absorption band centered at approximately 4420 Å, while both the citrine and amethyst from the same locale displayed considerably weaker (if any) iron absorption bands in the spectroscope. Slight color zoning and banding were observed in all the quartz specimens examined from this locality, with the amethyst showing the greatest zoning and the green quartz the least.

The rough material found yielded one faceted round-brilliant-cut amethyst of deep color weighing 3.77 cts., one round step-cut citrine of medium color weighing 5.74 cts., one round-brilliant-cut green quartz weighing 4.99 cts., and two oval-faceted light amethysts weighing 19.30 and 2.05 cts. each (all but the last are in figure 2). These stones were exceptionally large in comparison to the majority of the rough material, with the remaining material capable of yielding single-carat gems each for the most part. Again, the crystals were difficult to find; although some were found on the surface, others lay about two meters below. Many of the crystal clusters and fragments collected were heavily iron stained (a brownish translucent coating); they were subsequently treated in a warm oxalic acid bath to remove the film and divulge the actual color and clarity of the specimen.

CONCLUSION

Iron-enriched silica developed and crystallized in existing vesicles and vugs in a basalt-andesite body along the Nevada-California border. Low-grade radiation over a geologic period forced a hole color center to develop in the quartz and thereby gave it the purple color. We may then speculate that the secondary rhyolite extrusion and its tremendous accompanying heat caused the destabilization of the amethyst color and the subsequent development of the citrine and green-quartz coloration.

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Editorial Forum

HEAT TREATING CORUNDUM: 4000°C TOO HIGH, AUSTRALIAN SAPPHIRES DISTINCT

I was quite interested in reading Dr. Kurt Nassau's article on "Heat Treating Ruby and Sapphire: Technical Aspects" in *Gems & Gemology*, Fall 1981. However, I must complain about being misquoted in this article in regard to temperatures used in the treatment.

The article quotes my saying that sapphires are treated at 4000°C, but on reading my original text I quoted the following: "In the early part of 1978 a number of heat-treated Ceylon sapphires appeared on the market in Australia and toward the middle of the year there were reports in the local media (Sydney) on the treatment of these gems. These reports were either erroneous by accident or design as the temperatures of treatment reported were 4000°C. As corundum has a maximum melting point of 2050°C, and indeed can range from 750°C to the latter temperature depending on impurities, these reports of 4000°C would probably have produced a corundum glass and vapor under normal pressure conditions."

In all my papers on the subject I have suggested temperatures of 1200°C to 1700°C depending upon type of material and area of occurrence. In addition, electron microscope/microprobe analysis carried out by I. A. Mumme and myself has shown that there are two forms of AL_2O_3 present in Australian sapphires in their untreated state, but after treatment only the alpha form is present. Yes, it is true that the alpha and beta were reversed in the printing.

It is also interesting to note that reducing conditions for Australian sapphire results in a lighter color being produced (in direct contrast to the Nassau article) and that there is a vast difference in required temperatures and time of treatment between Glen Innes, Inverell, and Anakie material.

This is borne out by practical results that may bear no relationship to a theoretical possibility. Consideration should also be given to the following factors of chemical difference between Inverell (NSW) and Ceylon sapphires (results by Spark mass spectroscopy):

Element	Ceylon sapphire (ppm)	Australian sapphire (ppm)
Ca	3,500	40
Ti	550	2,000
Fe	1,500	17,000
Ga	95	1,000
Na	650	60
Mg	650	<300

I do not know whether these results will clarify or confuse the issue, but I do know that oxidizing conditions with Australian sapphires do not normally produce satisfactory results and bombardment by gamma and neutron particles have no effect.

There is obviously much work to be done on this subject before entirely predictable results can be obtained.

G. A. Tombs
Mansergh Pty., Ltd.
Sydney, Australia

Errata

In the article "Gem Garnets in the Red-to-Violet Color Range," of the Winter 1981 issue, two corrections should be noted. In table 1, on page 193, the formula for schorlomite should read $Ca_3Fe_2^{3+}Ti_3O_{12}$. In the second paragraph on page 203, under "Conclusions," the refractive index above which almandine predominates should be 1.779.

In the Lab Notes section of the Winter 1981 issue, figure 6 (page 227) was inadvertently printed in reverse. The dark-centered stone (type II_A) is incorrectly shown on the right instead of on the left as it should be. It is correctly identified in the text.

We regret any confusion that these errors may have caused our readers.

Gem Trade LAB NOTES

DIAMOND

The diamond shown in figure 1, which was examined in the New York Gem Trade Lab, has an unusual finish on the table. Although we have seen this effect before on a smaller facet, we are at a loss to explain it. The table does not have the whitish, burned appearance typical of a repolished burned stone on which the table has been overlooked; nor are there any polishing lines to suggest burning during polishing.

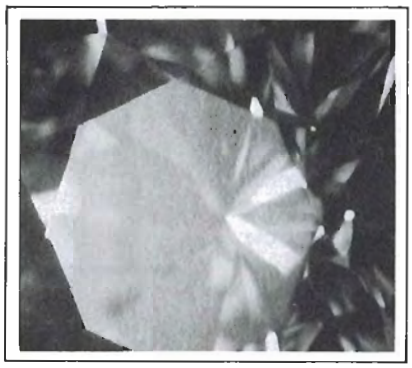


Figure 1. Irregular surface on the table of a diamond. Magnified 35×.

EMERALD

A True Treasure

An intriguing emerald ring seen recently in the Santa Monica Gem Trade Lab was set with a very fine natural emerald, measuring approximately 6.4 mm × 6 mm, that appeared to be of Colombian origin. Half of the golden shank and a portion of the bezel were encrusted with a calcareous deposit, probably a type of coral, as illustrated in figure 2. X-rays done by another laboratory revealed that the largest encrusted area around the shank contains a button-shaped object. The ring was recently recovered off the coast of Panama by a salvage diver–treasure hunter from Norwalk, California. The ship that carried the ring was believed to have gone down in a storm in 1687.

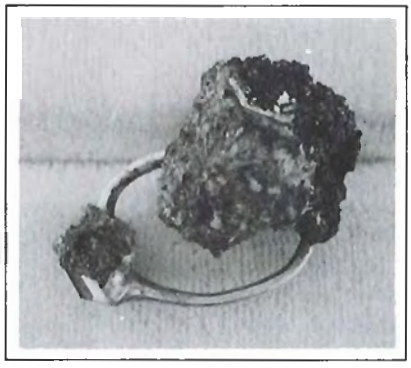


Figure 2. Emerald ring recovered from the ocean after approximately 300 years. The stone measures 6.4 mm × 6.0 mm.

Fake Specimen

Fake mineral specimens and fake gem minerals have been encountered in greater numbers lately. Some of these specimens are very cleverly crafted and would easily fool an inexperienced buyer. The Santa Monica laboratory recently examined the fake "emerald" crystal pictured in figures 3 and 4, which measured 16 mm × 16 mm × 22 mm long and weighed 41.19 cts.

Someone went to a great deal of trouble to deceive the potential buyer. A rough crystal of near-colorless beryl was meticulously hollowed out, leaving a very thin shell. The hole was then plugged with an unidentified crystalline material; a green cement served as the adhesive and gave the piece the color of fine emerald. The end of the assemblage was then coated with a mixture of mica flakes and epoxy to give the illusion of a natural mica coating at the crystal's original point of attachment to the matrix. The mica can be seen in figure 3, at the top right of the crystal, and is shown magnified six times in figure 5. Figure 6, taken at 25 times magnification, shows the thin, near-colorless skin, the green coloring inside, and a rather large bubble in the cement. Actually, the bubbles in the cement were the only indication of poor workmanship in the creation of this "emerald" crystal illusion, and they were the main clue to the skullduggery involved.

Synthetic Green Beryl Reported from Australia

I. Threadgold, M.Sc., Ph.D., and G. A. Tombs, F.G.A.A.—both of Sydney, Australia—have sent us the following information regarding some unusual green beryl that they examined recently. Although a more detailed article is scheduled to ap-

Figure 3. Fake emerald crystal, 41.19 cts.

Figure 4. Large bubble, plainly visible, in the emerald crystal illustrated in figure 3.

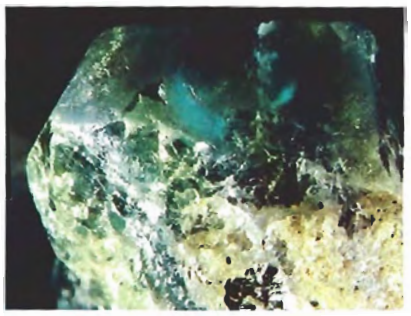
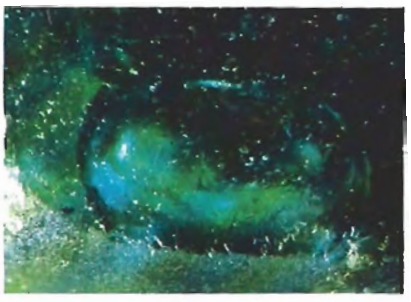


Figure 5. Mica flakes mixed into epoxy give a more natural appearance to the fake emerald crystal pictured in figures 3 and 4. Magnified 6×.

Figure 6. Large bubble and near-colorless skin of the fake emerald crystal illustrated above. Magnified 25×.



pear in the *Australian Gemmologist* within the next few months, they felt that people throughout the world should be made aware of this material as soon as possible.

Some cut beryl specimens, reportedly from Australia, along with two rough crystals that were supposedly from the same source, were submitted for examination to the Gemmological Association of Australia, in Sydney. The finely polished stones were highly transparent, with few inclusions, and ranged in color from medium dark green to a paler yellowish green.

The refractive index on the cut stones was a little low, at 1.567 to 1.572; the specific gravity was 2.67. The stones were inert to any ultraviolet radiation. One stone showed very weak chrome lines, as well as a faint line at approximately 4200 Å (probably due to vanadium) in the absorption spectrum.

An analysis of the chemistry of two of the cut specimens, the two crystals, and a natural Colombian emerald (for control) was conducted using an electron microprobe. Significant variations in chemistry existed between the rough crystals and the cut stones. The cut stones showed very little, if any, chromium, quite a bit of vanadium and chlorine, but no traces of iron, magnesium, or sodium. The rough crystals, on the other hand, had fair amounts of chromium, iron, magnesium, and sodium, with no vanadium or chlorine. On the basis of the test results, Dr. Threadgold and Mr. Tombs believe that the crystals are natural emerald but that the cut stones, which were purported to be from the same source, are actually synthetic beryl, colored by vanadium. The few inclusions present in the cut stones were of the flux type found in Kashan synthetic rubies.

Editor's Note: The cut stones described here would be considered synthetic emerald by American gemologists provided the color was dark enough. British and Australian gemologists, however, require chromium to be the coloring agent for the material to be described as natural or synthetic emerald.

Unusual Inclusions in Synthetic Emerald

A synthetic emerald submitted to the Los Angeles laboratory for iden-

tification contained a rather unusual appearing inclusion (see figure 7). The staff at the laboratory does not recall ever seeing an inclusion with a pattern quite like this one. The presence of typical flux veils in several areas and the low refractive indices of 1.561–1.564, low birefringence, and low specific gravity proved the stone to be synthetic.

A characteristic that is often observed in synthetic emeralds is a red transmission when exposed to strong light. This phenomenon results from the high chromium content of the stone, which gives a visible red fluorescence when excited by a strong light. As shown in figure 8, the stone discussed above was an extremely strong red transmitter. Some chromium-rich natural emeralds may transmit red, but rarely to the degree that this synthetic did.

The Los Angeles laboratory viewed another synthetic emerald that was unusual in that it had yellow two-phase inclusions randomly oriented among near-colorless two-phase inclusions (see figure 9) throughout the near-colorless seed plate that passed entirely through the stone (see figure 10). This synthetic also contained uniform parallel growth bands and typical flux veils, one of which intersected the near-colorless zone. The refractive indices, birefringence, and specific gravity were all low, as expected.

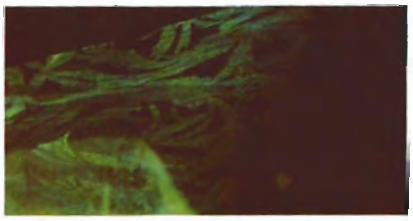
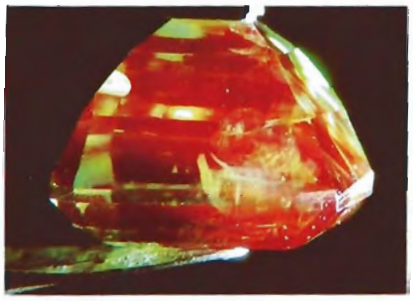


Figure 7. Unusual patterned inclusion in a synthetic emerald. Dark-field illumination, magnified 25×.

Figure 8. The stone pictured in figure 7 was also a strong red transmitter. Transmitted light, magnified 10×.



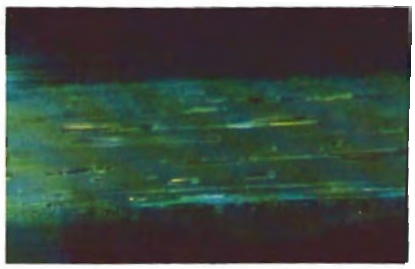


Figure 9. Yellow two-phase inclusions in the seed plate of a synthetic emerald. Dark-field illumination, magnified 70×.

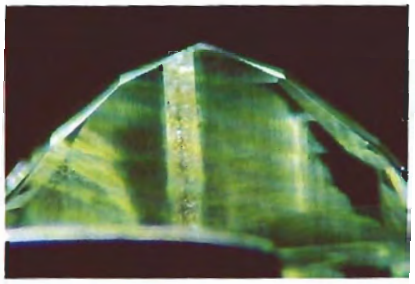


Figure 10. Seed plate in a synthetic emerald. Dark-field illumination, magnified 20×.

OPAL

A combination pin and pendant set with a beautiful light pink carving of a woman's head was recently submitted to the Los Angeles laboratory for identification (see figure 11). The carving measured approximately 33.2 mm × 26.4 mm. At first glance the material looked somewhat like coral, but subsequent testing proved it to be common opal. Microscopic examination revealed a structure with a slightly mottled appearance rather than the wavy parallel-fibrous structure seen in coral. The unique design of the piece was an attractive blend of metal and gemstone, with the metal around the carving following the pattern of the curls in the woman's hair.

PEARLS, CULTURED

Bob Crowningshield, our contributing editor from New York, reports on procedures currently used to cultivate Biwa pearls, which he observed during a recent trip to the Orient.

At Lake Biwa, in Japan, Mr. Crowningshield visited a completely artificial growing area that uses huge pond/tanks filled with artesian water rather than the lake itself. The mussels grow much faster in this environment than in the lake, and they deposit nacre almost all year. The mother mussels *(Hyriopsis schlegeli)* are about four years old and 10 cm long when the deft operators make from 15 to 20 careful incisions in each mantle and tuck a piece of

Figure 11. Carved opal (33.2 mm × 26.4 mm) mounted in a combination pin and pendant.

tissue into each cut. A variety of the genus *Odonata* (which itself is too fragile for use as a "mother") usually serves as the source of the mantle tissue inserts, since it has such colorful nacre. Only about 0.7 mm of the extreme outer edge of the mantle is used for the tissue inserts.

If all goes well, in about three years the animals will be carefully opened and the 30 to 40 cultured pearls squeezed out. At this point, the mother mussel is about 15 cm long, with additional mantle tissue that can be used to accommodate another row of incisions and inserts. The animals are returned for a second crop to grow in the old "sacs" and a first crop in the new incisions. If the mantle tissue of one of the colorful molluscs was used the first time, the second crop will also have that characteristic. Should the operator who makes the incision and inserts the tissue piece go through the mantle, the tissue may lodge on the shell and produce a blister or a row of blisters (figure 12).

Not only can the farmer-operators control the color somewhat, but they can also exercise some control over the shape of the cultured pearl. A long piece of tissue is used to produce "sticks" and "doublets," and two interlaced pieces will produce crosses. Mr. Crowningshield suspects that the fancy "dragons" are the result of serrated tissue inserts.

Second (and, in rare instances, third) crops are progressively less spherical and less abundant when harvested. Both salt-water and freshwater cultivators have made strides in propagating spat artificially.

In Perth, West Australia, Mr. Crowningshield was given a "Broome pearl" (see figure 13) that is actually a blister cultivated in the shell of *Pinctada maxima* near the northern city of Broome. The cultivators use plastic of various colors as nuclei; a bright red nucleus, for instance, produces an attractive red/pink blister. The X-radiograph in figure 14 shows the transparency to X-ray of the plastic nucleus in the "Broome pearl."

Figure 12. Fresh-water mussel shells, probably Hyriopsis schlegeli, *used to culture pearls in Lake Biwa, Japan. In these cases the tissue inserts have lodged on the shell and produced blisters.*

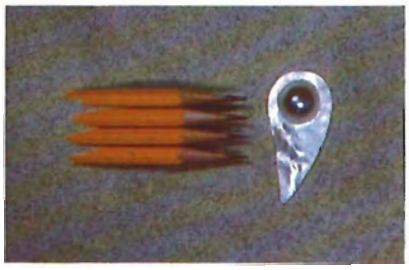


Figure 13. A cultured blister pearl from Broome, Australia.

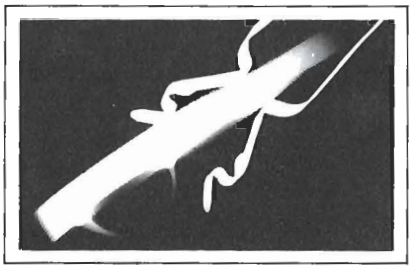


Figure 14. X-radiograph of a cross-section of shell and "Broome" cultured blister pearl.

Figure 15. Light yellow natural sapphire after heat treatment. It was reported to be subject to fading. Magnified 12×.

Figure 16. Dark yellow natural sapphire after heat treatment, reportedly not subject to fading. Magnified 10×.

SAPPHIRE

While in Sydney, Australia, Bob Crowningshield visited the sapphire-cutting factory of Arrowatta Holding Ltd. He was told there that virtually all the rough from certain mines is heated to lighten the color and diminish the green dichroic direction. Stones up to a carat in size are cut with automatic machinery and are quite beautifully done.

During Mr. Crowningshield's trip to the Orient, he received from the managing director of the Bangkok Gem Exchange a 2.5-ct. light yellow sapphire of a type produced seven or eight years ago by heating colorless sapphire (see figure 15). Since this type was likely to fade, it was not sold. The stone illustrated in figure 16 is a darker yellow sapphire of the type that is said to be produced by heating certain cloudy stones. The color is reported to be permanent, but it has not yet been tested in the GIA laboratory.

SUGILITE

In the Summer 1981 issue of *Gems & Gemology*, we mentioned a small, thin piece of manganoan sugilite that came into the laboratory for identification. Since that time, all three divisions of the Gem Trade Laboratory have had many cut examples of sugilite submitted for identification. The stones examined to date, both cabochon and faceted, have ranged in weight from approximately one to seven carats.

This particular color of sugilite, which originates from the Hotazel area of South Africa, is relatively new to the gem market. It is being marketed under the trade names Royal Azel and Royal Lavulite.

Figure 17 shows some jewelry fashioned from sugilite and some of the rough material. The three stones in figure 18 represent some of the cabochons seen in the Santa Monica lab to date, while figure 19 shows a sugilite carving that measures 7.6 cm wide by 3.2 cm thick and 13.6 cm high.

Figure 17. Jewelry fashioned from sugilite together with a piece of the rough material.

Figure 18. Sugilite cabochons, average weight 5 cts.

Figure 19. Sugilite carving, 7.6 cm wide × 3.2 cm thick × 13.6 cm high.

For more information on manganoan sugilite and its properties, see this section of the Summer 1981 issue of *Gems & Gemology*, pages 105 and 106.

WORLD'S LARGEST TAAFFEITE?

The Santa Monica laboratory recently issued an identification report on what is perhaps the world's largest taaffeite. The grayish-purple stone, pictured in figure 20, weighs 10.13 cts. Numerous small inclusions were observed under the microscope. One of the inclusions, shown in figure 21, appeared to be a negative crystal with a series of fingerprint-like, partially healed fractures radiating from it. Only a few taaffeites are known to exist, and to the best of our knowledge this is the largest one that has been recorded to date.

Figure 20. World's largest taaffeite? The stone weighs 10.13 cts.

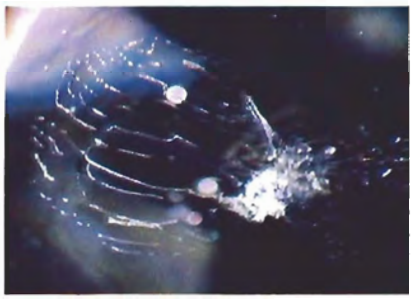


Figure 21. Inclusions in taaffeite. Dark-field illumination, magnified 45×.

ACKNOWLEDGMENTS

Bob Crowningshield in New York took the photographs in figures 1 and 14; and Andrew Quinlan, from the same laboratory, was responsible for figures 12, 13, 15, and 16. In Santa Monica, Karin Hurwit photographed the item in figure 2 and John Koivula furnished figures 5, 6, 20, and 21. Robert Kane, of the Los Angeles lab, supplied the photos in figures 7, 8, and 9. His colleague in Los Angeles, Shane McClure, provided figures 10 and 11. The items in figures 3, 17, 18, and 19 were photographed by Tino Hammid, of GIA Gem Media. Tony Kampf, of the Los Angeles County Natural History Museum, supplied figure 4.

GEMOLOGICAL ABSTRACTS

Dona M. Dirlam, Editor

COLORED STONES AND ORGANIC MATERIALS

The heat and diffusion treatment of natural and synthetic sapphires. R. Crowningshield and K. Nassau, *Journal of Gemmology,* Vol. 17, No. 8, 1981, pp. 528–541.

In discussing the heat and diffusion treatment of natural and synthetic sapphires, Mr. Crowningshield and Dr. Nassau reflect back on nearly 30 years of gem testing and relate this experience to identifying various types of heat and diffusion treatments that are currently being practiced. They discuss numerous specific accounts of treatments that have been encountered in the GIA Gem Trade Laboratory.

The authors first review the subject of heat treatment of corundum in the gemological literature, correcting several inaccuracies that have been reported. Information on the behavior of ruby and sapphire when subjected to heat treatment is available from the manufacture of the synthetic material as well as from other studies on natural material. On the basis of such information, the authors list nine distinct treatment processes that are currently being used on corundum. Four of the treatments correspond to processes that also occur in nature, two are used on synthetic material, and the remaining three treatments do not correspond to natural processes. The first six involve heating only; the latter three involve heating plus surface diffusion of impurities, such as TiO_2, Fe_2O_3, Cr_2O_3, NiO, and the like. A table lists the various types of treatment plus the results obtained from each treatment process. With

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

Inquiries for reprints of articles abstracted must be addressed to the author or publisher of the original material.

The reviewer of each article is identified by his or her initials at the end of each abstract. Guest reviewers are identified by their full names.

the aid of 16 color photographs, the authors outline the identification of these treatment processes.

Robert E. Kane

Die Eigenschaften der undurchsichtigen Schmucksteine und deren gemmologische Bestimmung (The properties of opaque gemstones and their gemological identification). E. Gübelin, *Zeitschrift der deutschen gemmologischen gesellschaft*, Vol. 30, No. 1, 1981, pp. 3–61.

The entire issue of this journal is devoted to Dr. Gübelin's article on opaque gemstones and techniques for identifying them. In his introduction, the author points out that unlike most of their nonopaque counterparts, opaque gemstones and especially those that are carved cannot be readily identified with the aid of a refractometer and a microscope. Testing methods such as specific gravity, absorption, and fluorescence are discussed, as are potentially destructive techniques such as the hardness test, the streak test, and chemical reactions. When describing the latter techniques, Dr. Gübelin provides a valuable reminder of how to perform them properly in order to avoid damage.

The greater part of the article consists of numerous tables of opaque gemstones, from agalmatholith to wernerite, grouped by color. For each category, Dr. Gübelin lists the properties of the gemstones and their occurrences, and provides special remarks. In addition, there are separate tables for groups such as cryptocrystalline quartz; jade substitutes; serpentine minerals; and turquoise, its substitutes and imitations. This compilation of opaque gemstones is a welcome addition to the field of gemology. *KNH*

Korite from Alberta, Canada. P. D. Kraus, *Lapidary Journal*, Vol. 35, No. 10, 1982, pp. 1994, 1996.

Korite, the aragonite portion of the fossilized ammonite *Placenticeras*, is a gem material that has been marketed in the past as ammolite and calcentine. It is mined commercially in two localities near Lethbridge in Southern Alberta, Canada.

It is interesting to note that while aragonite will normally convert to calcite after approximately 10 million years, these korite deposits have been radiometrically dated at about 70 million years. It is probable that the overlying shale layer allowed mineralization of the fossil shells, thus preserving the fossils.

This mineralization included small amounts (1% each) of iron and silica, and traces of titanium, copper, barium, and magnesium from the shale. The resulting material displays colors similar to those seen in fire agate as a result of the diffraction of light.

Because of the rather soft and flaky nature of korite, 95% of the commercially viable product is capped with synthetic spinel. The remainder is cut into completely natural stones. Korite Ltd. controls the production and claims that the company buries all materials that are not deemed fit for cutting. *RSS*

DIAMONDS

The genesis of natural, coated diamond crystals (in Russian). A. M. Asxabov and B. A. Mal'kov, *Papers of the Soviet Academy of Sciences*, Vol. 251, No. 4, 1980, pp. 954–956.

This investigation into the well-known phenomenon of yellow or greenish coatings on diamond crystals from the Soviet Union opens with a structural and chemical description of the jackets. High-density dislocations lend a fibrous impression to the outer diamond surface, which differs sharply from the typically transparent octahedral crystal it covers. Micro-inclusions with a constant, higher silica content contribute to the jackets' turbid appearance, while the characteristic tints result from increased nitrogen content.

Asserting that early theories on the mechanism of their growth fail to explain features of the coatings revealed by X-ray diffraction studies, the authors present a detailed hypothesis based on a concentrated supercooling of the original melt. The higher inclusion of admixtures into the growing crystal, formerly assumed to be a causal factor in the deformation of its faces, is described here as a result. Concentrated supercooling of the normal planar faces of the diamond octahedron leads to a chambered outer structure, with the accretion of impurities then occurring in the hollows. This accounts for the nature of the materials found in borders between the finished fibers, and also corresponds to known processes of crystal regeneration.

Having explained the process by which the jackets formed, the researchers approach the question of where and when the jackets took shape. Lack of repetition in the casings points to a single instance of formation; and despite extensive dissolution explained as oxidation occurring late in the kimberlite magma, earlier slippages can be identified. These carry through to the basic crystal and thus indicate that the formation of the coating preceded this plastic deformation in the already-consolidated mantlerock of eclogites and peridotites. Thus, the tinted jackets so typical of Russian crystals lend insight into the larger question of how diamond itself was formed. *MPR*

High-temperature electroluminescence in diamond (in Russian). V. S. Tatarinov, Ju. S. Muxačev, and I. A. Parfianovič, *Physics and Technics of Semiconductors*, Vol. 13, No. 8, 1979, pp. 1642–1645.

Scientists at the Ždanov University of Irkutsk, the Soviet Union, first review previous work on the subject of electroluminescence (EL) in diamond. They then describe the discovery of a yellow-green electroluminescence in diamond crystals placed in a constant electric field of up to 6 kilovolts/cm at temperatures ranging

from 300° to 750°C. This high-temperature electroluminescence (HEL) appeared in 12 of 600 natural specimens tested, as well as in one synthetic sample.

As part of ongoing detailed studies of the solid-state physics of diamonds, the spectral, thermal, and electrical characteristics of a natural crystal were examined and related by the authors to the process of HEL at an atomic level. In conclusion the authors present arguments for correlating this phenomenon with an S2 spectral center. They then suggest further applications of their studies, also describing an improved apparatus for applying voltage. *MPR*

The Monastery Mine. J. Gurney, *Indiaqua,* Vol. 29, No. 2, 1981, pp. 21–24.

The Monastery Mine has been known to be a diamond-bearing kimberlite pipe since 1876, but past preliminary investigations and some small-scale mining have always shown it to be unprofitable for large-scale production. Located in the Orange Free State in South Africa, the Monastery Mine was recently reopened for production using the most modern recovery methods.

The decision by the Monex Company, and more recently the Gemex Company, to proceed with mining was not made easily. The pipe is small and most of the diamonds are of very poor quality. The redeeming factor is a sprinkling of a few large stones of the very pure type IIa variety. The DeBeers' Letseng-la-Terai mine in Lesotho parallels Monastery in its need to discover a few large, top-color diamonds to remain profitable. The next important decision at Monastery was how to achieve a balance in setting the size of the mechanical jaws that crush the kimberlite so that both the small and the large stones could be recovered. By setting the width of the jaws at 30 mm, a diamond of up to 220 cts. can be liberated without risk; those larger may be crushed. *FLG*

Rubidium-strontium dating of the Udachnaya kimberlite pipe. M. Maslovskaya, S. Kostrovitskiy, V. Lepin, T. Kolosnitsina, L. Pavlova, B. Vladimirov, S. Brandt, *Doklady Akademii Nauk SSSR,* Vol. 242, No. 1, 1981, pp. 168–170.

An interesting topic in diamond research is that of determining the age of kimberlite pipes. Maslovskaya et al. first briefly review other efforts undertaken to apply radiometric age techniques to this problem. In radiometric dating, the age of the pipe is calculated by measuring the presence of a short-life radioactive element (such as carbon-14) or a long-life radioactive element plus its decay product (such as potassium-40/argon-40 [K-Ar] or rubidium-87/strontium-87 [Rb-Sr]).

Both K-Ar and Rb-Sr age dating methods have been applied to kimberlite pipes with controversial results. In an effort to circumvent the difficulties encountered by previous researchers, the authors chose two independent approaches in their use of Rb-Sr to date the Udachnaya pipe, the second largest Soviet pipe. One method dated the effect of kimberlite fluids on the host rocks, while the other dated the time of hydrothermal mineralization of quartz.

Samples were collected from the contact zone of a kimberlite vein into the surrounding host dolomites and from a hydrothermal zone within the Udachnaya suite. Determinations were then made on the strontium and rubidium ratios in these samples.

Isochrons (lines connecting rocks of the same age on the basis of radiometric ratios) were plotted from the data. The age for the kimberlite contact zone is 345 ± 30 million years and that for the quartz samples is 348 ± 40 million years. These are in agreement with the age 350 ± 15 million years that was previously reported.

In addition to providing an age for this important pipe, the authors have demonstrated the success of both techniques, which can be applied to other age determinations. *DMD*

GEM LOCALITIES

Emeralds from Itabira, Minas Gerais, Brazil. F. M. Bastos, *Lapidary Journal,* Vol. 35, No. 6, 1981, pp. 1842–1848.

This article discusses in detail the new emerald deposit that was discovered in 1978 on the Belmont Farm at Oliveira Castro Station about 18 km southeast of Itabira, Minas Gerais, Brazil. Access to the area is gained by dirt road from Itabira. The mine is situated in the Rio do Peixe (Fish River) Valley and is located immediately adjacent to the tracks of the Vitoria-Minas railroad, which services the famous iron mines at Itabira.

The emeralds were first found by the station manager at Oliveira Castro during construction of a dam for the station's water supply. The emerald crystal that the manager found was in a biotite schist matrix. He showed the crystal to the owner of the property who subsequently formed Belmont Gemas Ltda. and started mining operations. The mine is an open pit; although it was initially worked by hand, the operation is now automated, with mechanical shovels and bulldozers.

The emeralds occur as perfect hexagonal prisms commonly 1.5 to 2.5 cm long. Crystals up to 6 cm have been reported, however. The emeralds characteristically exhibit a light bluish-green color when viewed perpendicular to the c-axis. The crystals occur in biotite schist or as alluvium in a quartzite and schist gravel.

Reports indicate that up to 40% of the emeralds recovered are of cutting quality. Some of the stones studied by the author are comparable to the finest quality material found at Muzo and Chivor in Colombia.

Peter C. Keller

Garnets from Umba Valley, Tanzania: is there a necessity for a new variety name? K. Schmetzer and H. Bank, *Journal of Gemmology*, Vol. 17, No. 8, 1981, pp. 522–527.

Drs. Schmetzer and Bank raise the question of whether the type of garnet that has recently been referred to as "malaya" really justifies the adoption of a new variety name. They compare samples of the material from Umba Valley, Tanzania, with other garnets of the pyrope-almandine-spessartine solid-solution series, giving special attention to the property determinations that are readily available to gemologists. They found that while some members of this series can be distinguished from one another according to dominant end member of paired end-member series, pyrope-spessartine and pyrope-almandine specimens cannot always be separated by means of refractive index, specific gravity, and/or color. Spectroscopic determinations can be made, but these require considerable expertise as well as chemically analyzed standards for comparison; such tests are, therefore, not practical.

In light of this inability to distinguish gemologically between two of the types of garnets encountered in the pyrope-almandine-spessartine series, the authors recommend that all garnets from the Umba Valley be referred to by the term *pyralspite* and modified as needed by prefixing a color term. However, this term seems to this reviewer to be too general and, in particular, does not account for the often significant contribution made by grossular to the composition of garnets of the pyrope-spessartine series. Nor do the authors consider the all-too-common case in which the gemologist has no way of determining the locality from which his or her material originated. *CMS*

Modes of occurrence and provenance of gemstones of Sri Lanka. K. Dahanayake, *Mineralium Deposita*, Vol. 15, 1980, pp. 81–86.

Summarizing a major study of gem mining in Sri Lanka, Dahanayake describes the major gem localities and hypothesizes about their origin. First, he gives an overview of the geology of the island, which is underlain by Pre Cambrian rocks that can be divided into three parts: Highland, Vijayan, and Southwestern. The two gem areas near Elahera and Ratnapura lie within the Highland Group, and gem pits also occur in the Southwestern Group. Mining is done in the Vijayan Complex only around rivers draining from the other two groups.

The author describes three types of gem pits: (1) eluvial, with blue sapphires and rubies found in coarse, unsorted gem-bearing sediments; (2) residual, with blue sapphires and rubies occurring in argillaceous sand over weathered gneisses and marbles; and (3) alluvial, with fancy sapphires, cat's-eye chrysoberyls, and alexandrites in addition to the blue sapphires and rubies, contained in well-sorted sand and gravel sediments. A schematic cross-section illustrates the relationship of the three types of pits to the geologic setting.

The author concludes with a discussion of the source material for these deposits, examining in more detail the nature of these deposits. He describes how the pegmatites and the garnetiferous/cordierite gneisses and marble could be responsible for the development of gemstones in each of the three pits. *DMD*

JEWELRY ARTS

The ancient craft of granulation. A re-assessment of established concepts. J. Wolters, *Gold Bulletin*, Vol. 14, No. 3, 1981, pp. 119–129.

In his review of accepted concepts of the history of gold granulation, Mr. Wolters makes the following points:

1. Granulation is a formal discipline within the art of the goldsmith; however, it is not a technique that is based on one specific joining process.
2. In granulation, as in other jewelry techniques, both metallic and nonmetallic solders have been used, the latter predominating in antiquity.
3. Granulation was never a "lost" art; it survived with continuity until far into the 19th century.
4. The description of, or references to, joining techniques on which granulation is based can be found in numerous literary sources over a period of more than 2000 years.
5. Modern attempts to establish by experiment the origins and characteristics of the technique have contributed little to our knowledge of it. They have usually ignored the technical features of ancient work, materials, and processes known in antiquity.

The above points are substantiated by the author's extensively documented research, including a bibliography of 122 entries. The points made will be enlightening to the historian as well as to the practicing goldsmith-jeweler. This article is an abstract of a book by Mr. Wolters on the subject of granulation that is to be published soon.

In this article he states that granulation with clearly recognizable traces of solder appeared first in Egypt as early as the Middle Kingdom, in Iran at the end of the Parthian period, in prehistoric northern and central Europe, in Imperial Rome, in Byzantium, as well as in central and southern Europe from medieval time onwards. He further states that the granulation work of all other cultures shows no remnant of solder alloys. He concludes with the statement that "none of the numerous attempts at experimental reconstruction of the historical granulation technique has taken adequate account of the above important considerations."

This reviewer is concerned, however, that in all of Mr. Wolters's research he fails to credit the work done by H. A. P. Littledale in 1933, which was published in

1936 in *The Scientific and Technical Factors of Production of Gold and Silverwork* by the Worshipful Company of Goldsmiths. Mr. Littledale, in his research, came to essentially the same conclusions as Mr. Wolters. Mr. Wolters's work would be more convincing if greater attention were paid to Mr. Littledale's discoveries, inasmuch as Mr. Littledale did take into account the technical features of ancient work and developed a consistent theory based on his assessment of ancient technology.

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Chinese jade. K. R. Tsiang, *Arts of Asia,* Vol. 11, No. 5, 1981, pp. 77–83.

In this article, Katherine Tsiang weaves a brief survey of Chinese jade around photographs of carvings from the Indianapolis Museum of Art. Her introduction traces the origin and use of the two jades, nephrite and jadeite, and follows with a discussion of developments in jade cutting.

The main body of the article is devoted to jade artifacts from the Shang dynasty to the present. It begins with early jade daggers and blades, and then covers the kuei, a ceremonial blade used in later centuries as an emblem of official rank. Other ceremonial and funerary jades such as plaques and body stoppers are discussed and illustrated. The author also examines the pi and the t'sung with the aid of photographs. Since the Chou dynasty, the pi has been regarded as a symbol of heaven and the t'sung, a symbol of the earth.

The article concludes with two pages of color photographs that cover jades from the Ch'ing dynasty to the present. *ET*

Simulated materials in jewelry. R. K. Liu, *Ornament,* Vol. 4, No. 4, 1980, pp. 18–26.

Although we often view efforts to duplicate gems and other jewelry materials as recent developments, simulants have been an integral part of the history of jewelry. As early as 3500 B.C., people used faience to imitate turquoise. In the first section, Liu uses both early artifacts and recent jewelry items to describe how accurately people have tried to duplicate these objects, from exact copies to mere look-alikes.

Then the author focuses on the detection of simulants, stating that one must know the object being copied as well as the materials used to simulate it. Separation of the original from the imitation is often difficult, since countless clues must be considered. He emphasizes that one must examine carefully signs of age and wearing to see that aging has not been artificially induced.

Liu incorporates 38 fascinating photographs of jewelry that contain teeth, beads, turquoise, lapis-lazuli, coral, onyx, malachite, shell, agate, and jade, with their ingenious copies made of bone, shell, glass, ceramic materials, metal, and plastic. Those interested in these remarkable pieces will find the extensive bibliography helpful. *NPK*

The utilization of diamond powder—optimum abrasive for the lapidarist. B. A. Cooley and H. O. Juchem, *Indiaqua,* Vol. 29, No. 2, 1981, pp. 97–103.

In part one of a series, the authors describe the use of natural and man-made diamond abrasives to cut diamond and colored stones. They also comment on the development and use of cutting equipment.

Diamond is used to cut diamond. Sawing diamond is accomplished with 4-inch bronze alloy blades, 0.05 mm to 0.16 mm in thickness. The blades are dressed with 20- to 100-micron diamond powder. Sawing speeds vary from 4200 R.P.M. to 7000 R.P.M. The faces are cut and polished on diamond-charged laps. The diamond powder used to charge the laps is in a paste form, and varies in micron size depending on the cutter's preference.

In the sawing and cutting of colored stones, electroplated or mechanically bonded diamond-charged saw blades, laps, and grinding wheels are often used. Diamond abrasives can increase productivity, improve cutting quality, and reduce cost. Even in countries with low labor costs, such as Thailand, the use of diamond abrasives is very common.

Cooley and Juchem include 21 photographs which illustrate the preparation and use of equipment in cutting. Although the article is detailed in some parts it is vague in others, and the reader may be left with many unanswered questions. *Dino DeGhionno*

RETAILING

The carat weight. H. Tillander, *Journal of Gemmology,* Vol. 17, No. 8, 1981, pp. 619–623.

The word *carat* has been used both with reference to the quality of gold and as a measurement of size or weight in other materials. The smallest unit of weight once used in England and on the European Continent north of the Alps was the grain, based on the weight of a local grain of wheat. By the 16th century, this was replaced in the European trade by the "carat grain," which eventually became equivalent to one-fourth of a carat as we now know it. In many trade centers, the term *carat* referred to the bean of the carob tree; it became well established in the mid-17th century, although the exact weight varied somewhat. It was not until 1893 that Dr. G. F. Kunz suggested that the carat be incorporated into the metric system and be accepted as equal to 200 mg. Most countries legalized the metric carat as the unit for weighing gemstones just prior to World War I. Modern carat weights are now interna-

tionally written to two decimal places (e.g., 1.32), but a third decimal may be quoted in brackets to facilitate identification. *ERL*

Gemstone and jewelry appraisal guide. W. D. Shoup, *Lapidary Journal,* Vol. 35, No. 7, 1981, pp. 1524–1535.

Shoup reviews all aspects of appraising, from the take-in through cleaning, quality determinations, metal identification, and pricing. The information given is intended to help those with a basic gemological education gain insight into appraisal procedures and techniques.

The author recommends that 10 steps be followed in doing an appraisal. First, determine the reason for the appraisal, which will affect the appraised value. For example, insurance appraisals are usually given at retail replacement value, while inheritance tax appraisals are normally figured at market value. Second, determine which items are to be appraised. Some pieces are not worthy of the appraisal fee, and the customer should be informed that the cost of the appraisal might exceed the value of the item to be appraised. Also, frequently customers will bring in items that are beyond the capabilities of the gemstone and jewelry appraiser, for example, artwork, figurines, and the like. Third, establish charges and estimate time requirements for each job in advance. Fourth, photograph the items to be appraised. Fifth, examine, measure, and plot the major identifying characteristics of each piece and identify the potential hazards of working with the piece to the customer. Sixth, clean, assay, weigh, and measure the jewelry. (Different techniques for jewelry cleaning are explained in detail here. Metals testing and formulas for determining gram weight are also covered in this section.) Seventh, analyze the jewelry's construction; the value of the item may vary depending on whether it was handmade, die struck, or cast. (An informative section on jewelry design and decoration is also included here.) Eighth, price the metal and labor. Ninth, analyze the gemstones. Tenth, price the gemstones. Included with steps 9 and 10 are charts that explain the different pricing and grading techniques used by the author.

Shoup has done an excellent job of summarizing a subject that is both vast and complicated. He has included a number of helpful hints, cautions, and key points to be aware of at each step. This article supplies assistance to the beginner and useful information to the veteran appraiser. *Marcia Hucker*

The glory—and the nothing—of a name. M. E. Thomas, *The Goldsmith,* Vol. 160, No. 3, 1981, pp. 64–66.

Royal Lavulite and Royal Azel are the commercial names given to the new material identified by various professional sources as manganoan sugilite, a purple mineral that lies between 5.5 and 6 on the Mohs hardness scale, is dichroic, and has refractive indices of 1.605 to 1.611.

It is the royal purple color of sugilite in its translucent, finest quality that inspired the trademarked names, although the author points out that an opaque, grey-purple, lower-quality stone and a semitranslucent, rose-purple, middle-grade stone are also marketed under these names. The sugilite controversy is such that both commercial parties—those marketing the stone as Royal Lavulite and those selling it as Royal Azel—claim to control the world's supply and, consequently, to have more of the top-grade material. As a result, the author indicates, this relatively new gem is becoming engulfed in a confusion of commercial interests.

Gemologists will find this account fascinating not only for the information about sugilite, but also for the description of what happens when a new deposit or new gem material is discovered. *JCL*

Travels in China. P. Read, *Canadian Jeweller,* Vol. 102, No. 6, 1981, pp. 134, 135, 137.

In this description of his recent trip to China, Mr. Read focuses on the jewelry trade in Peking, beginning with his visit to the main office of the China National Arts and Crafts Corporation. This corporation consists of six divisions: (1) a hardstone jewelry department that sells polished and carved tiger's-eye, rose quartz, agate, turquoise, jade, and lapis-lazuli; (2) a gold jewelry department that sells 14K, 18K, and 24K gold jewelry set with gemstones; (3) a silver jewelry department that deals in gold-plated silver filigree ornaments and antique silver jewelry; (4) a costume jewelry department that specializes in enameled copper jewelry and enameled cloisonné horses; (5) a gems and pearls department that sells loose gemstones; and (6) a petit-point department that deals in handbags, eyeglass cases, and the like.

Having read articles describing China's deposits of diamonds, rubies, and sapphires, Mr. Read was eager to see examples and perhaps even visit the sources. He was disappointed, however, when the corporation's employees either professed to be unaware of such occurrences or expressed the opinion that Chinese rubies and sapphires were small and of poor quality. Nor was he able to substantiate the reports of kimberlites in the south and west. He was also unable to see any of the Chinese diamond-cutting operation in Peking, because the factory is out-of-bounds to visitors.

In a section entitled "Doing Business," Mr. Read describes the difficulties he encountered dealing with a foreign language, interpreters, and foreign customs. He gives a few pieces of advice: the "pecking order" of a group is assumed from the order in which its members enter the room or are introduced; you should remain standing until your host invites you to sit down; the drinking of green tea is a necessary business ritual, as are the formal "banquet" provided by the host and

the dinner given in return by the guests; expertise with chopsticks earns a bonus mark.

The author concludes with his impression of China and Chinese gemology. He felt that the surprisingly basic questions asked after his talks illustrate the isolation of the Chinese from the mainstream of gemological knowledge. But he feels that they are now eager to catch up with Western technology, and that they have traditional artistry and craftsmanship to offer in trade. *ET*

SYNTHETICS AND SIMULANTS

Characterization of crystals with gem application. M. O'Donoghue, *Progress in Crystal Growth and Characterization*, Vol. 3, 1981, pp. 193–209.

In his introduction, O'Donoghue states that the purpose of this article is to bridge the gap that exists between gemologists and crystal-growth scientists. The gemologist is interested in separating natural from synthetic gemstones, while the crystal-growth scientist is attempting to produce material with particular properties. In sections organized by the method of crystal growth, he reviews the historical development of the different processes and describes the mechanics of each.

O'Donoghue emphasizes the separation of the natural stone from the synthetic or the diamond from the diamond simulant, pointing out the varieties of inclusions found in each. Following the bibliography, he includes 11 line drawings of the common types of identifying inclusions. *DMD*

Polymeric synthetic opal (in Japanese). A. Kose, *Gemmological Review*, Vol. 3, No. 5, 1981, pp. 2–7.

Noting the advances made in the creation of synthetic and substitute gemstones, Akira Kose, author and researcher in colloid chemistry at the Institute for Applied Optics in Tokyo, explains that opal synthesis was first made possible in the 1960s. Man-made products can be divided into two groups: (1) those that have the same chemical composition as the natural, referred to as synthetics; and (2) those that duplicate natural beauty but have a different chemical structure, referred to as simulants. Kose's highly technical article focuses on an analysis of the institute's own polymeric opal simulant, which has the chemical composition of styrene-divinyl-methacrylate.

The process involves combining styrene-divinyl benzene copolymer with polymethyl methacrylate. Through the stages of mixing the ingredients, emulsion, and sedimentation, a closely packed structure of microspheres results. Sedimentation from the white, milky emulsion state takes up to one year, and provides an excellent case study for explaining crystallization and changes of matter. Dissatisfied with existing theories, Kose and his colleagues concentrated their search on new theories, which led to this process.

The final polymeric opal-like product closely resembles natural white opal with a beautiful play of color. The diameter of the microspheres is in the 2000–5000 Å range, compared with the 2000–3000 Å range for natural opal. Kose enumerates the other characteristics of this opal simulant, including specific gravity (1.19), hardness (2.5), refractive index (1.6–1.49), thermoconductivity (slight), and surface character (hydrophobic).

The polymeric simulant maintains its beauty better than natural or synthetic opal, since it contains no water and is more resistant to acids and alkalis. Softening can occur beyond 130°C, but with cooling the stone returns to normal.

Illustrations include one diagram depicting opal structure and four photographs taken at 1500× magnification that detail the crystallization process of the polymeric simulant. *ALS*

Editor's Note: Although the author has titled this article "Polymeric Synthetic Opal," the chemical composition of this material places it in the simulant category.

Report on coloured cubic zirconia. P. Read, *Journal of Gemmology*, Vol. 17, No. 8, 1981, pp. 602–605.

The high luster and dispersion of colored cubic zirconia makes it an attractive and durable gem material, but these properties also prevent it from qualifying as an effective simulant of natural gems other than sphene and fancy-colored diamonds.

Read examined seven colored Ceres crystals grown by the skull crucible process from which faceted stones were cut and also studied for their properties. The specific gravity of these stones ranged from 5.95 to 6.06, although the range has been reported from 5.54 to 5.95. This deviation may be attributed to the stabilizer (Y_2O_3) employed in the Ceres product. Refractive index ranged from 2.09 to 2.18. Luster tested on a reflectivity meter was consistently lower than on colorless specimens, but thermal conductivity was virtually the same.

Fluorescence to long-wave ultraviolet radiation varied, depending on the color of the crystal. The pink crystals fluoresced yellow-green, the orange crystal red, and the lilac a bright peridot green, while the other colors (red, green, brown, and purple) were inert. Short-wave ultraviolet radiation caused a faint green fluorescence in the pink and lilac crystals, a pink fluorescence in the orange cyrstal, a pale green and pale brown in the green and brown crystals, with other colors being inert. No phosphorescence was displayed to either long-wave or short-wave ultraviolet radiation.

Characteristic absorption spectra for the seven crystals are illustrated and indicate that rare-earth dopants were used in their manufacture. Prominent spectral lines were caused by the oxides of cerium in the orange and red varieties, and by the oxides of erbium and neo-

dymium in the pink and lilac crystals. The purple color may be due to ferrous oxides, while the olive-green and light brown shades might be due to the use of transition elements. Other manufacturers have employed oxides of terbium to produce various shades of green, and oxides of praseodymium to yield an amber color. Oxides of thallium and holmium have also been used. *ERL*

Synthetic emeralds. G. Brown, *Wahroongai News,* October 1981, pp. 15–19.

This brief review addresses our current knowledge of the growth and detection of synthetic emerald. The first part of the article includes fairly detailed outlines for the growth of synthetic emeralds by molten-flux techniques, the flux-transport growth technique, and hydrothermal growth. These outlines are accompanied by informative diagrams showing the growth apparatus. Following the discussion of synthetic emerald growth techniques, the author reviews the properties of natural emerald versus flux and hydrothermal synthetics. Because inclusions can be so important in the separation of natural stones from synthetics, the author outlines the types of inclusions that can be expected in both. The article then concludes with a comprehensive table for the identification of most known synthetic emeralds. However, no reference is made to synthetic emeralds from Japan or the U.S.S.R.

Peter C. Keller

Editor's note: Abstracts of articles that discuss the hydrothermal and flux-grown emeralds from the Soviet Union as well as synthetic material from Japan appear in this section of the Summer 1981 issue of Gems & Gemology.

MISCELLANEOUS

Exposure in jewelry photography. *American Jewelry Manufacturer,* Vol. 29, No. 5, 1981, pp. 84–88.

This article introduces the reader to the particular difficulties associated with photographing jewelry. It specifically addresses the subject of making proper exposures.

Many jewelry items commonly photographed are small, such as rings and brooches. In order to capture the detail of each piece, the camera needs to be brought in closer so that the image fills the picture area. Unfortunately, as the photographer moves in closer to an object, its depth of focus—that is, those areas that are in sharp focus—diminishes. The depth of focus can be increased by closing the lens down to a smaller aperture, f-16 or f-22. However, a serious problem arises from closing the lens down: a longer time exposure is needed because less light reaches the film. The time exposures may vary from 1/60th of a second down to one second and require the use of a tripod.

The last subject discussed is the use of hand-held meters versus the camera's meter. Many studio photographers prefer a hand-held meter in the *incident* mode, which is pointed at the light source rather than the object. Alternatively, the photographer may want to use a Kodak 18% gray card placed at the object in conjunction with the camera's built-in meter. Both methods give the same results—a properly exposed photograph. *Mike Havstad*

The growing pains of gemmology. B. W. Anderson, *Journal of Gemmology,* Vol. 17, No. 8, 1981, pp. 515–521.

On the 50th anniversary of the Gemmological Association of Great Britain, the author briefly reviews milestones in the history of gemology as well as drawbacks (e.g., the former variation in weight of the carat from country to country). Early books on gemstones and gemology were A. H. Church's *Precious Stones* (1883), G. F. Kunz's *Gems and Precious Stones of North America* (1890), Max Bauer's *Edelsteinkunde* (1896), and G. F. Herbert Smith's *Gemstones* (1912). Another stimulus to the science was early lectures, including two in 1897 at the Royal Society of Arts by Professor Henry Miers (who 40 years later became president of the Gemmological Association). The production of Smith's refractometer (first marketed in 1907) and the opening of a pearl and gem testing laboratory (Hatton Garden, 1925) were essential to the development of the science of gemology.

Anderson points to the establishment of gemology "in almost every civilized country" in 1931, with an organization in Germany, a laboratory in Paris, and GIA in the United States. The first "vehicle for the exchange of gemmological information" was *The Gemmologist.* Anderson concludes by mourning the end of that monthly, which left the gemological scene in 1962. *SLD*

The occult powers of gemstones. P. J. Abramson, *Lapidary Journal,* Vol. 35, No. 8, 1981, pp. 1710–1714.

In this well-written article, Abramson pairs popular gemstones with the powers that have been ascribed to them from the Middle Ages to the present. She cites stones that are purported to provide protection against general evils and others that supposedly ward off specific evils: amber and star stones protect against the evils of witchcraft, ruby against infectious diseases, and garnet against skin diseases, while emeralds are said to prevent epileptic seizures. She also comments on the positive powers of stones such as sapphire, which is said to improve intelligence. Some gemstones require special use to release their powers: the wearer of a sapphire must rub his or her tongue over the stone from time to time, and a ruby is most effective when embedded in the flesh. The author describes over 20 stones in this article, which is easily read and is a helpful reference to "powers of gemstones" for the jeweler.

DME

GEM NEWS

Stephanie Dillon, *Editor*

DIAMONDS

Australia. Ashton Mining predicts a total annual production of approximately 20 million cts. by 1986, estimating that about 2 million will come from alluvial deposits by late this year and the rest from the AKI kimberlite pipe at Argyle. Since it has been determined that the southern end of the pipe contains higher-quality diamonds, fewer stones will be produced. An initial production plant will be required to process only 2.25 million tons of material annually, rather than the originally anticipated 5 million tons.

Establishment of a local cutting and polishing industry will depend on whether Ashton decides to market through De Beers or independently.

Belgium. Because of the volume of cut diamonds being imported into Belgium from Russia, Belgian diamond workers in the "smalls" industry of Kempen fear for their survival. The proportion of cut diamonds imported from Russia jumped from15% in the 1977–1979 period to 22% in the first half of 1980. Secretary of State for the Flemish Community Paul Akkermans has stated concern over the situation, but he has thus far ruled out the possibility of import restrictions as damaging to Antwerp's reputation as world diamond trade capital.

Illustrated in figure 1, against a Belgian postage stamp, is a sample of modern-day diamond carving, a faceted reproduction of the head of King Baudouin of Belgium. It was presented to the king by Belgian cutter Robert Meeus. The finished piece measures 10.77 mm × 5 mm × 1.90 mm and weighs 1.03 cts. It was cut from a 2.85-ct. rough crystal.

Among Meeus's other diamond carvings are replicas of the Eiffel Tower, the head of King Hassan II, and one of President de Gaulle, which is displayed in the Louvre. He has also worked on reproductions of Prince Charles and Princess Diana. Diamond cutters use flat crystals to produce any number of fancy shapes, including personalized examples such as this.

Ghana. The Akwatia, Ghana's only remaining producing diamond mine, may be closed this May because of financial problems. Output has dropped to less than half of that produced in the mid '70s, and production to date has been continued by an emergency loan to Ghana Consolidated Diamonds. GCD's Managing Director Harry Parker claims the company's survival depends on more state aid (the government holds 55% of the company) or a major devaluation of Ghana's currency.

Figure 1. Diamond carving of King Baudouin of Belgium, 1.03 cts, by Robert Meeus.

Guinea. Australia's Bridge Oil plans to invest $22 million over the next three years in machinery and equipment for diamond production in Guinea. The lease involves 23,000 km² of the Kissidougou Eanankor section, close to the Sierra Leone border. The deposits, chiefly alluvial, will be worked by the Guinean government (50% shareholder), Bridge (45%), and two other companies, one Swiss and one British (the remaining 5%).

India. Indian diamantaires, concerned that the proliferation of automated cutting and polishing machines may deprive their industry of a portion of the rough traditionally provided by DeBeers, are seeking new sources for rough. Currently 40% of their material comes from DeBeers and 60% comes from Antwerp. The government's Minerals and Metals Trade Corporation has secured an agreement with Ghana and is pursuing new joint ventures with other African countries to increase supplies.

Israel. Following a slump, diamond processing in Israel appears to be reviving, with more than 30 new plants opened in recent months.

South Africa. The Diamond Club of South Africa opened that country's first bourse October 6 of last year. It is

expected to attract traders from other countries as well as raise domestic interest in diamonds.

Sweden. Sunsvall, Sweden, is the location of the first diamond discovery in Europe, made last summer. Two diamonds, each approximately 0.3 mm in length, were found by representatives of the State Geological Research Institute just a few months after they began prospecting.

Taiwan. Ochta Holdings, a South African company, is opening a diamond-cutting plant in the Republic of China which is expected to attain maximum polishing capacity of 10,000 cts. per month by 1984. The company intends to process South African rough for the Far Eastern market.

U.S.A. The General Electric Company announced in February a new method of creating invisible identification marks on diamonds. An ion implanter (a machine ordinarily used to make microscopic electronic circuits) bombards a crystal with a stream of ions. These produce a change in the ability of the material to conduct electricity. A stencil is placed on the diamond before its bombardment, causing the desired pattern (e.g., a number) of electrical conductivity to form. Subsequently, the gem can be rubbed on cotton or silk to build up a charge of static electricity, then dusted with a special powder that clings to the spots of ion implantation, showing the identification mark. The powder can be wiped away. This technique, which GE will make available for licensing, could provide positive and nondestructive identification of stones.

U.S.S.R. Mine shafts being driven at Miniy in Yakutsk represent the first underground diamond operations in the U.S.S.R. Until this time, mining has been done by open-cast methods. The shafts are driven under Siberian permafrost, where the galleries must be artificially frozen, since the earth would be too soft otherwise to support driven shafts. One shaft, from which a high yield is expected, will reach a depth of 1,000 m.

To man the local polishing industry, four Russian schools—in Moscow, Kiev, Barnaul, and Gomel—are training diamond cutters. The one-year course includes crystallography, drawing, and the technology of working with diamonds. The students work exclusively with diamonds, with processing losses reported at just 5% higher than those of experienced workers.

COLORED STONES

Aquamarine from Afghanistan. Dr. Edward Gübelin has followed up his report on gems of Pakistan (see this section of the Fall 1981 issue of *Gems & Gemology*) with a photograph of aquamarine with albite and muscovite from Dassu in Baltistan, Pakistan (figure 2).

Figure 2. Aquamarine with albite and muscovite from Dassu, Baltistan, Afghanistan.

Synthetic Amethyst. Synthetic amethyst offered to dealers as natural is currently causing concern in the jewelry industry. Material produced in Russia has been commercially available since 1970. Recently, the Japanese have also begun to produce and cut synthetic amethyst crystals. Although some specimens are recognizable by "breadcrumb" inclusions, much of the material is indistinguishable from natural, especially in mounted goods. The GIA Gem Trade Laboratory, therefore, does not specify the origin—natural or synthetic—of amethyst on identification reports.

Imitation Opal. Readers may be familiar with the synthetic opal first produced by Pierre Gilson in 1972, which has been marketed since 1974. Now we are indebted to Dr. Edward Gübelin for the announcement, originally published in Moscow, that Siberian and Tadshikian scientists have collaborated to produce synthetic opals in Isfaru, Tadshikistan. Another recent product is discussed in the Gemological Abstracts section of this issue of *Gems & Gemology*.

Israeli Emerald Industry. The largest emerald-polishing center is now Israel, where approximately 50% of the world's production for 1981 was cut. Numerous innovative techniques have been patented by Israeli plants, and domestic educational institutions are cooperating in research and technological training in the field. Ben-Zion Harel, chairman of the Israel Emerald Cutters Association, formed last summer, estimates that 40%–50% of the emeralds sold by jewelers are processed and marketed by Israel. Pointing to the technology behind the rapid development of the industry, he predicts that within two years production quality will be standardized and loss minimized by the use of robots as cutters.

Another Taaffeite. In 1981, a 4.02-ct. light mauve stone from the collection of a resident of Colombo, Sri Lanka,

was identified as taaffeite. The first such stone was discovered in 1945 by Count Taaffe of Ireland. David Dikinas, of Los Angeles, who made the recent discovery, estimates that fewer than 30 of the stones are known to exist.

New Pala Tourmaline Pockets. Four new pockets were revealed last fall at the Himalaya Mine in Mesa Grande, California. Bill Larson, owner of Pala Properties International, reopened the mine three years ago and directed exploration to reach previously undiscovered pegmatite. The pockets were located after 14 months and 715 feet of tunneling. Pink, green, and bi-colored material (figure 3) has been removed, including a number of sizable mineral specimens; less than one per cent of the material is considered suitable for faceting.

INTERNATIONAL GEMOLOGICAL SYMPOSIUM

February 12–15 were the dates of the first International Gemological Symposium, held by GIA at the Century Plaza Hotel in Los Angeles in celebration of the Institute's 50th anniversary. The event was attended by 750 people, representing 35 countries, and was, in the opinion of the participants, outstanding in both effectiveness and content.

The 12 sessions featured 60 noted international gemologists, who examined production, mining, culturing, marketing, treatment, and many other aspects of gemology. The keynote address, "Diamonds Today and Tomorrow," was delivered by G. L. S. Rothschild of I. Hennig & Company, Ltd., the largest brokerage firm for DeBeers' Central Selling Organization. Formal sessions culminated in an audience participation program of questions and answers.

In conjunction with the Symposium, the Los Angeles County Natural History Museum featured an exhibit of the Rainbow Gems Collection of 300 naturally colored fancy diamonds.

Forty-two of the speakers' presentations have been published in a proceedings volume. The talks have also been recorded on tape cassettes. The proceedings and tapes of this unique event are available from the GIA Bookstore, P.O. Box 2052, Santa Monica, California 90406. Telephone: (213) 829-3126.

TUCSON GEM AND MINERAL SHOW

This year, for Tucson's February show, 151 gem exhibitors were stationed at the Marriott Hotel, while 88 members of the year-old American Gem Trade Association occupied booths at the Doubletree Inn. A half dozen other locations contained booths featuring faceting and cabochoning rough, mineral specimens, findings, and lapidary and jewelry manufacturing equipment.

Beryl. Faceted aquamarines from Brazil and Afghanistan were plentiful, as were aquamarine specimens from Idaho.

Figure 3. Himalaya tourmaline mine as seen with miners' lamps. Photograph by Mike Havstad, GIA Gem Media.

There were very fine emeralds from Pakistan and Afghanistan in addition to those from Colombia. A new feature was the presence of a quantity of African emeralds in large and calibrated cuts offered by dealers from Israel.

Red beryl was present chiefly in mineral specimens, but some cut stones were available.

Corundum. There were many fine cut Umba River (East Africa) corundums, usually in sizes of one carat and under. These were in all colors, both faceted and en cabochon, some showing a change of color (usually blue to violetish blue).

Medium-quality rubies from Pakistan were on display.

Suddenly this year, there were trays full of the hitherto very rare orange sapphires. Pink and yellow sapphires were also in abundance. The presence of so many of these stones, reportedly from Burma and Ceylon, suggests the possibility of a newly discovered source or, perhaps, that color treatment is becoming either more widespread or more sophisticated.

Garnet. Orange garnets were plentiful, as were rhodolites, reportedly from Tanzania.

A number of large cut tsavorites were displayed. These may have been from old stock, but a plentiful supply of tsavorites up to one carat in size is predicted by mine owners.

Malachite. Malachite was on display in the mineral exhibit. There were many very fine stalactitic specimens of this mineral.

Pearl. Surprising to Tucson habitues was the quantity of pearls on display. In addition to strands of fresh-water cultured pearls from China, there were some from Japan's Lake Biwa and strands of 2- to 8-mm Japanese salt-water cultured *akoyas* (cultured over mother-of-pearl nuclei). Individual natural pearls from Tennessee were shown in sizes ranging from seed pearls of 2 mm to stones of 20 to 30 mm. The colors displayed included white, gold, pink, lavender, purple, bronze, and black. There were a few South Seas naturally colored black cultured pearls and some of treated color. A fair amount of the Chinese fresh-water product shown appeared to be dyed.

Peridot. Some fine peridots from Burma and from the San Carlos mine of Arizona were shown.

Spinel. Spinels of all colors were plentiful, including a few 10-ct. and "ruby" red stones.

Spodumene. Pink spodumene from Afghanistan was displayed primarily as rough material. There were also cut stones of Brazilian kunzite.

Sugilite. The purple stone introduced at Tucson last year was shown in quantity, in rough form and en cabochon, with the more translucent material faceted. Trade names are Royal Lavulite and Royal Azel.

Tanzanite. There were few fine tanzanites in evidence, and those available apparently came from old stock, inasmuch as little material is being brought out of Tanzania at present.

Topaz. Topaz was abundant in light blue stones and in yellow to orange colors. Because of recent concern over some marketed topaz emitting radiation (see the article by Robert Crowningshield in the Winter 1981 issue of *Gems & Gemology* for further information on this subject), a representative of the Nuclear Regulatory Commission examined numerous materials with a geiger counter. Dealers were universally cooperative in submitting stock for testing. All material proved acceptable by commission standards.

Tourmaline. Green tourmaline from Zambia was plentiful. There were a number of coppery earth colors in stones from Mozambique. There was also an unusually large quantity of fine colored rubellite, reportedly from a Brazilian source discovered last November. Tourmaline mineral specimens from Nuristan, Afghanistan, were displayed, as were tourmaline carvings from Idar-Oberstein.

ANNOUNCEMENTS

The Canadian Gemmological Association has announced that, in affiliation with the Gemmological Association of Great Britain, it has opened a course leading to a Diploma in Gemmology and Fellowship in the Canadian Gemmological Association. The course is available through correspondence and through evening classes held in Toronto. Registration for 1982 closes September 30. For further information, write to: The Registrar, Canadian Gemmological Association, Box 1106, Station "Q," Toronto, Ontario M4T 2P2.

The Adiel Steacy Memorial Scholarship is offered annually and is open to a resident of Brockville, Ontario, Canada, who needs aid to study gemology. The scholarship provides up to $2,500 for the recipient, who is expected to seek employment in the Canadian jewelry industry upon the completion of his studies, to attend GIA or its equivalent in Canada. Should no application be made by a Brockville resident, other residents of Ontario will be considered. Applications may be submitted to the Assistant Registrar (Student Awards), Queen's University, Kingston, Ontario K7L 3N6, prior to July 1.

The Henry H. Harteveldt, Jr. Scholarship, to cover the cost of the Resident Course in Diamonds at GIA's New York facility, is offered by the institute. It will be granted on the basis of financial need and the individual's desire to become a professional jeweler. Deadline for application is August 15. Applications are available through the Scholarship Office, GIA, P.O. Box 2110, Santa Monica, CA 90406.

Gems & Gemology welcomes news of exhibits and events of a gemological nature. Please contact Stephanie Dillon, Gemological Institute of America, 1660 Stewart St., Santa Monica, CA 90404. Telephone: (213) 829-2991.

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