Gems & Gemology

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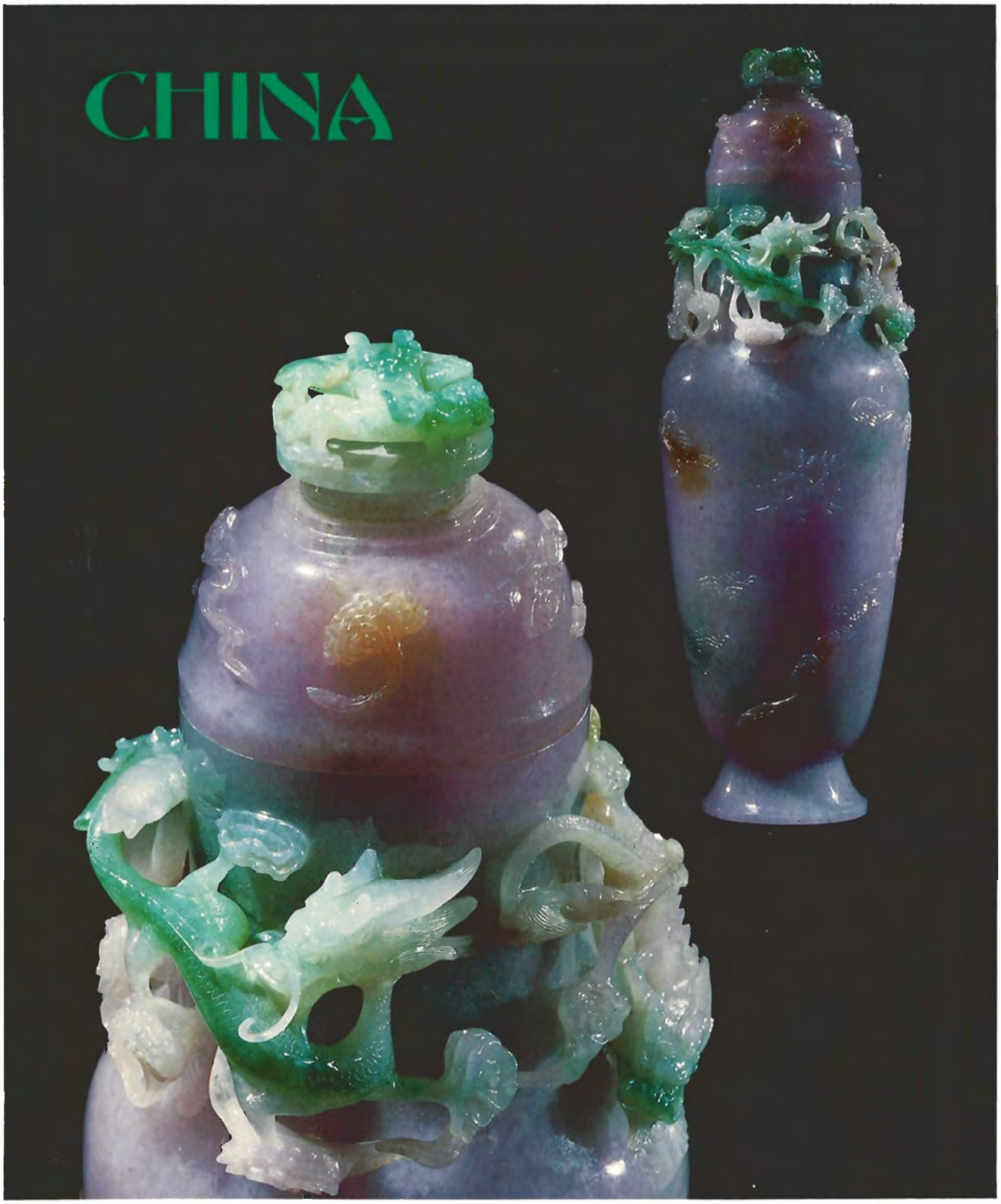

The quarterly journal of the Gemological Institute of America

SPRING 1986
Volume 22 Number 1

Gems & Gemology

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ABOUT THE COVER: For generations, China has been best known among gem enthusiasts for the spectacular pieces produced by its master carvers using jadeite and other ornamental materials. This extraordinary jadeite vase (35 cm high) illustrates the level of sophistication attained during the Ch'ing Dynasty (1644–1912). The article by Sally A. Thomas and Hing Wa Lee in this issue traces the history of gemstone carving in China from ancient to contemporary times. Interestingly, though, there is no jadeite in China; the stone was first imported from Burma in the late 18th century. The other articles in this special issue discuss the many gem materials that are currently found in the People's Republic of China, including diamond, sapphire, turquoise, and peridot. This vase is part of the collection at the Smithsonian Institution, Washington, DC. Photo © 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 in the Spring 1985 issue of the journal, or contact the editor for a copy. Letters on articles published in *Gems & Gemology* and other relevant matters are also welcome.

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CHINA

Spanning more than 3.5 million square miles and supporting more than one billion people, China is undeniably one of the most important countries in the world today. Yet, as a result of political and economic turbulence that has plagued the nation throughout most of the 20th century, relatively little is known about the existing and potential natural resources of this vast and geologically complex region. Gem resources, in particular, have been a low priority for the government of the People's Republic of China and its exploration agencies.

In recent years, however, the need for foreign exchange to finance development projects and introduce new technology has generated significant interest among the Chinese in determining and exploiting the country's gem wealth. One consequence of this new interest in gems was the invitation extended to *Gems & Gemology* Associate Editor Peter C. Keller and Editor Alice S. Keller to lecture on gemological topics at the Geology Museum in Beijing (Peking) in September of 1985 and subsequently visit and study the diamond-mining operation at Changma and the sapphire deposits at Mingxi. With the invaluable cooperation of Dr. Wang Fuquan, of the Geological Museum, and Mrs. Wan Guo-dong, of the Jinan Bureau of Geology and Mineral Resources, Dr. Keller was able to prepare the first comprehensive article in recent Western literature on the gemstone resources of China and the diamond-mining operation at Changma, as well as an introduction to the Mingxi sapphire locality. Detailed gemological studies of two gem materials currently being mined in economic quantities in China, turquoise and peridot, are provided by Dr. Wang and by John Koivula and C. W. Fryer, respectively.

Because it is impossible to discuss the impact of China on the gemological community without considering the carvings and carving materials for which the country has long been known, we are pleased to be able to include the article by Sally Thomas and Master Carver Hing Wa Lee on the history and current status of gemstone carving in China.

We readily acknowledge that, for the most part, information contained in these articles is preliminary, just as the work of the Chinese in the field of gems is still in its infancy. We hope, though, that this issue will serve as an introduction to this fascinating area and as a stimulus to additional research and writing on the gemstone resources of what has heretofore been one of the most enigmatic regions in the world.

Richard T. Liddicoat, Jr.
Editor-in-Chief

THE GEMS & GEMOLOGY MOST VALUABLE ARTICLE AWARD

Alice S. Keller, Editor

Gems & Gemology is pleased to announce the winners of its 1985 Most Valuable Article Award. This year's winning article was "A Proposed New Classification of Gem-Quality Garnets," written by Carol M. Stockton and D. Vincent Manson. This article represents the culmination of more than five years of research in this area. Keith Proctor was awarded second place for his two most recent articles in the series on the gem pegmatites of Minas Gerais Brazil: "The Tourmalines of the Araçuaí Districts" and "The Tourmalines of the Governador Valadares District." Capturing third place was "A Status Report on Gemstones from Afghanistan," written by Gary W. Bowersox.

Cash awards of $500, $300, and $100, respectively, will be awarded to these first-, second-, and third-place winners.

CAROL M. STOCKTON

Ms. Stockton is senior research gemologist specializing in chemical and spectral analysis in the GIA Research Department, Santa Monica, California. She is both a graduate and a certified gemologist, and received a B.A. in anthropology from the University of California, Los Angeles. She is also the technical editor for *Gems & Gemology*.

D. VINCENT MANSON

Dr. Manson is director of education at GIA. He received his B.S. and M.S. in geology from the University of Witwatersrand in South Africa, and his Ph.D. in geology from Columbia University. Immediately prior to joining GIA in 1976, Dr. Manson was curator of minerals and gems at the American Museum of Natural History in New York.

KEITH PROCTOR

As president of Keith Proctor, Fine Gems, of Colorado Springs, Colorado, Mr. Proctor is actively involved in the wholesale importing of colored gemstones and the design of custom-made jewelry. He is internationally known for his collection of museum-quality minerals with special emphasis on gem crystals, many of which were obtained during his extensive travels in the mining regions of Brazil.

Mr. Proctor received an M.S. in molecular biology from the University of Colorado.

GARY W. BOWERSOX

Mr. Bowersox is president of Gem Industries, Inc., in Honolulu, Hawaii. He has traveled to the Afghanistan-Pakistan area several times during the past decade, and is involved in buying and cutting gem materials from all over the world. Mr. Bowersox entered the jewelry and gemstone industry after several years in the accounting profession.

A SURVEY OF THE GEMSTONE RESOURCES OF CHINA

By Peter C. Keller and Wang Fuquan

The People's Republic of China has recently placed a high priority on identifying and developing its gemstone resources. Initial exploration by teams of geologists throughout China has identified many deposits with significant potential, including amber, cinnabar, garnets, blue sapphires, and diamonds. Small amounts of ruby have also been found. Major deposits of nephrite jade as well as large numbers of gem-bearing pegmatite dikes have been identified. Significant deposits of peridot are currently being exploited from Hebei Province. Lastly, turquoise rivaling the finest Persian material has been found in large quantities in Hubei and Shaanxi Provinces.

ABOUT THE AUTHORS

Dr. Keller, a geologist and gemologist, is associate director of the Los Angeles County Museum of Natural History, Los Angeles, California; Dr. Wang is a mineralogist and gemologist at the Geological Museum, Beijing, China.

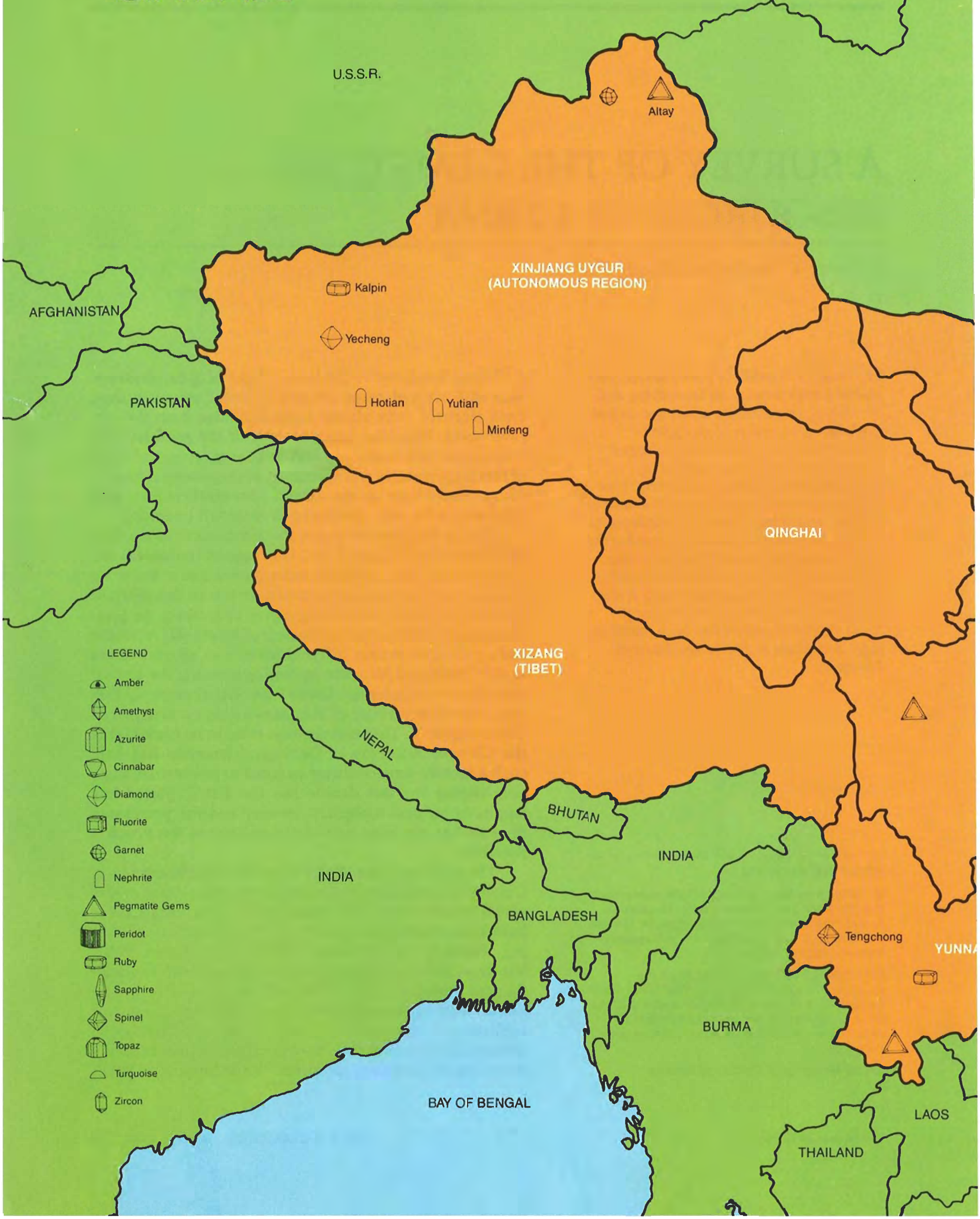
Acknowledgments: The authors thank the Geological Museum in Beijing and the Academy of Geological Sciences for inviting Dr. Keller to China. Dr. John Sinkankas was especially helpful in obtaining historical references on Chinese gem deposits.

China has historically been a land of great mystery, with natural resources and cultural treasures that, until recently, were almost entirely hidden from the outside world. From the point of view of the geologist and gemologist, one could only look at known geological maps of this huge country and speculate on the potential impact China would have on the world's gem markets if its gem resources were ever developed to their full potential.

During the past few years, the government of the People's Republic of China (P.R.C.) has opened its doors to the outside world in a quest for information and a desire for scientific and cultural cooperation. It was in this spirit of cooperation that a week-long series of lectures on gemstones and their origins was presented by the senior author and a colleague to over 100 geologists from all over China at the Geological Museum in Beijing (Peking). An important outcome of informal discussions with these geologists was a distribution map of the known gem occurrences in China (figure 1). This was the first time in its history that the Chinese Academy of Geological Sciences had held such a lecture series entirely devoted to gemstones, since only during the last decade has the P.R.C. placed any emphasis on gem materials. Jewelry and the possession of gems has not been part of the culture of the People's Republic.

The purpose of this article is to offer a brief overview of China's important gem resources as we know them at this very formative stage. There have been a number of articles both historically and recently on China's gem resources (e.g., Pumpelly, 1866; Ahnert, 1929; Sun, 1933; Ren, 1980), but these have concentrated for the most part on ornamental gem materials used in Chinese carvings. This article intentionally disregards most of these materials, except for nephrite and turquoise, in favor of materials that can be faceted and therefore may have the greatest impact on the world's gem markets in the future. While this article can in

CHINA


U.S.S.R.
Altay
XINJIANG UYGUR
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BANGLADESH
Tengchong
YUNNA
BURMA
BAY OF BENGAL
LAOS
THAILAND
LEGEND
Amber
Amethyst
Azurite
Cinnabar
Diamond
Fluorite
Garnet
Nephrite
Pegmatite Gems
Peridot
Ruby
Sapphire
Spinel
Topaz
Turquoise
Zircon

Figure 1. Map showing location of major known gem occurrences in the People's Republic of China. Because precise locations were not available for all deposits mentioned in the text, only those occurrences that could be placed with reasonable accuracy are included here. The spellings used are from Grosvenor (1980).

no way be considered definitive, we hope that it will serve as both an introduction and a stimulus to further research and exchange of information in this area.

AMBER

Large quantities of spectacular fossil insect- and plant-bearing amber have been recovered from the Fushun Coalfield, in the eastern part of Liaoning Province*, in northeastern China. According to Hong (1981), the amber occurs in the Eocene-age main coal seam of the Guchengzi Formation. To date, 44 species of fossil insects (figure 2) have been described from the Fushun amber. Of these 44 species, 41 were previously undescribed.

The Fushun amber is found as transparent to translucent irregular masses up to 10 cm thick. The material ranges in color from light yellowish brown to yellowish brown to yellow and occasionally occurs as pink or deep red. The amber is commonly used for jewelry; larger pieces may be carved. The Chinese also grind up amber for its perceived medicinal value in relieving stomach ailments.

Recently, amber was discovered in coalbeds near the city of Fuzhou in Fujian Province, southeastern China. No information on the quality and quantity of the Fujian amber is available at this time.

CINNABAR

Since the late 19th century, mineral collectors have considered China synonymous with the mercury sulfide, cinnabar. The world's finest cinnabar crystals, some as large as 6.5 cm, have come from the Wanshanchang mines on the border of Hunan and Kweichow Provinces. These mines have been active since the Ming Dynasty (14th century), and have employed up to 5,000 workers at a time.

The cinnabar ore occurs in two horizons, 5–6 m thick, in a brecciated limestone. These horizons outcrop on the steep sides of Wanshanchang Canyon. According to Tengengren (1920), one of the few Westerners to have visited the mines, the canyon is filled with wasterock from the mining operation. This wasterock has been thoroughly searched in recent times for overlooked ore.

**For the sake of consistency, place names given throughout this article and in the map in figure 1 are spelled in accordance with the* National Geographic *map prepared by Grosvenor (1981).*

Figure 2. Fossil insect in amber from the Eocene-age coal seams of the Fushun coalfield in Liaoning Province, China. This specimen measures approximately 10 cm across.

The deep red cinnabar crystals almost always occur as sharp rhombohedral penetration twins. Single, untwinned crystals are considered quite rare. Typically, the cinnabar crystals are found on a limestone matrix with transparent to translucent crystals of dolomite and quartz.

Cinnabar is the principal ore of mercury. In addition to its industrial value, the Chinese use it for medicinal purposes and as a pigment for paint, ink, and dyes. Cinnabar is also used as a coloring agent in lacquer applied to wood carvings. Massive cinnabar in limestone is a very desirable carving material among the Chinese.

Some of the larger cinnabar crystals have been faceted for the collector (figure 3). These stones are generally under 3 ct, although gems up to almost 25 ct have been recorded. These rich red stones have an adamantine to submetallic luster. Because cinnabar has a hardness of only 2–2.5 on the Mohs scale and is quite brittle, it is extremely difficult to facet. Furthermore, cinnabar is light sensitive, and will darken dramatically after prolonged exposure to sunlight.

CORUNDUM

Corundum, principally in the form of gem sapphire, occurs in several areas of China. The most important are the Penglai and Wenchang areas of Hainan Island, in the South China Sea, and the Mingxi area in west-central Fujian Province. A more detailed account of the Mingxi sapphire deposit is presented by Keller and Keller (1986). Sapphire has also been reported from southeast Jiangsu Province, but little information is available on this deposit.

The sapphire deposits on Hainan Island and at Mingxi are still relatively undeveloped, although they show great potential. In both instances, the deposits are thought to be the alluvial residue of alkali basalt deposits not unlike those found in Thailand and Cambodia (Jobbins and Berrangé, 1981) and in Australia (Coldham, 1985). Colorless to pale yellow zircon and dark red pyrope are common accessory minerals. The sapphires themselves look very much like those found in the alluvial deposits at Anakie, Queensland, and the New England area of New South Wales, Australia. They tend to be less than 1 cm in length and inky bluish green to greenish blue in color, although the transparency is generally good (see photo in Keller and Keller, 1986). Active geological exploration of both areas is underway, as is experimentation with heat treatment to improve the color of the sapphire. China has the potential to become a major supplier of sapphire to the world's gem markets.

It should be noted that perfect hexagonal prisms of translucent ruby up to 1 cm long are being recovered from little-known deposits in Sichuan Province (figure 4). Undescribed ruby has also been reported in gneiss in far western Xinjiang Uygur Autonomous Region, and in the Ailao Mountains of Yunnan Province.

DIAMOND

Perhaps no gem species evokes more excitement than diamond when one discusses the future gem potential of China. And for good reason: China has

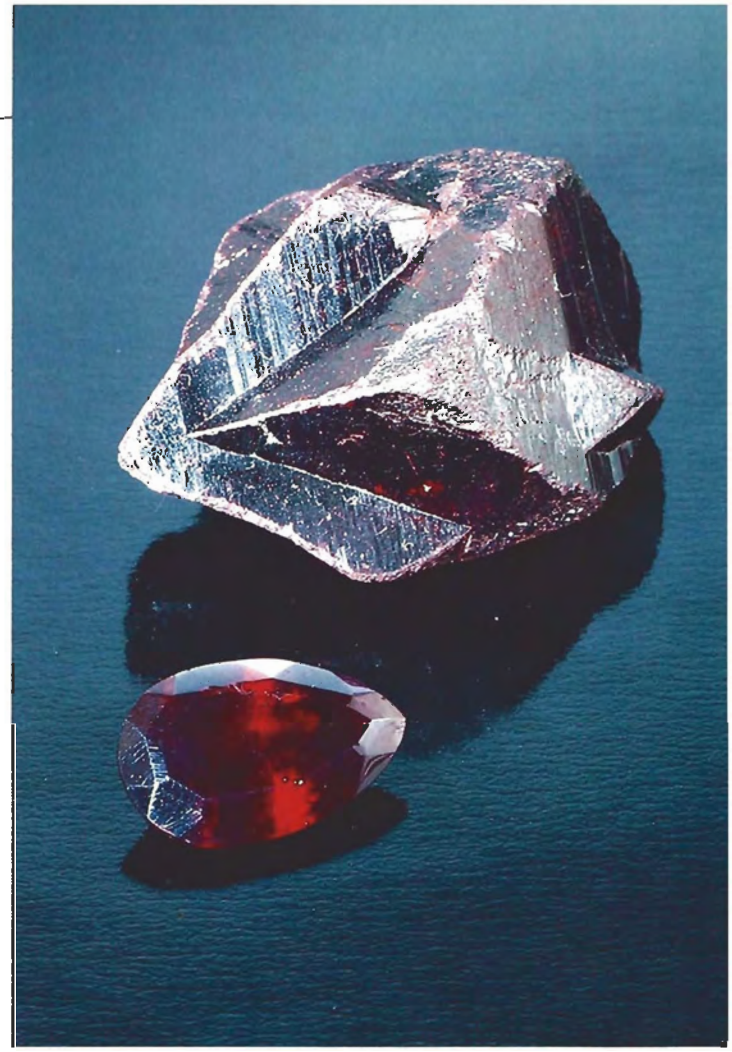

Figure 3. This cinnabar crystal and its 5-ct faceted mate come from the Wanshanchang mines on the border of Hubei and Kweichow Provinces, China. Stone faceted by Arthur Grant; photo © Tino Hammid.

Figure 4. Hexagonal prisms of ruby averaging 5 mm in length from Sichuan Province, China. Photo by S. Gipson.

Figure 5. To date, the largest gem-quality diamond found in China is the 158.79-ct Changlin diamond. This brownish yellow diamond was found in 1977 on the Jishan People's Commune in Linshu County, Shandong Province, China. Photo courtesy of the Geological Museum of China, Beijing.

the potential, from both kimberlites and their associated alluvial deposits, to play a significant role in world diamond production. The importance of this diamond potential, as is the case with most of China's other gem resources, is only now being realized. Alluvial diamonds have been found in China since at least the late 1940s. However, it was not until 1965 that diamonds were found in their kimberlite host.

Today there are two principal diamond-bearing kimberlite districts in China: the Fuxian district, in southern Liaoning Province, and the Changma district near Mengyin, in central Shandong Province. Very little has been published in the West on these two diamond-bearing kimberlites, although the Seventh Geological Exploration Team (1984) has published a paper in Chinese on the area.

A detailed description of the Mengyin-area diamond deposits, based on a recent visit, is discussed in Keller and Wan (1986). An excellent overview of Chinese kimberlites is found in He (1984).

As noted above, alluvial diamonds have been known in China for at least 40 years. We know of several major alluvial diamond-producing areas today. These include the Linshu and Tancheng counties south of Mengyin in Shandong Province, and the Yuan River, near Yuanling, in Hunan Province. In addition, alluvial diamonds have been found in southeastern Xinjiang Uygur Autonomous Region.

It is too early to say much about China's gem diamond potential in terms of annual production. A reasonable, educated guess of that figure would be about 45,000–75,000 ct per year. What is impressive, however, is the size of some of the diamonds recovered to date. The largest known gem-quality diamond found in China thus far is a gemmy 158.79-ct brownish yellow modified rhombic dodecahedron known as the Changlin diamond (figure 5). This impressive diamond was found by a farmer in December 1977 on the Jishan People's Commune at Changlin in Linshu County, Shandong Province. It is interesting to note that no further exploration of the immediate area where this crystal was found has been attempted. In August 1981, the second largest diamond from China, the 124.27-ct Chengfu No. 1 diamond, was found in Tancheng County, Shandong Province. Both diamonds were found in alluvial gravels that quite possibly derived from the Changma kimberlites located about 100 km to the north. The third largest gem-quality diamond known from China, and the largest from a kimberlite, is the 119.01-ct diamond discovered in the Victory No. 1 pipes near Mengyin (Keller and Wan, 1986). This diamond was named Mengshan No. 1.

Although the diamond industry in China is still in its infancy, the Chinese government is committed to its rapid development. Literally thousands of geologists are currently prospecting for new deposits throughout China. It is perhaps significant that in November 1985 these geologists were joined by geologists from De Beers.

GARNET

Large numbers of chrome-bearing pyrope garnets occur in Quaternary alluvial deposits near Donghai, in northern Jiangsu Province, eastern China (Wang, 1984). These garnets were probably derived from the diamond-bearing kimberlites that occur in the Mengyin area of Shandong Province, about 130 km northwest of Donghai. Numerous alluvial diamond deposits have been identified between Donghai and Mengyin.

The pyrope garnets found near Donghai are generally very dark red and less than 1 cm in diameter (figure 6). They are commonly transparent and, because of their chromium content, many exhibit a distinct purple to red color change. The relatively small size of the Donghai pyropes limits their use in jewelry, although the Chinese Gem and Mineral Development Company is considering cutting the material as melee. Pyrope garnets have also been found to occur with sapphire and zircon near Mingxi in Fujian Province (see Keller and Keller, 1986), but thus far no attempt has been made to determine the economic potential of this material.

Other types of garnet found in China include grossular, demantoid, rhodolite, and spessartine. The grossulars occur in green, yellowish green, yellowish brown, and brownish red hues. Fine crystals larger than 3 cm in diameter have been encountered from Altay, in Xinjiang Uygur Autonomous Region, where they occur in contact metamorphic rock deposits. Gem-quality demantoids of jade green to yellowish green hues have also been found in Xinjiang Uygur Autonomous Region. The crystals occur in serpentinized pyroxene-peridotites, in association with chrome spinel and asbestos, and are generally less than 3 mm in diameter. The Altay pegmatite mines have produced some spessartine; the authors were recently shown a 13-cm corroded crystal of gem spessartine similar to material from the pegmatites of Minas Gerais, Brazil, and Amelia, Virginia.

Figure 6. These faceted pyrope garnets from near Donghai in northern Jiangsu Province, China, average 0.20 ct each. Stones faceted by William C. Kerr; photo © Tino Hammid.

NEPHRITE

The term *jade* in China is often used to describe many different materials suitable for carving. For the purpose of this article, we will limit our discussion to nephrite jade. There are no known deposits of jadeite jade in China today, although the Burmese deposits of jadeite have been of great commercial interest to the Chinese since the late 18th century.

By far the most important nephrite deposits in China are found on the northern slopes of the Kunlun Mountains in southern Xinjiang Uygur Autonomous Region. The principal mining centers are near the towns of Hotan, Yutian, and Minfeng. Historically, the nephrite was found as alluvial boulders near the base of the mountain. Recently, however, a contact replacement zone of nephrite was found in place in the Kunlun Mountains at an elevation of 3,000 m (Wang, 1979). Generally, the individual deposits of *in situ* nephrite were small, consisting of irregular or banded masses.

The nephrite from the Kunlun Mountains does not differ significantly from that found in other regions of the world, such as Canada, the Soviet Union, and New Zealand. It consists of very fine grained, compact masses of tremolite and actinolite. The nephrite in the Kunlun Mountains occurs in a great variety of colors, spanning the entire spectrum. While green is the most common color, the most desirable to the Chinese is the white or "mutton fat" nephrite (figure 7). Nephrite from this area may also be called Hetian or Khotan jade, presumably referring to specific mines in the area.

Nephrite has also been reported from a number

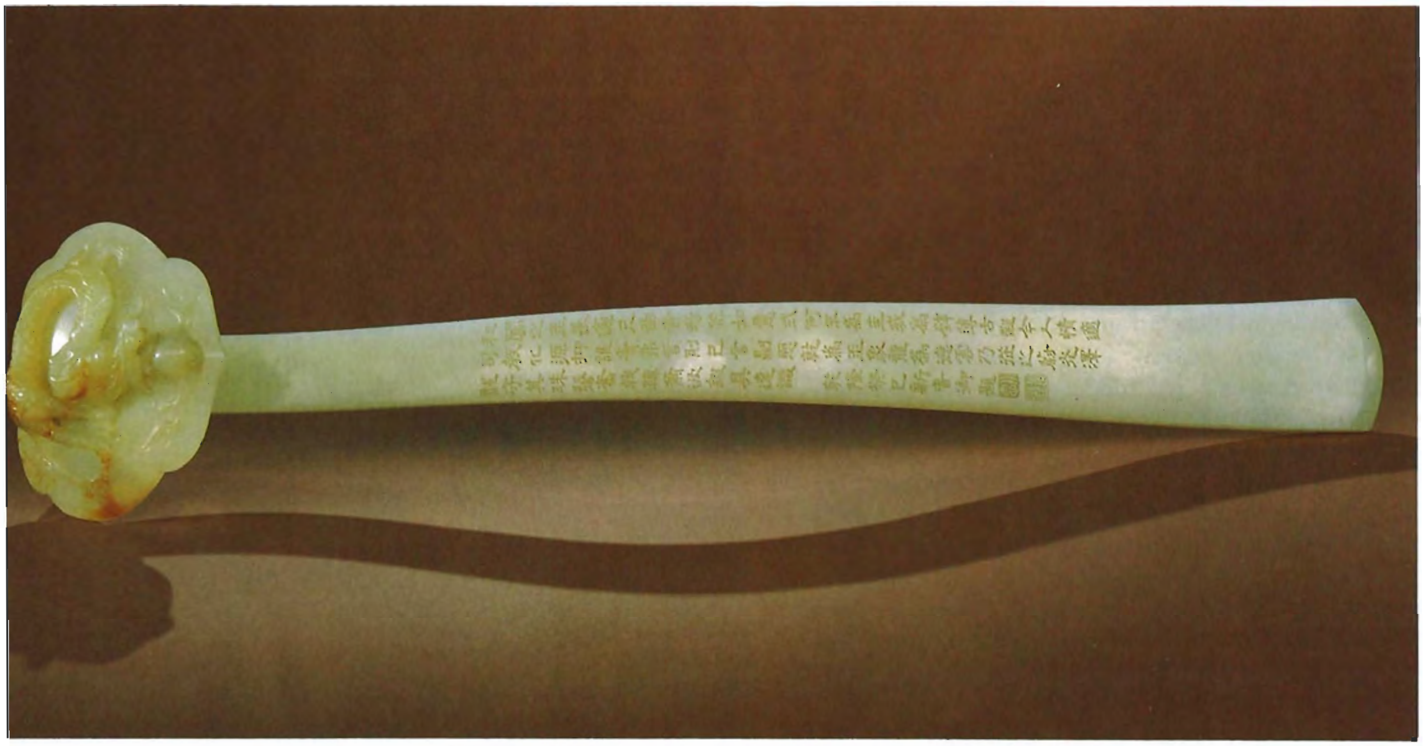

Figure 7. This late 18th-century ruyi *(34 × 8 cm) was carved from "mutton fat" jade. Courtesy of the Cyrstallite Collection; photo © Harold & Erica Van Pelt.*

of other localities. For example, Wang (1979) reports a green nephrite known as "Sister to Kunlun Jade" from near Manas, north of the Tian Mountains, in northwestern Xinjiang Uygur Autonomous Region. Nephrite also occurs in Sichuan Province and in Taiwan. There are reports of nephrite in Liaoning Province; however, this locality is for the most part unconfirmed and may very well represent a deposit of nephrite-like material. One example is cited in the April 3, 1984, issue of the *China Daily.* The front page photo shows a human chain around the "King of Jade," a 260.75-ton boulder extracted from the Xiuyan Jade Mine in Liaoning Province. It is questionable whether the "King of Jade" is indeed nephrite or one of its many simulants.

Figure 8. These fragments of a 1-cm in diameter rubellite tourmaline crystal (left) and a 1-cm in diameter aquamarine crystal (right) are from the Altay pegmatite district in Xinjiang Uygur Autonomous Region. Photo by S. Gipson.

PEGMATITE GEMS

Granitic pegmatites are known throughout China, although only those that occur in the northwest-southeast trending Altay Mountains of northern Xinjiang Uygur Autonomous Region are known to produce significant quantities of gem materials. Thousands of pegmatite dikes have been reported in the Altay Mountains (Chen Wen-ao, Xinjiang Altay Gemstone Technological Company, pers. comm., 1985). Of these, however, only those found just east of the city of Altay have been developed for their gem minerals.

According to Liu (1981), the Altay pegmatite region can be divided into more than 39 pegmatite provinces. The pegmatite dikes are concentrated along the contacts with the predominantly schist or gneiss country rock. As is common to granitic pegmatites elsewhere, the Altay pegmatites are concentrically zoned. Liu (1981) divides the pegmatites into nine zones, although these could be simplified into the four commonly reported zones: an aplitic (sugary) border zone; the thicker, more coarsely crystalline well zone containing abundant muscovite, feldspar, and beryl; an intermediate zone containing very large crystals of quartz, feldspar, mica, and some gem minerals; and, finally, the core zone consisting of massive quartz and feldspar. Most of the gem material recovered to date has been recovered from the primary pegmatite rather than from secondary deposits.

A total of 74 minerals have been reported from the Altay pegmatite dikes. Many of these are rare minerals such as ixiolite, but almost all of the gem minerals that one associates with pegmatites—i.e., tourmaline (figure 8), spodumene, beryl (figure 8), spessartine garnet, smoky quartz, and moonstone—have been found. Fine gem topaz appears to be absent from the Altay area, although very fine pale blue-green and rich yellow to red topaz crystals up to 24 cm in length have been found in the Xilingeleimeng of Inner Mongolia Autonomous Region, as well as in southern Yunnan Province.

It should also be noted that very fine tabular aquamarine, morganite, and goshenite crystals up to 5 cm in diameter have been recovered from pegmatites in Sichuan Province in central China.

To date, of all the Altay pegmatite gems, the various colors of beryl have shown the greatest commercial promise. Greenish yellow gem-quality beryl crystals up to 15 cm long and 5 cm wide have been seen by the authors. Large quantities of pale blue, finely developed aquamarine crystals have also been recovered and have, in fact, been observed on the mineral specimen market in the United States. It is unfortunate that until only recently, many of the beryl crystals were recovered for their industrial rather than gem value. The Altay pegmatites have yielded industry-grade beryl in crystals over 52 cm in length.

The Altay pegmatites have also produced gem tourmaline in red, green, yellow, and (in rare instances) blue hues. Gemmy pink tourmalines, some as large as 15 cm in diameter, have been reported. Very fine bicolored red-green crystals have also been observed up to 6 cm in length. In addition to beryl and tourmaline, crystals of kunzite and green to yellowish green gem spodumene have been found in sizes up to 20 cm.

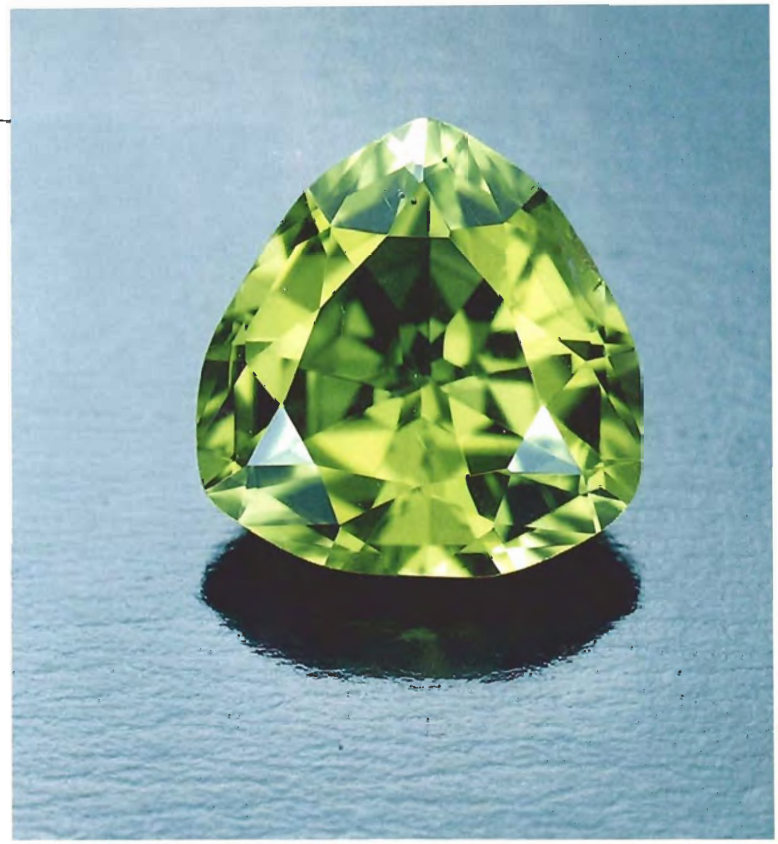

Figure 9. This 2.87-ct peridot is from the Zhangjiakou-Xuanhua area of Hebei Province, China. Stone faceted by William C. Kerr; photo © Tino Hammid.

PERIDOT

Gemmy pieces of attractive green peridot up to at least 5 g in weight are currently being produced from the base of the Tertiary-age Hanluoba basalt lava flows in the Zhanjikou-Xuanhua area of Hebei Province, about 150 km northwest of Beijing (figure 9). This deposit was discovered in 1979 by the

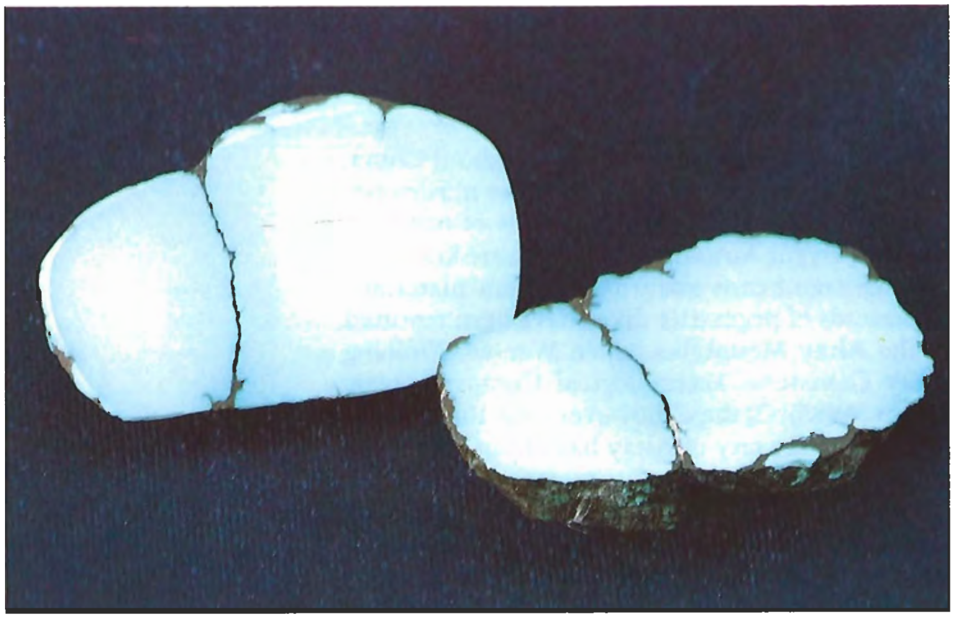

Figure 10. Sectional nodule of fine blue turquoise from the Wudang Mountain area of Hubei Province, China. The nodule is approximately 10 cm long and 4 cm in diameter. Photo by S. Gipson.

Ministry of Geology and Mineral Resources. Little more is known at this time about the occurrence of the Chinese peridot, although a recent gemological study of samples from this area indicates that the material resembles peridot from San Carlos (Arizona) and may have occurred in a similar fashion. Interestingly, the Chinese peridots appear to be somewhat harder than their San Carlos counterparts and thus produce a polish comparable to the Burmese material (Koivula and Fryer, 1986). It can be safely assumed, however, that significant amounts of the material will be seen on the world's gem market in the future. The Chinese Gem and Mineral Development Company in Beijing is actively acquiring the rough material and faceting it for commercial distribution.

TURQUOISE

It is generally accepted that the finest turquoise in the world comes from the Nishapur district of Iran, and hence "Persian turquoise" has become a trade term for the top grade of turquoise. China is now producing turquoise that rivals the finest of the traditional "Persian" (figure 10). It is uncertain as to just when the Chinese began mining turquoise; although it has been popular in China for jewelry and carvings for many centuries, much of the material could have been obtained from trading partners to the west. Still, archeological finds of turquoise carvings that date as early as 1300 B.C. indicate that China's own deposits may have been exploited for many centuries without the knowledge of the outside world. Many of the carvings now sold in Hong Kong are undoubtedly made of Chinese material.

Today, significant deposits of very fine turquoise are mined at Yunxian and Zhushan in the Wudang Mountain area of northwestern Hubei Province, and near Shanyang in Shaanxi Province, about 150 km northwest of the Wudang Shan area. The gemological properties of Chinese turquoise are discussed in detail by Wang (1986).

The turquoise from Hubei and Shaanxi occurs as compact nodules on or very near the surface of the ground. Nodules up to 8 cm are relatively common, and masses several times that size have been observed. The Geological Museum in Beijing has a 24-cm-high, 3,000-g turquoise statue called the Nine Lions which is carved of material from Hubei Province (Wang, 1986). The Chinese turquoise ranges in color from various shades of blue to light green with increasing iron content. It is not unusual to find perfectly homogenous masses, although very fine "spider web" nodules have also been observed.

CONCLUSION

A number of other gem materials have been reported from China. These include fluorite from Wenxhou Province, zircon from Fujian Province, and amethyst and azurite from Guangdong Province. Given the size and varied geology of the country, it is likely that many other gem materials, as well as other deposits of materials already identified, will be found as the current program of exploration and research continues.

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THE CHANGMA DIAMOND DISTRICT, MENGYIN, SHANDONG PROVINCE, CHINA

By Peter C. Keller and Wan Guo-dong

Since the early 1960s, Chinese geologists have conducted extensive exploration for diamonds. One of their most important discoveries to date is the Changma kimberlite district in Shandong Province, which encompasses two pipes and eight dikes. The most active mine currently, the Victory No. 1, produces approximately 6,000 ct of diamonds annually, 20% of which are gem quality. The ore is processed locally and the rough stones are given a preliminary sort before they are sent to special factories for cutting. Large, good-quality stones have been recovered at Changma; the largest to date weighs more than 119 ct.

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All of the photos taken at the mine and treatment plant are by Dr. Keller.

In recent years, the People's Republic of China has taken a keen interest in identifying and developing its gemstone resources. The most notable of these resources is their potentially important diamond deposits. Since the Chinese initiated a concerted diamond-exploration program in the early 1960s, at least six diamond-bearing districts have been brought into production. Four of these—the Yuan River, Changde County, in Hunan Province; Yingcheng in Hubei Province; and Linshu and Tancheng counties in Shandong Province—are secondary or alluvial. In the remaining two districts, diamonds are currently mined from kimberlites: the Binhai mine near Fuxian in Fu County, Liaoning Province, and the Changma kimberlite district in Mengyin County, Shandong Province (see the map in figure 1, Keller and Wang, 1986). The purpose of this article is to describe the little-known Changma kimberlite district, one of the most important in China, and specifically the mining and processing observed at Changma by the authors in September 1985.

Generally speaking, Shandong Province, in eastern China, exhibits extraordinary potential as a diamond producer. Including Changma, a total of 10 diamondiferous kimberlite pipes and dozens of diamondiferous kimberlite dikes have been identified in this mineral-rich province. These kimberlites are concentrated in three districts: Xiyu, Poli, and Changma. While kimberlite bodies in all three have been shown to contain diamonds, only a few of them are believed to contain sufficient quantities to be considered economical by today's standards.

The most important of the three kimberlite districts in Shandong Province, and perhaps in all of China, is the Changma, located near the town of Mengyin in Mengyin County. The Changma kimberlite district is about 14 km long and 2 km wide, and consists of two kimberlite pipes and a series of eight subparallel dikes which generally strike to the north-northwest. The two pipes are situated

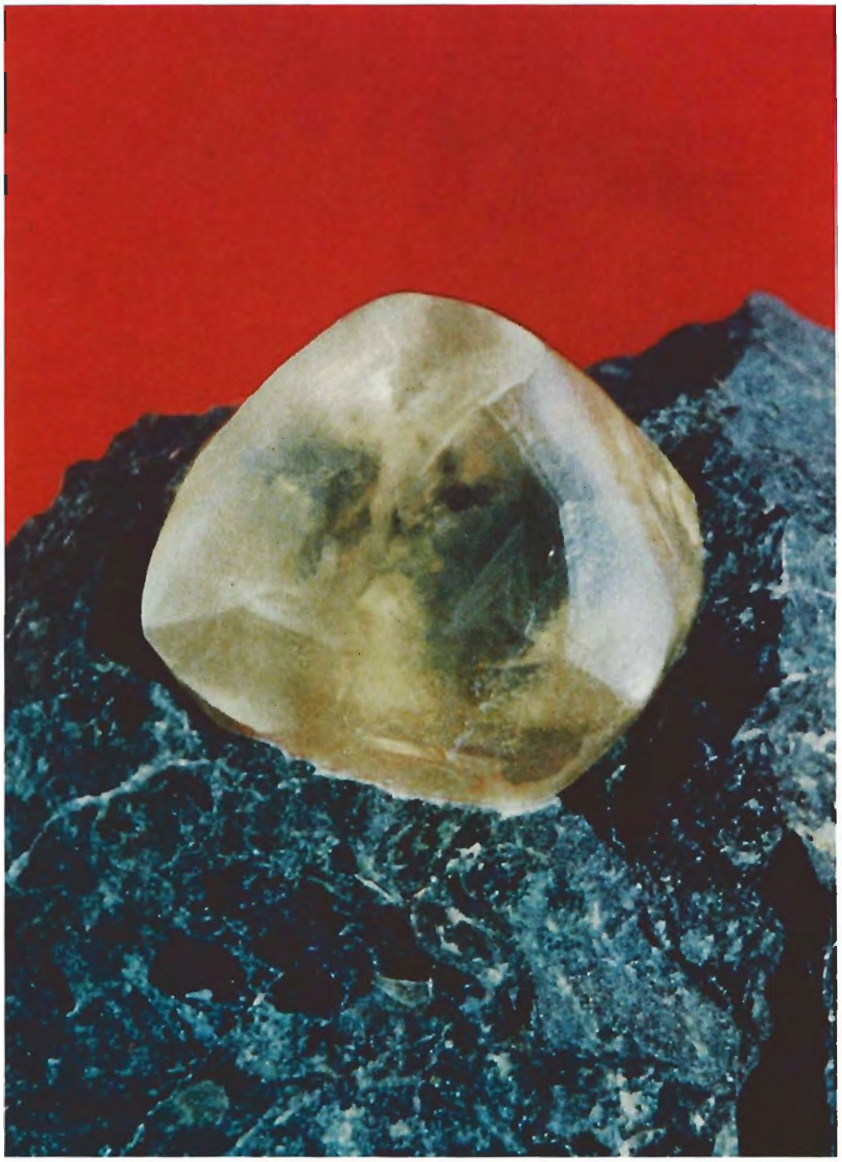

Figure 1. The largest diamond recovered to date from the Victory No. 1 pipes is this spectacular 119.01-ct yellowish octahedron in kimberlite which is known as the Mengshan No. 1. The crystal, discovered in 1983, measured over 4 cm in diameter. Photo courtesy of the Shandong Bureau of Geology and Mineral Resources, Jinan.

in the center of the series of dikes and have been given the collective designation of "Victory No. 1." The large open-pit mine that has resulted from the mining of the pipes is also called Victory No. 1, while the most important of the eight dikes have been designated Victory or Red Flag. The Victory No. 1 pipes and the Victory No. 2 and Red Flag No. 1 dikes have been the most significant producers to date.

While the quantity of gem-quality stones produced thus far has not been economically significant on a world scale, fine stones as large as 119.01 ct have been recovered (figure 1). Several rough diamonds recovered from Victory No. 1 and Victory No. 2 were examined at the mine office and are also described here.

LOCATION AND ACCESS

The Victory No. 1 open-pit mine and its associated treatment plant (figure 2) are located approximately 14 km south of the town of Mengyin, in south-central Shandong Province. Mengyin is approximately 500 km southeast of Beijing (Peking).

Access is by train or airplane from Beijing to the Shandong Province capital of Jinan. The approximately 170-km journey from Jinan to Mengyin requires about four hours of travel by automobile over a well-maintained paved road through beautiful agricultural areas with extensive terracing. At Mengyin, the authors first stopped at a state-owned hotel where the papers authorizing the visit to the mine were cleared with local authorities. From Mengyin, the Victory No. 1

Figure 2. A view looking west toward the Victory No. 1 open-pit mine. The structure in the foreground is a portion of the diamond treatment plant constructed in 1975.

mine is an additional 30-minute drive over paved road. It is important to note that the Mengyin area is generally not open to foreigners and special government permission is required to visit the diamond deposit.

HISTORY AND PRODUCTION

Alluvial diamonds have been found at the Chengjiafu mine, Tancheng County, in Shandong Province since the late 1940s. According to Green (1985), the Chengjiafu mine has produced stones as large as 96.04, 124.27, and 158.79 ct. (The largest stone is known as the Changlin diamond, which—contrary to Green's information—the authors were told came from neighboring Linshu County.) The discovery of the Changma kimberlites was the result of an intensive diamond exploration program that initially concentrated on sampling the region's river gravels. In August of 1965, after more than five years of work, a team of eight geologists from the Shandong Bureau of Geology and Mineral Resources discovered their first kimberlite in the form of a dike (Red Flag No. 1). The dike lay dormant until August of 1970, when mining was initiated and a small treatment plant erected. Red Flag No. 1 produced diamonds until it was shut down in 1981. During its 11 years of operation, the approximately 10,000 tons of ore processed yielded an impressive 20,000 ct of diamonds. The dike is now overgrown by peanut fields, and the treatment plant is in ruins.

Following the discovery of Red Flag No. 1, exploration continued in the area, and in December 1968 the Victory No. 1 pipe was located. However, mining of the pipe did not begin until October 1975, when a large treatment plant was constructed nearby. Today, diamond production appears to be limited to the now relatively large Victory No. 1 open-pit mine (figure 3). The nearby treatment plant processes about 120 tons of ore, yielding 100–150 ct of diamonds, each day. Of these diamonds, an estimated 20% are considered gem quality. After the diamonds go through a rough sort at the treatment plant, they are sent to Shanghai for detailed examination and cutting. Most of the gem diamonds are faceted at the state-owned Shanghai Diamond Factory which, according to Green (1985), employs about 200 cutters. Unconfirmed reports state that diamond cutting also takes place in the Shandong Province coastal city of Yantai (Shor, 1985) and at the collectively owned Beijing Diamond Factory, which employs approximately 100 workers (Green, 1985).

The primary organization within China for marketing and distributing diamonds is the National Arts and Crafts Import-Export Corporation

(Art China). According to Green (1985), domestic gem diamonds meet only 10% of the overall production capability of China's cutting and polishing facilities; the remaining 90% (150,000–200,000 ct of rough per year) are purchased in Antwerp. As recently as 1983, the Chinese were using all of the industrial diamonds they produced and were, in fact, forced to import significant amounts of diamond—358,123 ct in that year alone (Green, 1985)—to meet their growing industrial needs. Industry sources report that this situation has changed in the last three years: With the increased mining of diamonds and the capability of producing synthetic industrial diamonds, the Chinese are better able to meet their own industrial needs and are even offering synthetic industrial material for export (Bruce Komarow, Erwin Komarow, Inc., pers. comm., 1986). Industry sources also indicate that some exporting of domestically mined and manufactured gem-quality rough is being undertaken on a small scale through joint ventures with Western firms.

Official figures on annual diamond production from the Victory No. 1 mine were not available. However, a conservative estimate supports an average production of 600 ct of diamonds each week, or over 31,000 ct a year. About 6,200 ct would be of gem quality. According to Green (1985), China's total annual diamond production was estimated by the China Nonmetallic Minerals Industry Corporation at between 300,000 and 500,000 ct, of which about 15%—or 45,000 to 75,000 ct—are gem quality. Given the importance that the Chinese place on the Victory No. 1 mine, either production estimates for the mine are vastly underestimated, or the figures supplied by Green (1985) are exaggerated. In view of the fact that the Soviet Union produced an estimated 12,000,000 ct of diamonds in 1977, the Chinese production is, by any standard, in its infancy.

Diamonds of notable size have been found in China, however. In December 1977, a farmer from the Changlin Brigade of the Jishan People's Commune of Linshu County, south of Mengyin, discovered the 158.79-ct "Changlin" diamond while plowing a field. The yellowish diamond is China's

Figure 3. A view looking east in the bottom of the Victory No. 1 open-pit mine. The smaller of two kimberlite pipes is apparent and is being mined using power shovels.

Figure 4. This brown modified octahedron measuring 2.47 cm in diameter and weighing 52.71 ct was found in Jiangsu Province. It is now in the collection of the Geological Museum in Beijing.

largest. Since the discovery of the Changlin diamond, several other large stones have been recovered, mostly from the alluvial deposits south of Mengyin. The Geological Museum in Beijing has a 52.71-ct brown octahedron that was found just across the Shandong Province border in Jiangsu Province (figure 4). Later, we will describe in detail the 119.01-ct diamond in matrix from the Changma district.

GEOLOGY AND OCCURRENCE

The diamond-bearing kimberlites of Shandong Province appear to be limited to the Menshan anticlinorium of the western Shandong (Huabei) platform. This is part of the Sino-Korean Craton (Zhang et al., 1984) and consists of Precambrian metamorphic gneisses, and Paleozoic and Mesozoic igneous and sedimentary rocks. It is bounded on the east by the north-northeast–trending Tanan or Yishu fault zone (a portion of the Tancheng-Lujiang deep fault belt) and on the west by the Liao Kao fault zone. To date, no kimberlites in Shandong Province have been identified outside the boundaries of the western Shandong platform. The kimberlites of Shandong Province, including the Changma kimberlites, are clustered along the crest of the Mengshan anticlinorium. Geologists from the Shandong Bureau of Geology and Mineral Resources believe that the anticlinorium was uplifted contemporaneously with kimberlite emplacement during the Jurassic period (Geological Bureau of Shandong Province, 1982).

The Changma kimberlite penetrates over 12,000 m of Taishan gneiss, dated at about 2,400 million years and predominantly consisting of a hornblende gneiss in the Changma area. Geologists from the Shandong bureau have further subdivided the gneiss into four units based on variations in mineralogy. While it is beyond the scope of this article to provide a detailed description of the stratigraphy of the Changma district, such can be found in the report of the Seventh Geological Exploration Team (1984). A brief synopsis is as follows: The Taishan gneiss is unconformably overlain by over 800 m of Paleozoic limestones, shales, and sandstones. Particularly important is a thin layer of sandy conglomerate near the top of the section which contains alluvial diamonds. The Paleozoic rocks are, in turn, overlain by approximately 1,000 m of red to greenish gray sandstone of Mesozoic (Jurassic?) age. The Mesozoic sandstones have been called the Mengyin group, and the entire section is capped by about 2,000 m of volcaniclastic rocks of probable Cretaceous age.

According to the report of the Seventh Geological Exploration Team (1984) and He (1984), the two Changma pipes intersect at a depth of 250–300 m to become one, known as the Victory No. 1 pipe. The eight subparallel dikes strike to the north-northwest, and vary from 100 to almost 1,500 m in length. The average width of the dikes varies from 0.1 m to 0.6 m.

THE KIMBERLITE BODIES

The Victory No. 1 pipes are mined by the open-pit method, which provides good exposure of their form and size (figures 3 and 5). One of the kimberlite dikes, the Victory No. 2, outcrops as a highly serpentinized dike less than a meter wide, in the northeast and southwest walls of the mine (figure 6). In the bottom of the open pit, the two pipes are visible as an elliptical body almost 100 m across on the west, and a much smaller, "L-shaped" pipe about 15 × 65 m to the east. At the time of our visit in September 1985, most of the mining appeared to be on the smaller pipe.

The Changma kimberlites, bluish gray in color, range from a fine-grained to a highly por-

Figure 5. Mrs. Wan Guo-dong, a member of the geological team that discovered the Changma diamond district in 1965, stands on a ledge overlooking the Victory No. 1 mine. Note the terracing in the background created by the open-pit method.

Figure 6. The highly serpentinized Victory No. 2 dike can be seen in the wall of the open-pit mine.

phyritic rock. Locally, pyrope garnet is common enough to call the rock a porphyritic pyrope-kimberlite. Other important minerals include serpentinized olivine, phlogopite, chromite, ilmenite, and chrome diopside. Minor minerals include rutile, perovskite, anatase, magnetite, and apatite. Wherever the kimberlite has been exposed to the elements, it has undergone rapid weathering and takes on a green to yellowish color. The weathered kimberlite is extensively serpentinized, carbonatized, and silicified.

The kimberlite found in the Victory No. 1 pipe locally contains abundant breccia fragments of gneiss, limestone, sandstone, and other unidentified rocks. Small rounded mantle xenoliths (inclusions of mantle rock in the basalt) were also collected. Diamond concentrations in the pipes are said by mine officials to average one carat per cubic meter, which is comparable to that obtained at most other, well-known diamond deposits. Recovery estimates at the treatment plant appear to substantiate this figure.

Figure 7. The diamond treatment plant is adjacent to the Victory No. 1 mine. The plant, which has been in operation since 1975, processes about 120 tons of kimberlite ore each day.

The age of the kimberlites is still a matter of debate. The geologists working in the area contend that the kimberlites were emplaced during Jurassic time, basing their conclusions on field relationships, including the fact that older, Paleozoic limestone fragments, as well as fragments of Precambrian gneiss, have been found in the kimberlite. The Institute of Geochemistry, Chinese Academy of Sciences, in Beijing undertook potassium/argon whole-rock analysis of the kimberlites and found one age of 81–88 million years. Other ages, however, were placed at 341–530 million years (He, 1984). It is entirely possible that there may have been more than one episode of kimberlite emplacement in the region. The argument for an older (Precambrian) kimberlite age is somewhat substantiated by the presence of alluvial diamonds in the Paleozoic conglomerates.

TREATMENT AND RECOVERY

The ore-treatment plant (figure 7), located approximately 1 km east of the Victory No. 1 mine, has been in operation since 1975. It processes about 120 tons of ore daily.

Kimberlite is brought to the treatment plant from the open-pit mine by dump truck. When the ore arrives at the plant, it is deposited through a series of evenly spaced rails known as a "grizzly," which allows only chunks of ore less than about 15 cm in diameter to pass into the treatment plant for preliminary jaw crushing (figure 8). Pieces of ore larger than 15 cm are removed and broken down by hand before going into the crusher.

After crushing, the ore is carried on a conveyor belt upward (figure 9) into a series of trommels, crushers, and screens which ultimately break down and sort the ore into sizes suitable for treatment in the water-filled rotary washing pans, where it forms a muddy slurry. The lighter rock fraction and water pass through an opening in the top part of the washing pan as it is stirred by a series of large vertical arms, while the heavier concentrate, including diamonds, is removed through an opening in the bottom of the pan.

After washing, the heavier concentrate is passed over a grease belt (figure 10). The diamonds, being water resistant, adhere to the grease on the belt, while mineral and rock fragments are washed

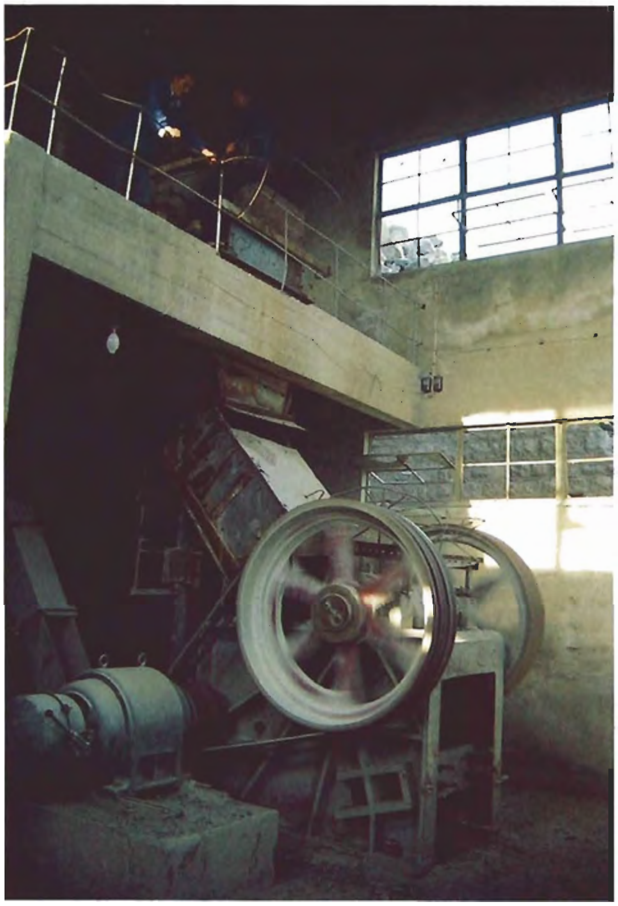

Figure 8. Ore from the Victory No. 1 mine first passes through a 15-cm "grizzly" and jaw crusher.

Figure 9. After initial crushing, the kimberlite ore is taken by conveyor belt through another series of crushing and screening, to break the ore further for treatment in the rotary washing pans.

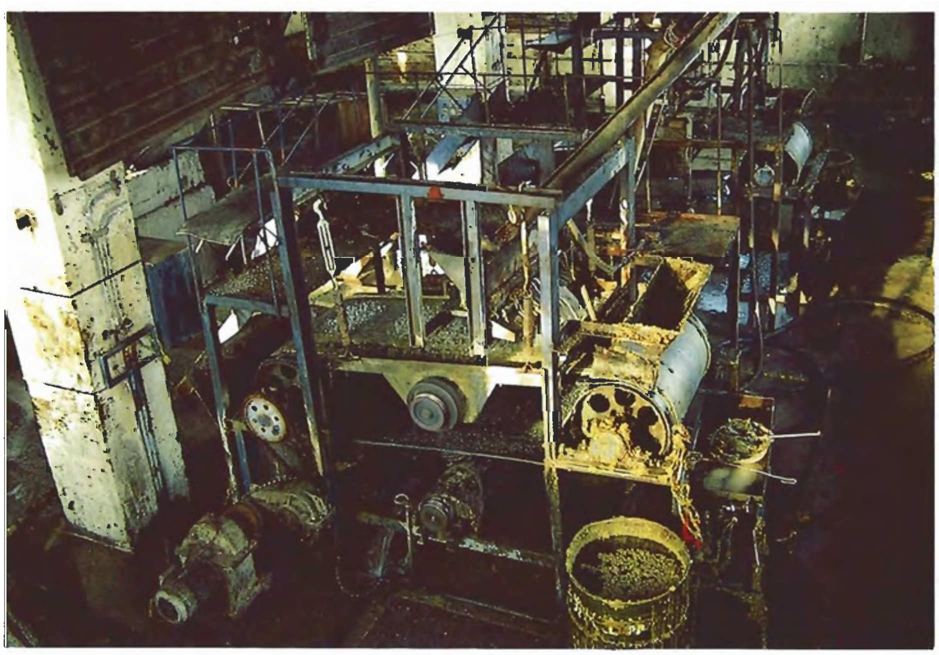

Figure 10. The final step in the recovery process is to pass the heavy concentrate over grease belts. Diamonds, being resistant to water, stick to the grease while other material passes over the belt. Periodically, the grease is scraped off and boiled to free the diamonds.

Figure 11. The diamond concentrate recovered from the boiled grease is sent to the sorting room, where any remaining kimberlite material is removed and the diamonds are separated into initial grades. The sample shown here is representative of mine-run diamonds from the Victory No. 1 pipe.

off by a steady stream of water. Periodically, the grease belts are scraped and the diamonds are subsequently freed from the grease when it is boiled in water. The diamonds are then sent to a sorting room to remove any remaining kimberlite debris and for a preliminary sort into industrial grade or gem quality (figure 11), the latter subsequently divided into 40 different categories based on color, clarity, shape, and size. Lastly, all of the diamonds are shipped to Shanghai for final grading and distribution.

THE CHANGMA DIAMONDS

By international standards, the quality and quantity of the diamonds recovered from the Changma kimberlite are not particularly noteworthy. Most stones tend to be yellowish in color, and the average weight is less than one carat. As figure 1 shows, however, stones of considerable size have been recovered. This 119.01-ct diamond, discovered in 1983 during the initial crushing of ore from the Victory No. 1 pipe, is the largest recovered to date from the Changma kimberlite. The modified octahedron crystal was over 4 cm in diameter and, although yellowish, was relatively free of inclusions; it must be considered one of the finest matrix specimens of diamond ever found. Unfortunately, the diamond was removed from its kimberlite matrix and faceted in Shanghai. Its final yield in cut stones and their whereabouts today are unknown.

During our visit to the Victory No. 1 open pit on September 28, 1985, a 1.1-cm yellowish diamond octahedron in kimberlite was found in a pile of loose ore by one of our drivers (figure 12). This find provides some indication of the potential of this district. Six other significant diamonds were studied by the authors at the mine office (figure 13) and exhibited an interesting range in characteristics of the Chinese diamonds. The stones varied in color from an extraordinarily high-grade colorless to a particularly rich coffee-brown. The stones were predominantly modified octahedrons. Inclusions were difficult to study given the limited

Figure 12. This 1.1-cm diamond in kimberlite was found on September 28, 1985, at the Victory No. 1 mine.

Figure 13. A collection of six rough diamonds examined at the Changma mine office. The stones ranged in weight from approximately 2 to 13 ct.

gemological facilities available in the mine office; however, a pyrope inclusion was noted in one crystal, while the other stones appeared to be relatively free of inclusions. The six specimens ranged in weight from approximately 2 to 13 ct. The largest stone was a glassy octahedron that weighed 12.88 ct and measured 1.41 cm in diameter, of a color that would be relatively high on the GIA diamond-grading scale if the stone were faceted; this stone contained the pyrope inclusion noted above. The highest-color (comparable to E, F, or G on the GIA color-grading scale) stone was a rounded and highly distorted octahedron, almost 12 ct in weight and 1.4 cm in diameter, with, as indicated above, few if any inclusions. The other stones examined were a glassy macle, one small twinned octahedron, a fine glassy octahedron, and a 7.41-ct rich coffee-brown modified octahedron.

At the sorting table, the authors observed a much larger production sample (figure 11) and made additional notes. Modified octahedrons up to 1.3 cm in diameter were common, although most were less than 0.5 cm in diameter. Macles were present, but seem to be quite rare. The most common crystallographic forms were modified cube-octahedrons. The stones varied greatly in color, ranging from very high quality whites through the cape series to fancy browns and canary yellows. A few light pink diamonds were also observed. A more detailed study will be undertaken when a representative sample is received in the United States.

SUMMARY AND CONCLUSION

Diamond mining in China is a relatively new endeavor. While some very fine and very large diamonds have been mined since the first stones were discovered in the late 1940s, the total production is small at this time. However, exploration continues throughout the Changma district and other promising areas of China, and outside assistance is being sought to make the mining and recovery operations more efficient. Given the vast size of China and the performance of the deposits uncovered to date, the long-term prospects for diamond production are promising.

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GEMSTONE CARVING IN CHINA: WINDS OF CHANGE

By Sally A. Thomas and Hing Wa Lee

The Chinese have labored to perfect the art of gemstone carving for several thousand years. Beginning with primitive tools and limited materials, they eventually developed the iron-tipped spindles and treadle machines that were to become the traditional tools of the trade for two millenia. With these relatively simple implements and meticulous craftsmanship, Chinese master carvers have produced some of the world's most sophisticated gemstone carvings. Within the past 10 years, however, increased governmental participation, the availability of power-driven machinery, and more varied carving materials have had a major impact on gemstone carving in China.

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Gemstone carving is one of China's most ancient and important art forms. It is a craft steeped in history and tradition, continually reflecting the philosophy and culture of the Chinese people. Using primitive tools and native nephrite, early Chinese carvers created crude tools and weapons. Over the course of several thousand years, however, master craftsmen worked to perfect the tools and techniques that would help them create smooth, flowing carvings from intractable blocks of stone. Using only simple foot-driven machines and iron-tipped spindles, as many as 50 carvers might labor more than 10 years to complete a single masterpiece (figure 1).

Through generations of traditional training—long apprenticeships with masters in the art—Chinese carvers became extremely talented at adapting their designs to the patterns, colors, and imperfections within each stone. The result of such skill is particularly evident in those pieces that depict many differently colored figures, all carved from the same piece of rough (figure 2). The art of gemstone carving reached its zenith during the reign of Emperor Ch'ien Lung (1736–1795). Dedicated to the advancement and perfection of all the arts, Ch'ien Lung established several imperial workshops in Peking (now Beijing) which produced some of the finest carvings ever created. Surviving specimens of these magnificent carvings can be seen today in the Forbidden City Museum in Beijing.

After Ch'ien Lung's abdication in 1795, China plunged into political turmoil and cultural darkness that dominated the 19th and early 20th centuries. Only within the last 50 years has gemstone carving experienced a major revival. During the past 10 years, in particular, increased governmental participation, the introduction of modern, power-driven tools, and access to a greater variety of carving materials has changed the gemstone-carving industry in China.

Figure 1. This intricately designed jadeite incense burner was carved almost 200 years ago. It measures 68 cm tall × 40 cm wide, and may have taken as many as 10 years to complete. Courtesy of H. W. Lee Gallery; photo © Harold & Erica Van Pelt.

EARLY HISTORY

The glyptic arts have ancient roots dating back to Paleolithic man, who first made crude carvings using bits of hard rocks for tools. As man's technology progressed, so did his ability to carve stones. Ancient carvers in China first used a thin, sharp sliver of sandstone sluiced with wet sand as a primitive saw for large pieces of rough stone. Next they used a bow drill, a tool common to many early cultures (Long, 1982). This drill consisted of a simple, flexible wooden bow braced with a bowstring. Snared in the middle of the taut bowstring was a thin wooden shaft that had a sharp drill point at one end and a handle or a mouth brace at the other. By sawing the bow back and forth, the pointed shaft rotated very quickly, the friction drilling a hole into the stone beneath the point. Although it was a vast improvement over chip-

Figure 2. This jadeite vase (14 × 8 cm) demonstrates how skillful Chinese craftsmen have utilized the bright orange rind, a brownish green core, and a patch of emerald green on a single piece of jade. Reproduced courtesy of the Lizzadro Museum of Lapidary Art.

ping, only very basic carvings could be fashioned with this tool. The Chinese eventually employed tubular drills made of bamboo (Long, 1982). Because bamboo is porous, abrasive grit clings to its cross section, making the bamboo shaft a more effective, if still tedious, drilling tool.

Although China contains large deposits of quartz, primarily from the provinces of Hunan and Hubei, and Chinese carvers have produced a great number of quartz carvings over the centuries (figure 3), the primary carving stone for China historically has been jade (Lytle, 1982). Jade—specifically nephrite jade until jadeite was first imported from Burma in the late 18th century—is uniquely bonded to Chinese culture, tradition, and aesthetics (Tucker, 1982). Chinese carvers first prized nephrite for its toughness, relative ease of sawing and drilling, and variety of color. Ancient nephrite deposits were located in the Khotan and Yarkand regions, and later in Yunnan Province and the interior of Turkestan (Hansford, 1950).

Nephrite was renowned for its durability, and many of the uninitiated were skeptical that such a stone could be cut and carved. Some ancient Chinese writers even believed that jade must have been a soft material when it was initially removed from the earth, and that it hardened only after exposure to the elements. Others believed that jade could be softened for carving by smearing it with a grease extracted from a rare species of toad (Long, 1982).

THE METAL ERA

Although bronze certainly played a pivotal role in the advancement of Chinese technology and culture, there is no evidence that it was used in gemstone carving (Long, 1982). Iron was first introduced into China around 500 B.C., about the time that word of the *K'un-wu*, or "sword-knife," began to spread throughout China (Hansford, 1950). Popular legend had it that this knife was made from a material that was so strong it could cut through jade as though it were clay. Although evidence to establish the existence of such a knife is lacking, it is interesting to note that the name *K'un-wu* corresponds to a tribe of people in a region to the northwest of ancient China that was an ancient source of iron ore (Howard, 1950).

The advent of iron and metal alloys revolutionized Chinese lapidary work. Stone carvers eventually developed a metal saw that could cut its way through the largest nephrite boulders. A length of iron wire was doubled and twisted to form a blade, which was stretched between the ends of a large wooden bow. Two men held opposite ends and sawed the wire across the stone, while a third person fed a slurry of abrasive grit and water into the groove where the wire entered the stone. Although it was a slow process, it enabled very large pieces to be sectioned off with very little loss of material.

During this period, the Chinese invented the rotary foot-treadle carving machine that would be used for centuries to come, up to and including the present day (figure 4). This machine consists of a simple wooden bench with two foot treadles attached to a leather thong. Iron-tipped wooden spindles of various shapes and sizes can be attached horizontally to a wooden holder. Then the leather thong is looped over the spindle. When the foot treadles are pumped vigorously, they cause the iron-tipped spindles to rotate rapidly back and forth; the carver then presses the stone against the metal tip to carve out a pattern. The tips range from large metal discs, or circular saws, up to a foot in diameter down to the extremely small points used for engraving (figure 5). Bow drills can also be used with the treadle machine. The real merit of the treadle machine is that very slow speeds can be used to start cuts or finish delicate designs, and that resistance or other "feedback" can be felt in the hands of the carver or in the pedals (figure 6).

To keep the stone cool and damp, early Chinese carvers used an abrasive mud or sand composed of grains of quartzite, garnet, and corundum. Diamond was sometimes used as a point for a drilling tool even before the Christian era (Hansford, 1950), but not as an abrasive.

The development of the foot treadle allowed the carver a great amount of control while shaping the piece. The skill needed to operate the machine as adeptly as possible was not easy to learn, and apprenticeships could last as long as 10 years. The carving process itself was extremely slow and tedious, and many carvers received deep cuts and slashes when their fingers or hands came too close to the whirling iron tools after many hours on the bench. But with skill, patience, and luck, a master carver could produce an intricate piece that would be treasured for generations to come.

The Chinese have followed the same basic carving procedures for many centuries. First they decrust and cut open the main jade boulder. Next they examine the stone closely, noting all flaws, patterns, and color variations, and then they design their carving accordingly. The unwanted pieces are sawed away, and the pattern is carefully drawn on the stone with ink. Then comes the long carving process, using a variety of tubes, drills, round gouges, and reamers. The last step is a painstaking polishing. Nephrite is somewhat difficult to polish, and special care must be taken to achieve the finest possible finish. Early polishing tools were made of fine-grained wood covered with dried gourd skin and ox leather charged with ruby dust (Bushell, 1914).

THE GOLDEN ERA

Over the centuries, gemstone carving became a very intricate art form. The best carvings were produced during the Sung (960–1280), Ming (1368–1644), and early to mid Ch'ing (1644–1912) dynasties. It was during the reign of Emperor Ch'ien Lung (1736–1795), in particular, that the art of gemstone carving reached the height of sophistication and beauty (Burwell, 1948). Ch'ien Lung established several workshops at the imperial palace in Beijing which were devoted to this art. He also imported skilled Moslem gem carvers from the province of Sinkiang, men who could trace their skills back to the ancient cities of Chaldea and Susiana at the head of the Persian Gulf (Bushell, 1914). Moghul carvings were typi-

Figure 3. China has also been known for its beautiful rock crystal quartz carvings, such as this undercut ornamental bottle (27 × 12 × 10 cm). The butterflies, birds, blossoms, fruit, and cicadas collectively symbolize the summer solstice. Reproduced courtesy of the Lizzadro Museum of Lapidary Art.

Figure 4. For two millenia, fine gemstone carvings have been created by master carvers such as T. C. Chang using this type of foot-treadle machine. Photo © Harold & Erica Van Pelt.

Figure 6. Through feedback from the pedals and his hands, the carver can exercise the control necessary to produce delicate carvings. Photo © Harold & Erica Van Pelt.

Figure 5. These tools of the Chinese master carver are used in conjunction with the treadle machine shown in figure 4. Photo © Harold & Erica Van Pelt.

cally finely detailed and skillfully executed; the sides of many fine Moghul carvings are so thin that the stone appears to be translucent (figure 7).

One of the imperial workshops was called *Hsi Fan Tso,* or "Indian School," and produced graceful, delicate carvings reminiscent of the style then popular in India (Bushell, 1914). It is also probable that the jeweled jades from this period were inspired by this same source. These pieces were usually flat plates carved from white jade and mounted in small screens. They were inlaid with rubies, amethysts, lapis lazuli, and emerald-green jadeite, cut in thin slices or set en cabochon and etched with golden lines.

In 1784, China opened up trade relations with Burma and began to import large quantities of various colors of jadeite, including lavender and the rarer blue, as well as white and the various shades of green (Lytle, 1982). Because jadeite fractures more easily than nephrite, carvers were initially reluctant to work with this new material (Long, 1982). Through experimentation, however, they soon learned to adapt their techniques, and in turn produced magnificent carvings from the sometimes multicolored jadeite (see cover).

Figure 7. This white nephrite vase (27 × 15 × 7 cm) displays the skill that is so evident in Moghul carvings. The walls of this piece are only one-sixteenth of an inch thick. Reproduced courtesy of the Lizzadro Museum of Lapidary Art.

MAJOR MOTIFS

Although the subjects of the carvings have varied throughout history, most reflect the basic Eastern philosophy that man is only a small part of a greater scheme (Tucker, 1982). The Chinese artisans sought to emulate nature by observing its way, and thus became highly skilled at capturing the spirit of nature within their carvings. Taoism, the oldest extant religion in China, is a form of nature worship, and helped to imbue animals, insects, trees, and flowers with their own special symbolism. For example, bats symbolize happiness and the metamorphosis between heaven and earth. Fish represent wealth, abundance, and marital bliss. A fox is associated with evil spirits. The pine tree is believed to contain an abundance of vital energy and therefore represents long life and immortality. Interestingly, cats are believed to be capable of both creating and dispelling evil (Lytle, 1982). Other, mythical creatures, such as the phoenix, the dragon, and the Qilin (an amalgamation of all creatures), have all been important motifs in Chinese carving.

The types of items that are carved include ornate incense burners, vases, covered jars, bowls, wine holders, and snuff bottles, as well as ornaments for clothing and special *objets.* Buddhism has historically been one of China's major religions, and its influence can be seen in many figurines. Boulder carvings were especially popular during the mid- to late 18th century. Carved from a solid boulder of jade, these pieces often depicted a Buddhist monk inside an austere cave, an appropriate setting for those dedicated to the contemplative life (Lytle, 1982; Tucker, 1982).

In addition to the larger carvings, many smaller pieces are produced. Expert craftsmen carved tiny bottles—most only 1½ in. (about 4 cm) high—to hold a nobleperson's precious supply of snuff, a powdered form of tobacco mixed with pungent herbs (Perry, 1960). These miniature bottles with their tight-fitting lids were fashioned from almost every gem material, including chalcedony, amethyst, quartz, and even ruby and emerald (Thomas, 1986). Jade was especially popular, since

Figure 8. These nephrite and nephrite-inlaid wood ruyi *(12 cm × 45 cm) are believed to have been tokens of good luck and long life. Reproduced courtesy of the Lizzadro Museum of Lapidary Art.*

carvers could use the yellowish "skin" found on some rough to create interesting, colorful effects.

Beads and baubles of all sorts were created from nephrite, jadeite, rose quartz, and lapis lazuli. Small pendants were often carved in low relief out of white nephrite, as were scabbard fittings, buckles, and imperial seals. One particularly interesting piece was the *ruyi,* which literally means "as you desire." The ruyi was usually 10–18 in. (25–45 cm) long and scepter shaped, somewhat like a modern dental mirror (figure 8). It is widely believed that this shape represented the dragon constellation or the plant of immortality, and *ruyi* are thought to have been tokens of good luck and longevity. Records show that Emperor Ch'ien Lung presented a *ruyi* with jade insets to each of the attending court elders on the 50th anniversary of his reign (Lytle, 1982).

DARKNESS DESCENDS

Tragically, China's next emperor, Chia Ch'ing (1796–1820) proved to be the antithesis of his predecessor. Almost fanatically repelled by the corruption and waste that he associated with the arts, he started China's plunge into cultural darkness. The great imperial workshops in Beijing were disbanded, and carvers were left to pursue their craft as best they could.

China's turmoil grew worse as the country became entangled in both foreign and domestic upheaval. During the next century, China's imperial houses, and even imperial rule itself, collapsed. Few documented accounts of gemstone carving during that time have been found. Almost one hundred years after Chia Ch'ing's death, however, Stephen Bushell reported in 1914 that the traditional treadle machines and carving methods were still in use, and noted that carvers were working with more rock crystal, carnelian, sardonyx, onyx, and agate. At that time, carvers in Beijing were using special types of abrasives, in increasing power: (1) yellow sand (quartz crystals), (2) red sand (garnets) used with the circular saw, (3) a kind of emery (black corundum sand) used with lap wheels, and (4) "jewel dust" (ruby crystals) from Yunnan and Tibet smeared onto the leather polishing wheel.

From 1920 to 1940, a quantity of fine, apple-green Siberian nephrite known as Liu's Jade (figure 9) appeared in Beijing (Lytle, 1982). This unusual jade had been stored in the Imperial Russian Treasury until the Communist takeover, when it was confiscated and shipped to Beijing to raise revenue. The quality of both the jade and the carvings created from it is generally very fine. Interestingly, most of the carvings made from this material bear the seal of Emperor Ch'ien Lung on their bases, although it is certain that Liu's Jade was not introduced into China until 1920, 125 years after that emperor's abdication.

In the years preceding World War II, Beijing again became active in the gemstone-carving industry, particularly in jade. Hansford (1950) reported that several hundred craftsmen and apprentices were employed in that city during those years. Many fine vessels and figurines were being produced there, and antique carvings were also available. Other carving centers were established in Canton and Shanghai, which mainly produced jadeite jewelry. The size of the workshops varied greatly, and many specialized in carving one particular stone or one particular item. Certain elaborate items that had previously been commissioned by the royal family, such as objects with long inscriptions and huge "mountains" complete with

Figure 9. Known as Liu's Jade, this deep apple-green nephrite (11 × 30 × 20 cm) was popular during the 1920s and 1930s. This bowl was carved in a style that was common in the mid-Ch'ing Dynasty. Reproduced courtesy of the Lizzadro Museum of Lapidary Art.

figurines, groves, and pavilions, were no longer being carved because there was no market for such ornate—and expensive—pieces.

In 1948, Calvin Joiner reported on a special area of Beijing called Jade Street, located just outside the Ch'ien gateway. Stretching for half a mile, it was lined with tiny shops that featured a fantastic variety of carvings. Behind the shops were carving workshops, many of which were occupied by descendants of the Moslems who had been brought to Beijing by Emperor Ch'ien Lung. According to Joiner, carvers were still using the traditional machines and methods, but had instituted a production-line type of carving whereby the workmen and beginning apprentices did the heavy slicing, the more advanced apprentices did the rough carving, and the final detail was accomplished by the master carvers, who also completed the polishing.

REVOLUTION

The Communist Revolution that occurred in China during 1949–50 brought a great many economic reforms (Langer, 1972). Overall state planning in industry, including gemstone carving, was instituted during this period.

With time, however, factions developed within the government as many of the new leaders felt that China was leaning too far toward capitalism. The antagonism came to a head in 1965, when China was shaken by the Great Proletarian Cultural Revolution. Three years later, the revolution was officially at an end, but its effects interrupted the country's economic and industrial progress for several more years; China was essentially closed to all foreigners for almost 10 years. Gradually, under the leadership of Lin Piao (Mao's successor), the giant country began to open its doors to the Western world.

MODERN CHINESE GEM CARVING

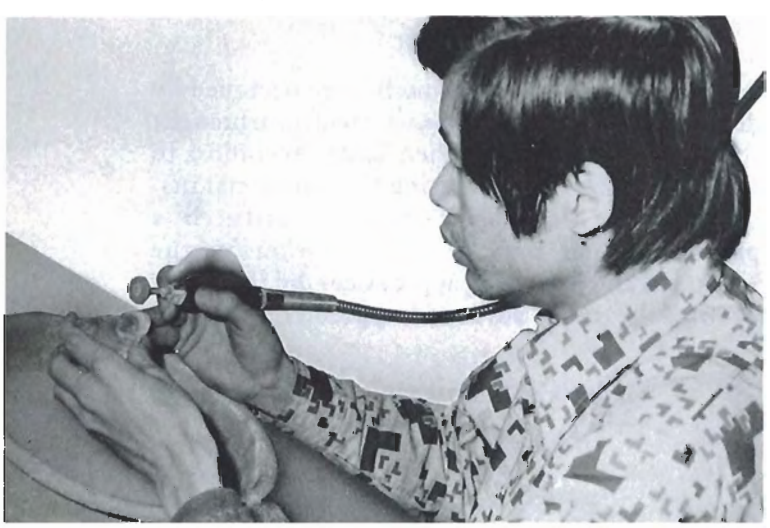
Within the last 10 years, the gemstone-carving industry in China has undergone several major changes (Markbreiter, 1985). Most notable is a marked increase in governmental participation and control. Virtually all major carving is now accomplished at government-owned factories, which also supply the carvers with all rough material. The new factories employ anywhere from 20 to 10,000 people, and both men and women may learn the craft. The factories appear to be well lighted and ventilated, with rows of machines for the workers. The government is very interested in the success of this particular industry, and is offering tax incentives and other benefits to encourage Taiwanese gemstone carvers to both carve and teach their craft on the mainland (Tucker, 1982).

Perhaps one of the biggest changes in the industry is the introduction of power-driven machinery (figure 10). About a decade ago, the Chinese began to import modern electric tools from Europe. More recently, they have begun manufacturing their own machinery and tools (Read, 1981; Markbreiter, 1985). Most of these machines are high-speed saws, and drills similar to those used by a dentist. Instead of the powdered abrasives used in the past, the carving tools are now impregnated with diamond dust or corundum. Water is supplied from thin rubber tubes installed above the machinery. Diamond dust is also used in the polishing process, and produces a glossier finish than do the traditional abrasives.

Power-driven tools have played a major role in changing the carving industry. Large, intricate pieces can now be completed in a fraction of the time that was needed only a few years ago. The period of apprenticeship has dropped to about four years, and may now require successful completion of examinations (Markbreiter, 1985). The new carvers are now being taught a mixture of old and new methods. Although they use the new, power-driven machinery, the traditional carving steps are still basically the same. As in the past, several people often work on a single piece. For example, an apprentice may do a rough preform from the design the master has drawn on the stone, but then "specialists" may be brought in to do various aspects of the detail work. Faces and hands are particularly difficult and may be assigned to one person with well-developed expertise in carving such delicate areas. Often, the master does the final detail work and finishes polishing the piece.

Although the new machines and tools can produce a greater quantity of delicate relief work in far less time, they do have drawbacks. The new diamond-impregnated saws waste from 2 to 5 mm more of the material, an important consideration when carving gem-quality rough. In addition, the rapidly rotating saws and drills do not offer the instant control of foot-driven treadles, and costly mistakes can occur in a fraction of a second. Con-

Figure 10. Modern Chinese power-driven carving machinery now uses diamond-impregnated tips instead of the traditional powdered abrasives.



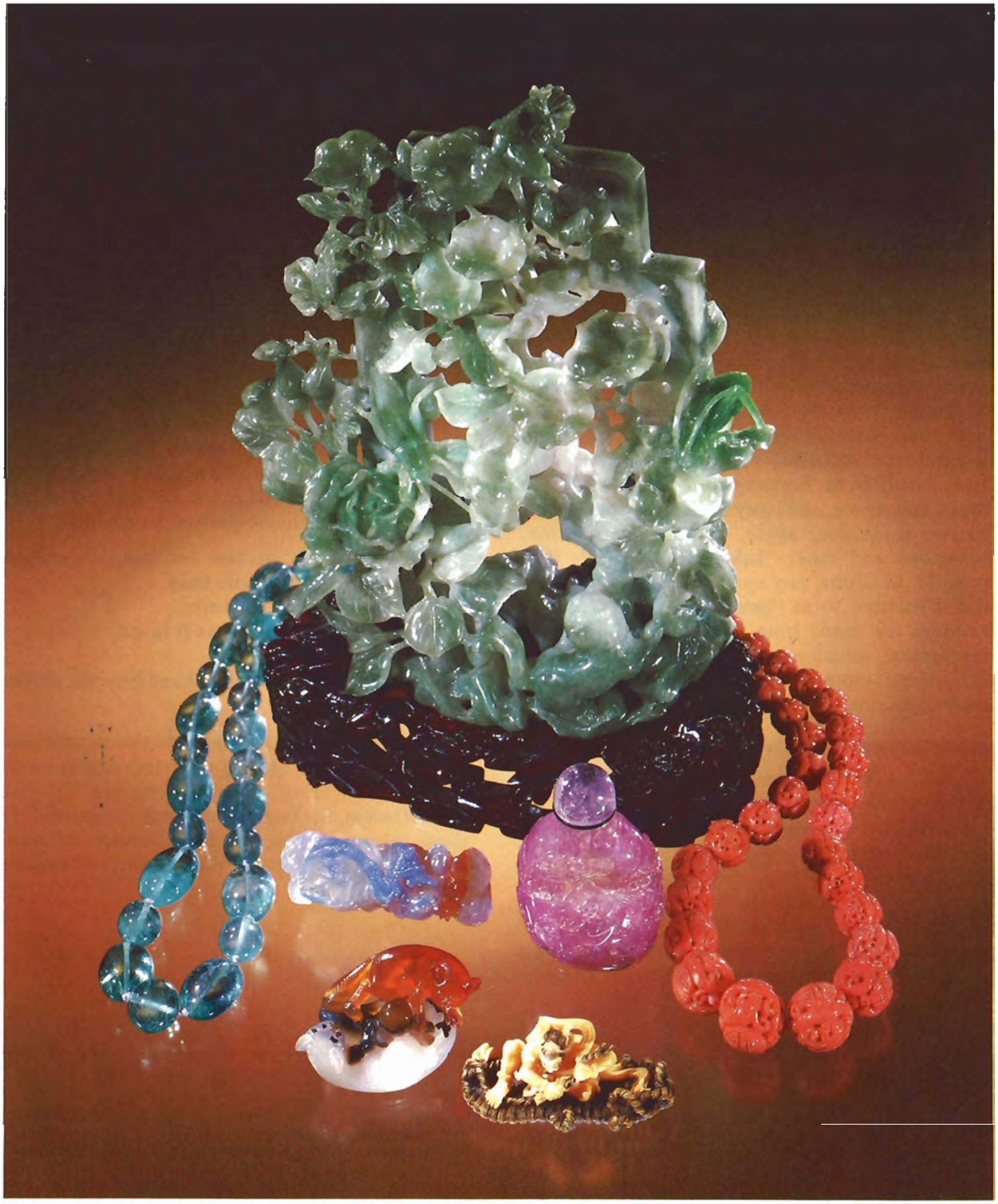


Figure 11. This variety of contemporary carved items includes a jadeite statue, aquamarine and coral beads, a pink tourmaline snuff bottle, an ivory netsuke, orange and white agate cats, and a blue agate dragon. Courtesy of H. W. Lee Gallery; photo © Harold & Erica Van Pelt.

sequently, treadle-powered tools continue to be used to finish the more delicate pieces. Today, however, relatively few of the "old masters" remain in the trade, and students are increasingly reluctant to learn and use the time-consuming traditional carving methods.

In general, neither the types nor the styles of the modern pieces (figure 11) have changed significantly from their predecessors. However, some factories are diversifying. For example, in one large establishment in Canton, one division produces "largely unoriginal and highly commercial" work, while another division creates the larger, better-quality carvings (Markbreiter, 1985).

Beads, pendants, and other items of jewelry are among the most common objects carved, although statues, vases, and other large items continue to be popular (figure 11). In addition to nephrite from Xinjian Province and jadeite from Burma (the Chinese government is the single largest purchaser of jadeite), the materials used most often include lapis lazuli from Afghanistan, rose quartz from Brazil and Africa, and ivory from Africa, as well as native turquoise, agate, fluorite, serpentine, soapstone and other "jade-like" materials (frequently, in China, any opaque ornamental material is referred to as "jade"). On rare occasions, carvings are made from gem materials such as tourmaline, amethyst, and aquamarine, in most cases using imported material. Carved opal is also seen occasionally.

MARKETING AND DISTRIBUTION

The China National Arts and Crafts Corporation in Beijing presently controls the distribution of all finished carvings. Most pieces are sold locally to tourists through the Friendship Stores (where only foreigners can make purchases, using a special currency required of foreigners and not allowed to Chinese citizens) and smaller state-owned "antique" or "jade" shops found in most of the major cities of China, or are exported, primarily to Japan and Hong Kong. Tens of thousands of carved pieces of jewelry and other items are now exported every year.

CONCLUSION

Despite the growing trend toward the use of power-driven machinery in carving, there are still a few masters who remain faithful to the traditional treadle machines and tools. In 1963, Mr. T. C. Chang (again, see figure 4), a Hong Kong gem carver and former head of the Beijing Jade Craftsman Union, was commissioned to recreate from memory two vases that he had seen as a boy. When asked why he preferred to use the traditional foot treadle for this delicate project, he replied:

> "The old tools are best because they permit you to use your whole body,
> Feet to regulate the cutter,
> Ears to hear the stone as it is cut,
> Hands to hold it,
> Eyes and Heart to seek out and hold the design in the stone."*

Modern machinery has made the commercial Chinese gemstone carving industry roughly equal in quality to those in Hong Kong and Taiwan. Nevertheless, the larger fine pieces, comparable to those created during the 18th century, are still being created by a few, dedicated Chinese master craftsmen.

**Lytle, 1982.*

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NOTES
· AND ·
NEW TECHNIQUES

A GEMOLOGICAL STUDY OF TURQUOISE IN CHINA

By Wang Fuquan

Gem-quality turquoise is currently being mined in Hubei Province, China. The material ranges in color from light blue to bluish green; it usually occurs as nodules 1 to 5 cm in diameter, although much larger pieces have been found. For the most part, the gemological properties of this Chinese turquoise are similar to those of material from other localities; one specimen was found to approach end-member turquoise in chemical composition.

According to ancient literature, turquoise has been known in China for more than 3,000 years. In 1977, more than 1,000 turquoise relics in the forms of cicadas, frogs, and other animals were unearthed from ruins dating to the Yin Dynasty (about 1300 B.C.) in Anyang, Henan. More recently, a turquoise necklace dating from about 100–7 B.C. was unearthed at Lijiashan, Jiangcheng County, Yunnan Province. Today, significant quantities of gem-quality turquoise are being mined at Yunxian and Zhushan in Hubei Province (Wang Fuquan, 1979). This article reports on the gemological characteristics of turquoise currently being mined in Hubei.

PHYSICAL AND OPTICAL PROPERTIES

Chinese gem-quality turquoises are light sky blue, greenish blue, and bluish green in color (see figures 1 and 2). Mössbauer and optical absorption spectroscopy of a greenish blue sample revealed that it contains iron (Fe^{3+}), which apparently plays an important role in affecting the color variability of turquoise from blue to greenish blue. Mineralogist Zhang Huifen (1982) showed that the light sky blue color (see photo in Keller and Wang, 1986) depends mainly on the presence of copper (Cu^{2+}) and that, with increasing amounts of iron, the color shifts from sky blue to bluish green and then to green. In addition, absorbed water darkens the color (Webster, 1983, p. 242).

Chinese gem turquoise is normally opaque but is translucent in thin section; it has spot refractive indices of 1.62–1.64, a waxy luster, a Mohs hardness of 4.6–5.5, a specific gravity of 2.696–2.698, weak greenish yellow fluorescence to both long- and short-wave ultraviolet radiation, and is tough and compact-massive, appearing as a scaly aggregate when observed in the SEM (figure 3). The optical absorption spectrum as seen with a hand spectroscope reveals a typical turquoise spectrum, with bands at about 432 and 460 nm. Color reflectivity measurements of the greenish blue sample described above indicate a dominant wavelength of 490 nm.

CHEMICAL COMPOSITION

The ideal chemical composition of gem turquoise is $CuAl_6(PO_4)_4(OH)_8 \cdot 4-5(H_2O)$. Chemical analy-

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Acknowledgments: All photographs are courtesy of the Geological Museum, Beijing, China.

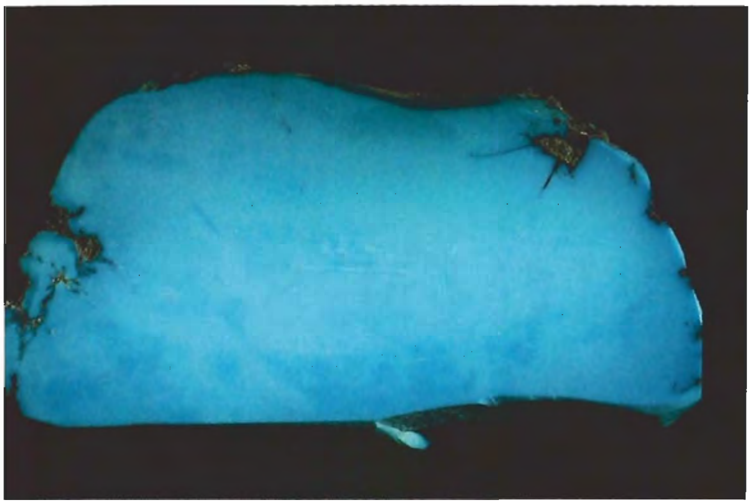

Figure 1. This 5.5-cm-long section of a turquoise nodule illustrates the almost solid blue color that can be seen in some of the finer specimens from Hubei Province.

sis of a sample of Chinese turquoise revealed that the specimen belongs to the turquoise-chalcosiderite isomorphous series and approaches end-member turquoise in composition, with trace amounts of zinc, calcium, fluorine, and ferric iron present. The CuO content of the sample analyzed is slightly lower than that of the theoretical value, but the Al_2O_3 and P_2O_5 contents approach the theoretical values for end-member turquoise more closely than do those of turquoise from any other famous locality (see, for example, Cid-Dresdner and Villarroel, 1972).

CHINESE TURQUOISE AS A GEM MATERIAL

Gem-quality Chinese turquoise is relatively pure and tough, with a fine and smooth appearance like jade, simple and elegant in color, and glittering like porcelain when polished.

In China, turquoise with a Mohs hardness above 5 is known as "porcelain turquoise," of which those specimens with a brilliant, unadulterated sky blue color are considered highest in quality. Less desirable is the turquoise with a hardness below 4.5 and those specimens that have been faded by weathering. Turquoise that is reticulated with fine-veined limonite (ferrian lines) is referred to by jewelers as "spiderweb turquoise"; specimens with clean, sharp lines are considered the finest quality.

The finest Chinese turquoise is comparable in quality to that from Iran, the Soviet Union, and the southwestern United States. It can be used in jew-

Figure 2. This snuff bottle (3.5 × 9.3 cm) has been carved from reticulated Chinese turquoise. Note the difference in color of the material used for the top as compared to that used for the body.

Figure 3. Chinese turquoise appears as a scaly aggregate when viewed with the scanning electron microscope.

Figure 4. This 3-kg vase (24 cm high), intricately carved with nine lions, is a particularly fine example of Chinese turquoise. Courtesy of the Geological Museum, Beijing.

elry that will sell at moderate or even high prices, and is one of the traditional materials used for handicrafts such as beads, vases, incense burners, and figurines. Among the exhibits in the Geological Museum of China is a fine turquoise vase carved with nine lions and weighing 3 kg (figure 4) that is an exceptional example of such carving.

GEOLOGY AND OCCURRENCE

In China, gem-quality turquoise is generally found in silicified limestones, primarily in tension fracture zones or in the axial part of folds. The turquoise is usually nodular in appearance (again, see figure 1) with various structures that include oolitic, pisolitic, botryoidal, or brecciated. As a rule, the nodules range from 1 to 5 cm in diameter. Vein deposits may be single or multiple in the fracture zones; they are usually less than 1 cm in width and more than 1 m in length. Common associated minerals include quartz, halloysite, allophane, limonite, sericite, variscite, pyrite, and jarosite. The boundaries of the deposits are well defined, with no trace of hydrothermal alteration having been observed, which indicates that the ores represent leaching deposits produced by weathering.

SUMMARY AND CONCLUSIONS

Significant quantities of gem-quality turquoise are currently being mined in Hubei Province, China. This material ranges in color from light blue to bluish green. The finest specimens are evenly colored "sky blue" nodules, and rival the finest turquoise from other, more famous localities. Chinese turquoise is currently used in jewelry and carvings, including beads and statuettes.

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THE GEMOLOGICAL CHARACTERISTICS OF CHINESE PERIDOT

By John I. Koivula and C. W. Fryer

Significant deposits of gem-quality peridot have been found in the People's Republic of China. This Chinese peridot has geologic origins and gemological properties almost identical to the peridot found on the San Carlos Apache Reservation in Arizona, and cannot be distinguished gemologically, at this time, from peridots from other known localities.

In 1979, geologists from the Ministry of Geology and Mineral Resources discovered gemologically important peridot deposits in the Zhangjikou-Xuanhua area of Hebei Province, about 150 km northwest of Beijing (Peking), in the People's Republic of China. The peridot is found as gemmy nodules in extrusive vesicular alkali basalt lava flows (Keller and Wang, 1986). Like the peridot found in San Carlos, Arizona, which also occurs in basalt (Koivula, 1981), no well-formed single crystals of rough peridot have been found in the Chinese deposits. Gem-quality peridot nodules and fragments 2 cm in diameter and up to 25 ct in weight were examined by the authors (figure 1). Excellent gems (figure 2) can be cut from this rough.

GEMOLOGICAL PROPERTIES

Of a total of six rough nodules, three were selected for faceting so that they could be tested gemologically along with two other previously faceted stones. The faceted gems ranged in weight from 0.70 to 10.51 ct. A triangular mixed-cut 2.87-ct stone (figure 2) had the best clarity. The samples examined ranged in color from a light yellow-green

Figure 1. Two of the rough peridot nodules from China that were used in this study. The larger measures 20.6 × 13.7 × 10.1 mm and weighs 23.71 ct. Photo © Tino Hammid.

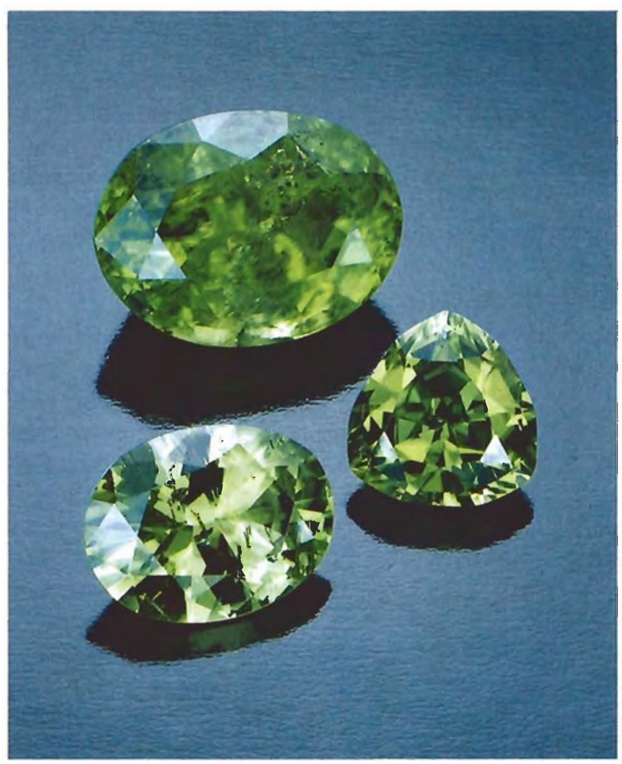


Figure 2. These three faceted peridots from China weigh 2.87, 3.86, and 10.51 ct, respectively. Stones faceted by William C. Kerr. Photo © Tino Hammid.

NOTE FROM THE CUTTER

The Chinese peridot shows great promise as a gemstone. Unlike peridot from Arizona, the Chinese material exhibits no directional hardness variations during either cutting or polishing. Both processes took slightly longer than is typical for peridot, which suggests a slightly higher hardness. Transparency is excellent, and material free of all but the smallest inclusions could produce fine gems in the larger sizes.

William C. Kerr, G.G.

to a darker, richer yellow-green. Using a GIA-GEM ColorMaster on the darker stones, we determined a color equivalent reading of A-25/61/00.

Refractive index readings on the five faceted gems were identical: biaxial positive with indices of $\alpha = 1.653$, $\beta = 1.670$, and $\gamma = 1.689$. The corresponding birefringence was 0.036.

The visible-light absorption spectra of the Chinese peridots were studied using a Beck prism spectroscope. All of the stones showed the same pattern, typical for peridot: A band between 493.0 and 481.0 nm had its strongest absorption at 492.0 nm; the strongest single absorption line was visible at approximately 471.0 nm; another broad band, situated in the blue, covered the spectrum from 460.0 to 450.0 and was strongest at 453.0 nm.

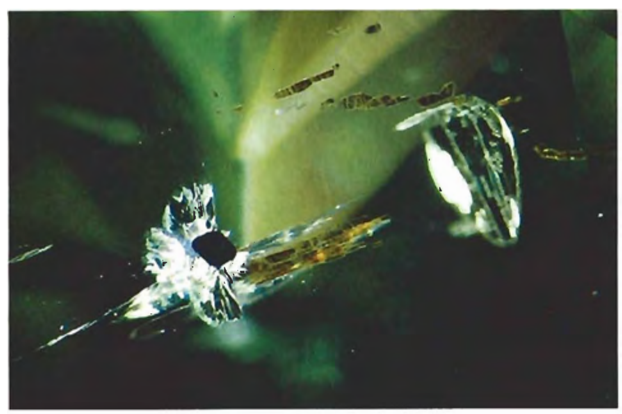
Using a Voland double-pan balance, we determined the specific gravity hydrostatically to be 3.36. The Chinese gems are inert to both long-wave and short-wave ultraviolet radiation.

Using standard hardness points, we determined hardness to be between 6½ and 7 on the Mohs scale, although observations about the hardness of these peridots made during faceting (see box) suggest that this material might be slightly harder than the 6½ normally attributed in gemological texts to peridot. It may be very near 7, the hardness assigned to forsterite, the magnesium-rich end member of the olivine series.

INCLUSIONS

The inclusions in this new material are typical of peridot formed in an alkali basalt. All of the inclusions observed in the Chinese peridots studied have also been noted in peridot from Arizona (Koivula, 1981). For example, in figure 3, the black opaque grain surrounded by a tension halo is a crystal of chromite, the transparent brown crystals are probably biotite mica, and a circular cleavage disc ("lily pad") is also visible edge-on. Partially healed secondary fractures, as shown in figure 4, were observed in all of the Chinese stones. In figure 5, a partially healed cleavage is pictured. The iridescent portion shows few signs of repair. The round white dot is the negative crystal that ruptured, producing the original separation. A dark "emerald-green" chrome diopside crystal (figure 6) was observed in only one of the Chinese peridots. Growth undulations were observed through the table of the triangular mixed cut. These growth undulations are the result of incomplete solid solution and visibly strained dislocations in the

Figure 3. This photo shows characteristic peridot inclusions of black chromite, brown biotite, and a "lily pad" cleavage as observed in a Chinese peridot. Dark-field and oblique illumination, magnified 25×.



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All photomicrographs in this article were taken by John I. Koivula.

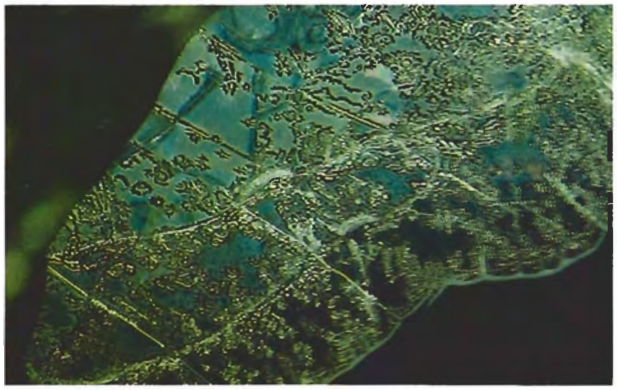

Figure 4. A delicately veined, partially healed secondary fracture is visible in this Chinese peridot. Dark-field and oblique illumination, magnified 45×.

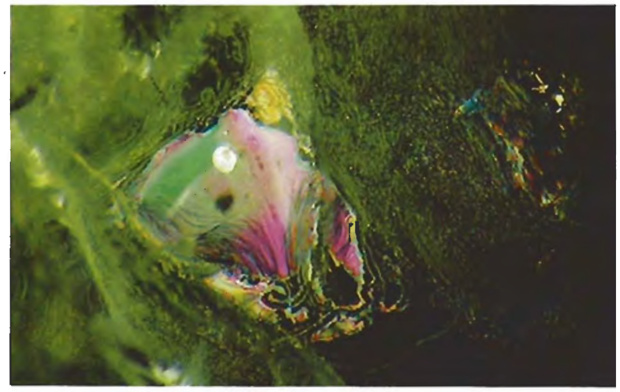

Figure 5. This partially healed cleavage shows brightly colored iridescent thin-film areas where no repair has occurred. The white circle is the negative crystal that ruptured and produced the original separation. Oblique illumination, magnified 50×.

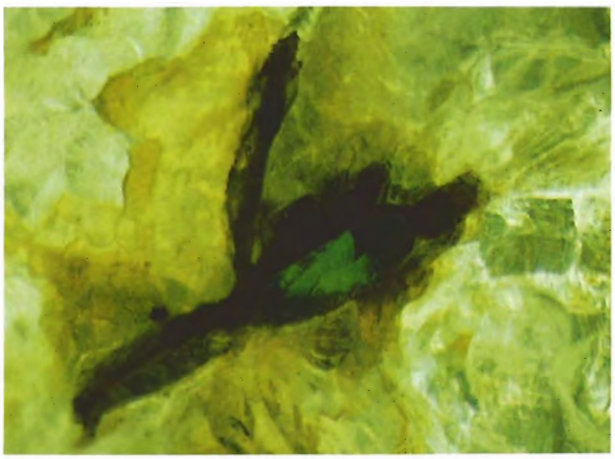

Figure 6. A dark green chrome diopside crystal is surrounded by dark tension cracks in a Chinese peridot. Diffused transmitted and oblique illumination, magnified 40×.

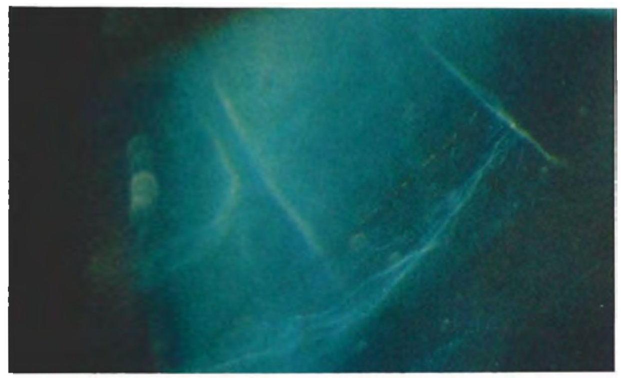

Figure 7. The growth undulations in a Chinese peridot appear as delicate wispy, smoke-like veils when observed in dark-field illumination. Magnified 50×.

peridot (Koivula, 1981). With dark-field illumination they usually appear as smoke-like veils (figure 7).

CONCLUSION

Because of the limited sample of stones available for study, only a narrow range could be determined for the gemological properties of the Chinese material, although a wider range of properties is known to exist for other peridot from similar geologic environments (Koivula, 1981). However, the Chinese peridots examined show gemological characteristics similar to and within the range noted for peridot from any other known locality. Thus, on the basis of the samples examined, we do not feel that the Chinese stones can be separated from peridots from other localities by means of their gemological properties.

The Chinese government and specifically the Chinese Gem and Mineral Development Company, headquartered in Beijing, are now actively mining and cutting the peridot for commercial purposes (Keller and Fuquan, 1986). Therefore, it should not be surprising if significant amounts of Chinese peridot begin to appear on the world gem market in the near future.

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THE SAPPHIRES OF MINGXI, FUJIAN PROVINCE, CHINA

By Alice S. Keller and Peter C. Keller

Blue sapphires are currently being mined on an exploratory basis from alluvial deposits at the Lindi mine, near the town of Mingxi in Fujian Province. The geology and occurrence of the sapphires appears to be similar to that of the gem corundum from Australia, Thailand, and Kampuchea (Cambodia). For the most part, the rough sapphires are greenish blue to dark blue in color and average approximately 2 ct; their gemological properties are also similar to those of sapphires from comparable geologic environments.

One of the greatest potential gem resources in China today is sapphire. Currently, there are two major areas producing gem-quality material: Hainan Island and Fujian Province. Because weather conditions on Hainan Island are so severe, these deposits have been largely inaccessible to Westerners for study. Recently, however, the Bureau of Geology and Mineral Resources of the People's Republic of China opened their operation at the Lindi mine, near the city of Mingxi in Fujian Province, to the authors. Although the current operation is solely for purposes of research and exploration, local officials hope to develop an economic facility and to begin marketing and distribution in the near future.

It is interesting to note that although large, crudely cut sapphires (as well as rubies and cat's-eye chrysoberyls) can be seen in the imperial regalia of the Ming (14th–17th centuries) and later dynasties, virtually all of these stones appear to have been obtained from Sri Lanka. There is little evidence of the use of native Chinese sapphires in historical pieces in China (Dr. Hu Chengzhi, pers. comm., 1985).

Sapphires were first discovered near the town of Mingxi in 1980, during the course of exploration for diamonds in the area. Since 1980, exploratory mining for sapphires has yielded 5,000–7,000 ct of largely blue rough from river gravels near the town. The geologic setting from which the sapphires have been recovered is similar to that of many alluvial corundum deposits elsewhere in the world: Kampuchea (Jobbins and Berrangé, 1981), Thailand (Keller, 1982), and Australia (Coldham, 1985). Most of the blue sapphires found to date are similar in appearance to the very dark stones (figure 1) commonly associated with the Australian deposits (Coldham, 1985).

The current review of the Mingxi sapphire fields and the gemstones found there is based on the authors' October 1985 visit to Mingxi.

LOCATION AND ACCESS

The Lindi mine is located 10 km northwest of the town of Mingxi in Fujian Province (see map in figure 1, Keller and Wang, 1986). The most direct access requires a seven-hour train ride from Fuzhou, the capital of Fujian, approximately 170 air kilometers northeast to the town of Sanming, and then approximately two hours by field vehicle over 80 km of winding, but mostly paved, mountain road to Mingxi. On their visit, the authors encountered several places where rock slides from a recent rain had blocked part of the road; access could be greatly impeded during heavy rains.

The town of Mingxi, although quite a distance from other population centers, has more than 50,000 inhabitants. The climate in this area of China is largely tropical, and rice paddies represent the dominant agriculture. Water buffalo are still seen pulling the ploughs as they have for centuries, although modern tractors are now far more common on the contryside.

All mining is controlled by the national Bureau of Geology and Mineral Resources; the headquarters of the Fujian branch of the bureau is in

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Mrs. Keller is editor of Gems & Gemology, *published by the Gemological Institute of America in Santa Monica, California; Dr. Keller is associate director of the Los Angeles County Museum of Natural History, Los Angeles, California.*

Acknowledgments: The authors wish to thank Dr. Li Chun Ren and Dr. Bian Xiao Zeng, of the Fuzhou branch of the Bureau of Geology and Mineral Resources, for arranging the visit to Lindi mine and for their helpful discussions. The assistance of interpreter Mrs. Lu Dao-Ying and geologist Dr. Wang Fuquan, both of the Geological Museum in Beijing, was invaluable during the visit. All photos are by Dr. Keller unless otherwise noted.

Figure 1. This 9.5-ct sapphire crystal was found at the Lindi mine, near the town of Mingxi, in Fujian Province. Photo © Tino Hammid.

Fuzhou. Access to the sapphire mine is by government invitation only, since it is not open to the general public.

GEOLOGY AND OCCURRENCE

Detailed geologic field mapping has only recently been initiated in the Mingxi area, and what information is available is a result of a widespread stream-gravel sampling project undertaken by geologists from the Fujian Bureau of Geology and Mineral Resources. Understanding the geology of the area is further complicated by the fact that the region's subtropical climate has led to deep chemical weathering and massive erosion. Rock outcrops of any type are very rare, and the sapphires are limited to alluvial stream gravels.

In the Mingxi area, sapphires have been detected over a distance of 50 km in Ginxi Stream, a tributary of the Minh River. Alkali basalt flows with mantle xenoliths (foreign rock fragments) have been mapped locally by Chinese geologists. They reported that some small crystals of sapphire have been found in these basalts. The authors were taken to a small, heavily weathered outcrop of what appeared to be an alkali basalt containing large weathered nodules, typical of mantle material. Furthermore, a detailed examination of the stream gravels revealed abundant black spinel, pyroxene, enstatite, and roughly equal amounts of pyrope garnet, zircon, and olivine (peridot) as detrital minerals along with the corundum.

Preliminary investigations into the geology of the area suggest that this sapphire occurrence may be very similar to the sapphire occurrences in the New England district of New South Wales, Australia (Coldham, 1985) and the ruby occurrences in Chanthaburi-Trat, Thailand (Keller, 1982) and Pailin, Kampuchea (Jobbins and Berrangé, 1981). These areas are also deeply weathered and the corundum is either alluvial or eluvial. In all instances, there appears to be an association between the presence of alkali basalt flows and the distribution of corundum. Furthermore, the minerals associated with the corundum in the alluvium are consistent with those found in an alkali basalt, particularly the type of alkali basalt that contains mantle xenoliths.

MINING AND PROCESSING

Mining. At the current time, mining is restricted to the Ginxi streambed itself. During the authors' visit, approximately 10 miners were working the deposit (figure 2), with active mining in only one small area of the stream. To retrieve the gem materials, the miners dam up various parts of the stream, thus shutting off the flow of water, and then shovel gravel from the drained stream bottom onto the adjacent bank (figure 3).

The gravel is trucked to a processing plant 5 km southeast of the mining area, halfway between the deposit and the town of Mingxi. In this fashion, the miners remove approximately 7–8 cubic meters of gravel per day.

Processing. To retrieve and sort the gem rough, the mine operators use a five-step recovery process:

First, the gem gravel is placed in a pulsator and washed. The larger pieces are removed by hand, while the smaller gravels are passed through a mesh 2.5 cm (1 in.) in diameter (figure 4).

Next, these smaller pieces are sent through a second pulsator, where they are sorted into five different groups via four different meshes: less than 1 mm, 1–2 mm, 2–4 mm, 4–8 mm, and 8–16

Figure 2. Several miners leave the small area of Ginxi Stream that they have been working for sapphire.

Figure 3. Various sections of this small portion of Ginxi Stream have been dammed up so that the miners can retrieve the gem gravel from the drained stream bottom.

mm. A final machine sort uses gravity to remove the lighter rock particles so that only the gem concentrate—approximately one-third garnet, one-third zircon, and one-third sapphire—remains (figure 5).

In the fourth step, the gem concentrate is taken to the local office of the Bureau of Geology and Mineral Resources. Here the gem crystals are sorted out on a glass table top that is lit from below so that the gem materials can be more readily identified by virtue of their translucency (figure 6). Lastly, the gems are sorted according to color and gem quality.

Since 1980, this small operation has produced 5,000–7,000 ct of predominantly blue sapphire, approximately one-third of which is gem quality. Equal amounts of dark red garnet and colorless zircon have also been found, but the Chinese have not yet investigated the commercial potential of these two materials.

Figure 4. In the first of a five-step recovery process, the smaller gravels are passed through a 2.5-cm mesh; the larger material that remains on top is removed by hand.

DESCRIPTION OF THE MATERIAL

Color. The sapphires from Mingxi occur in yellow-green, green, greenish blue, and blue. No ruby has yet been found at this deposit. The blue stones typically are very dark; some are heavily included with rutile silk.

The rough sapphire averages 2 ct per piece. The largest nongem sapphire crystal found to date at the deposit is 89.5 ct (15 × 30 mm). Gem-quality sapphires as large as 9.5 ct have been reported (again, see figure 1). The largest faceted stone produced thus far is 2.1 ct. It should be emphasized, however, that since the deposit was first discovered in 1980, only a small segment of the known gem-producing region has been examined. Therefore, these stones represent a very small sample of the potential gem product in this area.

Gemological Properties. The authors were able to obtain only one gem-quality sample of greenish blue sapphire from the Lindi mine (figure 1). Tests on this crystal revealed gemological properties very similar to gem corundum found in Australia, Thailand, and Kampuchea: refractive index 1.762-1.770, specific gravity (by the hydrostatic method) 4.01, inert to long-wave and short-wave ultraviolet radiation.

HEAT TREATMENT

Since early summer, 1985, geological engineers in the Bureau of Geology and Mineral Resources in Mingxi have been experimenting with heating the sapphires. For this procedure, they have been using a Choy industrial oven (an electric oven manufactured in Shanghai). As of October 1985, they had processed several hundred carats at temperatures up to 1600°C (the upper limit of the oven is 1800°C) in an oxidizing environment for a maximum of 10 hours. The rough crystals are placed in the oven as loose gems. Crucibles are not used; nor are the gems coated with any chemicals.

Thus far, the Chinese geologists with whom the authors spoke do not feel that the results are conclusive. The sample stones (a group of eight different types—i.e., different colors and intensities of color—with each treated sample accompanied by an untreated control sample) observed by the authors indicated little if any lightening of the dark blue stones. Those stones with significant amounts of oriented rutile show po-

Figure 5. A preliminary sort of a random concentration of gem gravels produced equal amounts of blue and blue-green sapphire, garnet, and zircon, in agreement with production information provided by local geologists.

Figure 6. A glass table top lit from below is used to sort the gem crystals from the rest of the concentrate.

tential to produce asterism with heat treatment (see Nassau, 1981, 1984). Tests are currently being conducted at the California Institute of Technology to treat a dark greenish blue gem-quality sample of blue sapphire from the Lindi mine in a high-temperature reducing environment (as is commonly used on Australian sapphires, per Coldham, 1985) to see if any improvement in color can be achieved. The results will be reported in a future issue of *Gems & Gemology.*

DISTRIBUTION AND FUTURE POTENTIAL

As mentioned above, the current operation at the Lindi mine is for research and exploration only. However, the bureau does hope to establish an economic operation, including treatment and faceting, in the near future.

While the yield of sapphire to date is too small to justify a major marketing effort, the authors feel that a full-scale mining effort along the entire distance (50 km) of the stream that has been found to produce sapphire should increase the production significantly. More efficient mining methods, such as a mechanical dredging operation for the streambed and the use of a high-power water cannon to break up the alluvial material along the banks, are currently under consideration and should also help to improve the yield. The future prospects for sapphire production in this area appear to be quite good.

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Gem Trade LAB NOTES

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ALEXANDRITE, with Unusual Silky Zones

Natural alexandrites frequently exhibit fine silk-like inclusions when a narrow beam of light strikes them. Figure 1 illustrates unusually coarse silk in a 2.10-ct natural alexandrite. Scattered along the silky zones are oval iridescent discs with an appearance unlike any we have ever before encountered. Although most of the alexandrites we have seen show a feeble color change, or only somber colors, this specimen showed a near-textbook change from green to red. *RC*

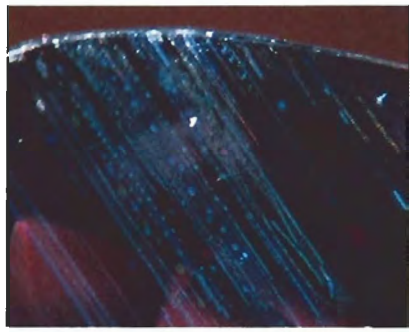


Figure 1. Unusual oval discs along coarse needles in a natural alexandrite. Magnified 30×.

CALCITE Marble Beads

During the past several months, the Los Angeles laboratory has received for identification several strands of round drilled beads that range in color from a yellowish white (figure 2) to a deeper brownish yellow (figure 3). Indistinct refractive indices of 1.48 and 1.66, with the high birefringence that is indicative of a carbonate, were obtained by the spot method. Microscopic examination showed a granular structure. The beads also exhibited a very weak orange fluorescence when exposed to long- and short-wave ultraviolet radiation. The specific gravity was estimated with heavy liquids to be approximately 2.65, which ruled out the possibility of magnesite (3.0–3.1) or even dolomite (2.85), both carbonates that can also occur in massive forms. Therefore, the beads were identified as calcite marble.

During this same period, the laboratory also examined several opaque white beads and cabochons of magnesite that might be confused with calcite marble. Magnesite, however, can be distinguished from calcite on the basis of its higher R.I.

Figure 2. These 9-mm yellowish white beads were determined to be calcite marble.

Figure 3. These 9-mm brownish yellow beads were also identified as calcite marble.

as well as higher specific gravity, and by its inert reaction to a drop of a room-temperature 10% HCl solution (calcite will effervesce). Care must be taken when testing with the HCl solution: Because this is a destructive test, it should only be performed under magnification, with a very small drop of the solution applied to an inconspicuous area of the material, such as in a drill hole. Also, magnesite *will* effervesce if the solution is warm. *RK*

Golden Yellow DANBURITE from Sri Lanka

The Los Angeles laboratory was asked to identify two yellow stones (weighing approximately 11 ct and 4 ct) that appeared to have been cut from the same piece of rough. Both showed the same high luster and golden yellow color, and resembled very fine yellow sapphire (figure 4). Testing, however, proved that the stones were not corundum, but rather were a much rarer gem mineral. The refractive indices were determined on a Duplex II refractometer to be 1.630 and 1.638. Using a glass ball with crossed polaroids in the polariscope, we resolved a biaxial optic figure. The specific gravity was estimated with the use of heavy liquids to be approximately 3.00. There was no reaction to ultraviolet radiation. When examined with a hand spectroscope, both stones showed a very faint, though distinct, absorption line at 585 nm (figure 5), which is probably evidence of a rare-earth absorption spectrum. On the basis of these properties, we identified the stones as danburite, a calcium borosilicate. Our client informed us that both stones had indeed been cut from the same piece of rough, which had been mined in Sri Lanka. We believe that this is the first report of gem-quality danburite from this locality. *KH*

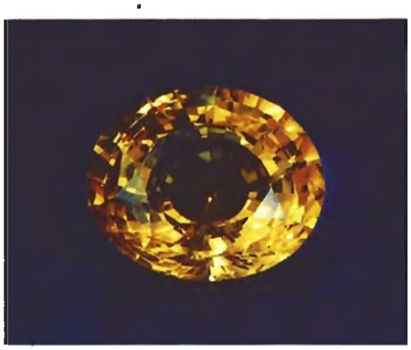


Figure 4. This beautiful yellow danburite (approximately 11 ct) reportedly was mined in Sri Lanka.

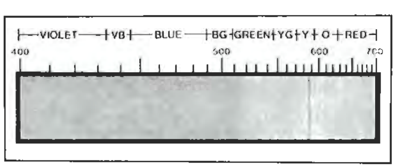


Figure 5. The 585-nm line in this absorption spectrum indicates the rare-earth elements present in yellow danburite.

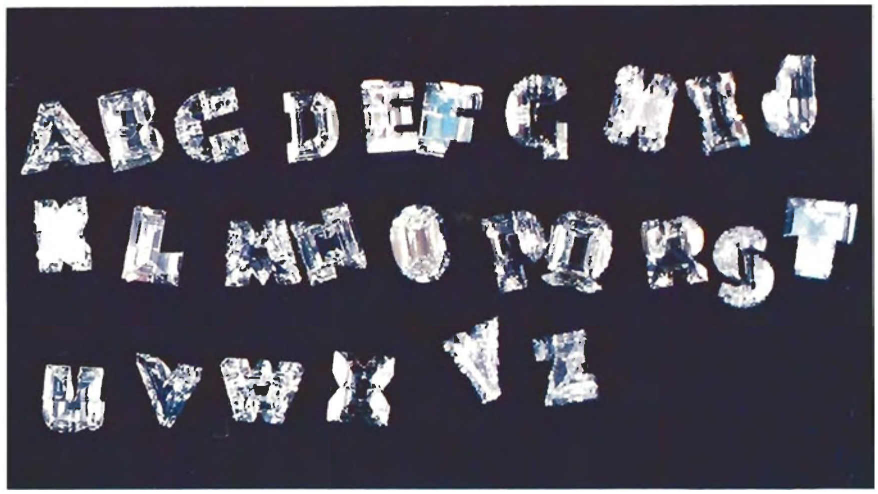


Figure 6. An alphabet cut by laser from diamonds. Each letter measures approximately 6.5 × 4.5 × 2.0 mm.

DIAMOND Alphabet

Since the advent of lasers in diamond cutting, we have seen diamonds cut into shapes that were previously impossible—such as horse heads, four-leaf clovers, Christmas trees, and even a wedding band. Figure 6 shows yet another unusual item: a complete alphabet carved out of diamonds. Each letter is approximately 6.5 × 4.5 × 2.0 mm. *RC*

EKANITE, A Markedly Radioactive Metamict Gemstone

In 1953, a translucent green stone was found in a gem gravel pit in Sri Lanka by F. L. D. Ekanayake. It was subsequently identified as a new mineral, and later given the name ekanite. Since then, we have examined a few of these rare gemstones, the largest of which was a 41.7-ct square emerald cut (see *Gems & Gemology,* Summer 1962, p. 317, and Summer 1977, p. 295). During the past year, the Los Angeles laboratory has had the opportunity to identify three faceted ekanites (figures 7 and 8), each submitted by a different client. These rare gemstones ranged from 0.75 to 3.59 ct. The largest stone (figure 8) in this group was reportedly cut from an 80-ct piece of rough that yielded four

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

Figure 7. These 1.27-ct (left) and 0.75-ct (right) ekanites are reportedly from Sri Lanka. Note the haziness of these metamict gemstones.

Figure 8. This 3.59-ct ekanite, also said to have come from Sri Lanka, is unusually clean.

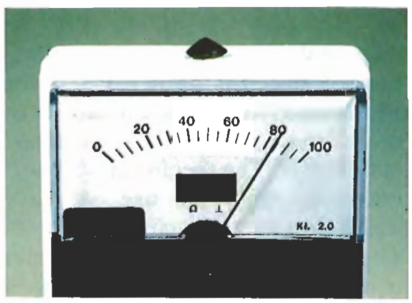


Figure 9. Note the radioactivity of the 3.59-ct ekanite as indicated by a Geiger counter.

faceted stones ranging from 3.59 to 18.29 ct.

Ekanite [chemical formula $(Th, U)(Ca, Fe, Pb)_2 Si_8 O_{20}$] in a metamict form has only been reported from Sri Lanka. The term *metamict* is used to describe minerals that have become amorphous, or nearly so, as a result of atomic rearrangement (breakdown) caused by radioactive constituents (such as the thorium and uranium in ekanite). Extremely small samples of a yellow crystalline (that is, non-metamict) variety of ekanite have been recovered from a glacial syenitic boulder found in the Tombstone Mountains of the Yukon Territory in Canada.

The faceted metamict ekanites that we recently examined were light yellowish green, dark yellowish green, and dark greenish, yellowish brown in color. The refractive index was 1.593 for one of the ekanites, and 1.595 for the other two. All three stones were hazy as a result of inclusions and optical irregularities typical of metamict gemstones, such as are often observed in metamict green zircons, although this haziness was much more pronounced in the stones shown in figure 7. Specific-gravity values were estimated with heavy liquids to be approximately 3.30. The stones were inert to short- and long-wave ultraviolet radiation, except for several small orange spots on the large oval stone that were observed when it was exposed to long-wave U.V. With a hand-held spectroscope, a band at approximately 665.1 nm and a weaker one near 637.5 nm were observed in each of the three stones.

The relatively high content of the radioactive element thorium and lesser concentration of uranium causes ekanite to be strongly radioactive, which can be readily detected when the stone is tested with a Geiger counter (figure 9). Dramatic proof of radioactivity was also provided when one of the stones was placed on unexposed X-ray film for two days. The radiation from the stone was so strong that it exposed the film, in the same fashion as most radium-treated green diamonds will do. *RK*

EMERALD, with Iridescent Coating

A ring set with an approximately 2-ct transparent green rectangular step-cut stone, recently examined in the Los Angeles laboratory, revealed numerous inclusions that are typical of emeralds from Zambia. The absorption spectrum observed was also typical of emerald. Interestingly, though, when this stone was tested with a refractometer in conjunction with a monochromatic light source equivalent to sodium vapor, a reading of only 1.48 was obtained. This suggests that the emerald was tarnished, or coated with a substance that was causing the very low refractive index reading. Microscopic examination with reflected light showed an iridescent coating (figure 10) similar in appearance to what we have seen previously on aquamarine, natural emerald, and occasionally on some synthetic emerald (see *Gems & Gemology*, Spring 1984, p. 45).

Using an ordinary ink eraser, we removed a small portion of the coating on one edge of the table (again, see figure 10). We then took another refractive index reading on this area,

Figure 10. A refractive index of 1.48 was obtained on the coated area of this emerald, and indices of 1.579 and 1.588 were found on the cleaned area. Reflected light, magnified 50×.

which revealed indices of 1.579 and 1.588. These values are typical of Zambian emeralds. This is the first time that we have observed that an iridescent coating or "tarnish" on beryl has noticeably affected the refractive index readings. *RK*

GLASS Microbilles from Arizona

An Arizona gemologist found some unusual material while prospecting an alluvial deposit in a canyon near Nogales, Arizona. The material was collected by sweeping dust from the pockets and seams in the bedrock with a small paintbrush onto a plastic card pressed to fit the contour of the rock. A large number of tiny (0.3–0.5 mm) glass-like spheres (figure 11) were separated from the dust under magnification and subsequently sent to the Los Angeles laboratory for identification. Examination with a polarizing microscope revealed them to be strained glass. Most were spherical, although a few were slightly oval. A couple had small protruberances, so that they resembled a dumbbell.

These tiny glass spheres were identified as microbilles. They have also been found in South Africa and Western Australia, as well as in lunar soil samples (*Science News*, February 1, 1986). There are several theories regarding their formation. One states that they were originally formed during volcanic eruption. They are also known to occur in fly ash, a product of combustion. Another theory is that they are debris from meteorite impacts. Although it is not certain how the microbilles from Arizona were formed, it is possible that they may be related to the large meteor crater near Winslow. *John I. Koivula*

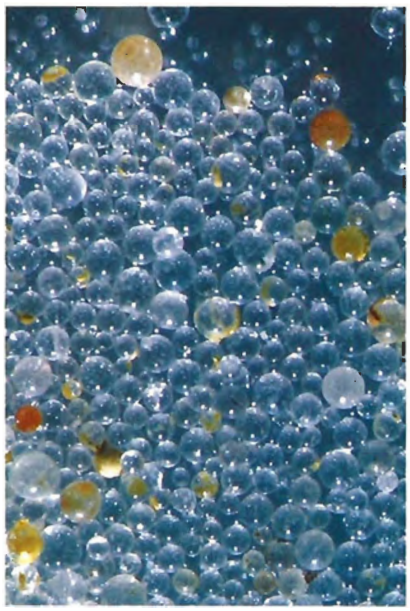


Figure 11. These microbilles, or glass microspheres, were found in Arizona. Note that some are stained and others occur in color. Magnified 20×.

HORNBLENDE AMPHIBOLE, Magnesian Hastingsite (?)

The translucent variegated green hololith ring illustrated in figure 12 was submitted to the Los Angeles laboratory for identification. When the material was examined with the unaided eye, the very uneven polish and dull waxy luster suggested that it had a very low hardness. Because of the poor polish, no definite refractive index reading could be obtained. The specific gravity was estimated with heavy liquids to be in the area of 2.90–2.95. Using a hand-held spectroscope, we observed no distinct lines or bands. The ring was inert to both long- and short-wave ultraviolet radiation. Using hardness points on an inconspicuous spot inside the ring, we estimated the hardness to be approximately 3–3½ on the Mohs scale.

Figure 12. This ring is an amphibole, probably magnesian hastingsite in the hornblende series.

Further testing was deemed necessary, so a minute amount of powder was scraped from inside the ring for X-ray diffraction analysis. The results indicated that the material was an amphibole that was neither tremolite nor actinolite; thus, the possibility of nephrite jade was ruled out. The X-ray diffraction pattern came closest to the magnesian hastingsite pattern in the hornblende series. Chemical analysis would be needed for a more precise identification. *RK*

LAPIS LAZULI IMITATION, Dyed Blue Quartzite

A few months ago, the Los Angeles laboratory examined a broken portion of a dyed blue quartzite bead (approximately 8 mm in diameter) that had been represented as lapis lazuli (figure 13). However, as shown in figure 14, the material is actually white with a blue dye penetration of approximately 1.5 mm. The gemological properties of this imitation,

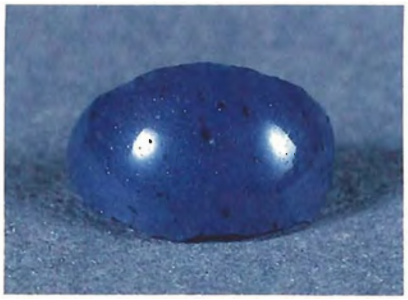


Figure 13. This quartzite bead (which measures approximately 8 mm) was dyed to imitate lapis lazuli.

Figure 14. This broken portion of the imitation lapis lazuli bead in figure 13 shows the dye penetration into the quartzite.

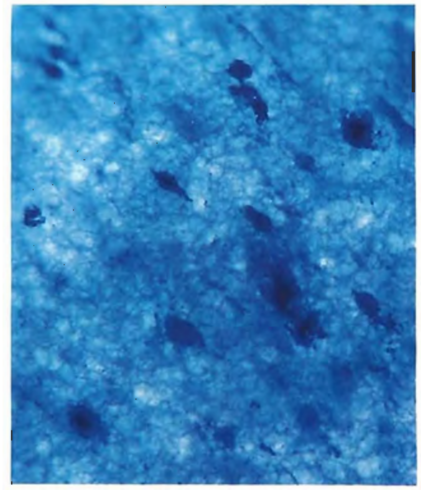


Figure 15. With 25× magnification, dye concentrations can be seen in the pits and fractures of the quartzite imitation of lapis lazuli.

TABLE 1. Gemological properties of dyed blue quartzite and natural-color lapis lazuli.

Property	Dyed blue quartzite[a]	Lapis lazuli
Transparency	Translucent to semi-translucent	Semitranslucent to opaque; shallow transparency (0.5 mm)
Color	Medium blue to violetish blue; coloration often even	Light to dark blue; even coloration to mottled with white calcite and yellow metallic pyrite
Refractive index	1.53 or 1.54[b]	1.50; may show 1.67 R.I. due to calcite or diopside inclusions, or both 1.50 and 1.67, or an R.I. between 1.50 and 1.67
Magnification	Dye concentrations in surface cavities and in fine intertwined network of small thin fractures	Nearly opaque white to transparent colorless calcite and "yellowish" metallic pyrite often present; pyrite has convolution outlines and is usually unevenly distributed; dark blue outline commonly seen around pyrite; may see dye concentrations if the material has been dyed
Fluorescence	Inert to LW and SW	Usually fluoresces moderate to strong chalky yellow, yellowish white to yellowish green (SW); calcite inclusions may fluoresce moderate to strong chalky white or chalky orange (LW)
Fracture	Dull to waxy, conchoidal; may appear granular to uneven under high magnification	Dull, granular to uneven
Acetone	No reaction	No reaction unless dyed
10% HCl acid solution	No reaction	Produces rotten egg odor; if calcite is present, may effervesce

[a]*Results listed are based on one sample.*
[b]*Spot refractive index readings.*

especially the higher refractive index, easily distinguish it from lapis lazuli (see table 1). With magnification, the dye concentrations are visible (figure 15). *RK*

Oolitic OPAL with Chalcedony Matrix

Recently submitted to the Los Angeles laboratory was a 62.56-ct translucent to opaque, variegated white-and-brown free-form polished slab with many areas that displayed a play of color; tiny dark brown circular spots confined to the areas displaying play of color were faintly discernible to the unaided eye (figure 16). In other areas, the variegated white-and-brown material occasionally exhibited a faint, agate-like banding. There was also a cavity lined with small, well-formed colorless quartz crystals. Examination with a microscope and oblique lighting confirmed that the small circular inclusions were the same as those characteristic of oolitic opal.

The variegated white-and-brown areas revealed a refractive index reading of approximately 1.54, which is much too high for opal but does fall within the range for chalcedony. The areas that showed a play of color had a refractive index of 1.45, which is typical of opal. This material was therefore identified as oolitic opal with chalcedony matrix. *RK*

PEARLS, with Unusual Drilling Features

We have on rare occasions identified natural pearls with "Chinese drill-

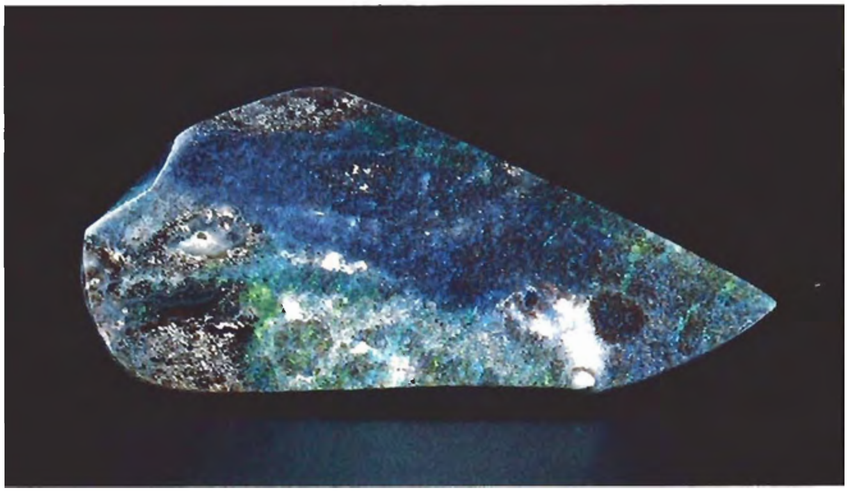


Figure 16. This polished slab was identified as oolitic opal with chalcedony matrix.

ing," a technique whereby two holes are drilled to meet within the pearl so that it can be sewn to a robe. Figure 17, taken in the New York laboratory, is the X-radiograph of a pearl that appeared to be drilled in this manner. Note the two drill holes and what appears to be the "crossover" where they meet. However, thread could not be passed through the holes and the client questioned the notation of "Chinese drilling." A subsequent X-ray (figure 18), taken from a different angle, shows that the two drill holes are actually parallel and that the apparent crossover is merely a dark-appearing center. Experienced pearl dealers we contacted indicated that they had never seen this style of drilling before. One drill hole has always been considered to be sufficient. This approximately 12-mm pearl was unusual for another reason: Although it appeared to be a typical, slightly dull, bone-white freshwater pearl, it did not fluoresce to X-rays as one would expect of a freshwater pearl.

In recent months, the New York laboratory also examined a pair of 20 × 13 mm half-drilled button pearls with suspiciously large drill holes (figure 19). The pearls were determined to be saltwater, mantle tissue–nucleated cultured pearls; however, the X-radiograph revealed that an attempt had been made to drill the bead repeatedly to eliminate evidence of tissue nucleation (figure 20). Although the pearls were of saltwater origin, the laboratory is

Figure 17. This X-radiograph of a 12-mm pearl shows what appear to be two drill holes angled to meet.

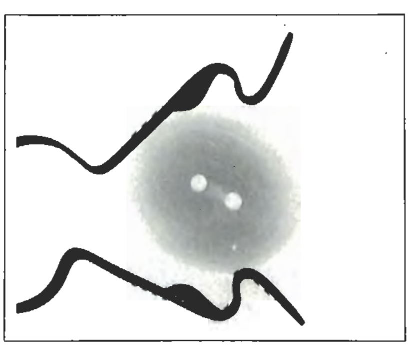


Figure 18. A second X-radiograph of the pearl shown in figure 17, taken from a different angle, shows that the drill holes are actually parallel and do not meet.

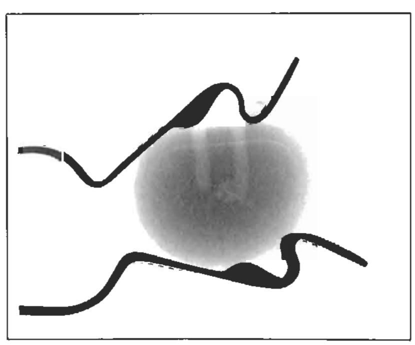


Figure 19. Note the large drill hole in this saltwater mantle tissue–nucleated cultured pearl.

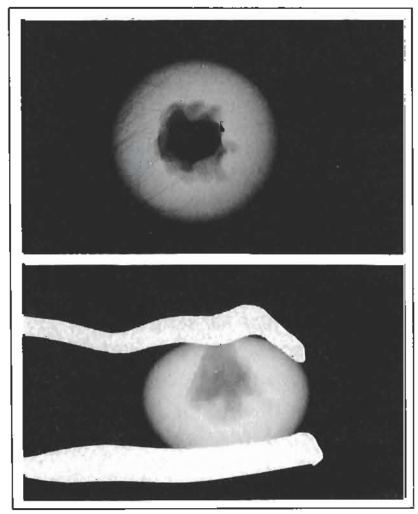


Figure 20. These X-radiographs show efforts to drill out the nuclei of the pearls shown in figure 19.

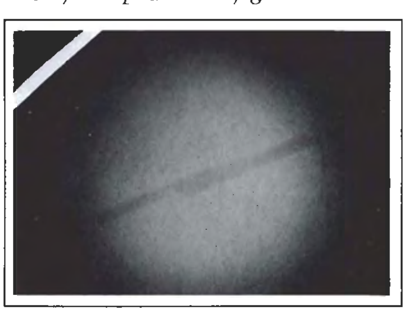
Figure 21. The dyed cultured pearls in this strand have predrilled nuclei.

unaware of any commercial ventures using mantle-tissue nucleation to culture pearls in a saltwater environment.

Not a problem, but of considerable interest to the New York laboratory, was an undrilled light orange pearl that measured over 17 mm in diameter. We were surprised to find that it was a freshwater cultured pearl with a predrilled bead nucleus. Although the use of predrilled nuclei was mentioned in *Gems & Gemology* as long ago as the Spring 1962 issue, the resulting pearls have usually been a disappointment because of color problems. Figure 21 shows a handsome necklace of these pearls which have been dyed a uniform light orangy brown. Sapphire and diamond rondelles separate the pearls in the necklace. Mr. Fred Ward, writing in the August 1985 issue of *National Geographic,* states that one enterprising pearl farmer in Japan is growing both tissue-nucleated and predrilled bead–nucleated pearls, the largest of which to date has been 17 mm. Freshwater mussels cannot be opened for nucleus insertion as wide as the saltwater "akoya" mollusk. To compensate, the nuclei are predrilled (figure 22) so that they can be maneuvered into position with a tool that resembles a toothpick rather than the traditional "spatula."

RC

Figure 22. This X-radiograph shows the predrilled nucleus of one of the pearls in figure 21.



SAPPHIRE, Pinkish Orange ("Padparadscha")

Attracting a great deal of attention during the February 1983 Tucson Gem & Mineral Show was the 1,126-ct pinkish orange sapphire crystal from Sri Lanka shown in figure 23. The firm displaying the crystal expected it to yield a cut stone weighing at least 200 ct. This unusual crystal was illustrated and discussed in the article "Padparadscha: What's in a Name?" by Robert Crowningshield (see *Gems & Gemology,* Spring 1983). Discussed in this article was the term *padparadscha* and the fact that the precise hue represented by this term is often a subject of controversy and discussion. Most of the gem dealers who saw this spectacular crystal agreed that the color was aptly referred to as padparadscha. Because of the subjectivity of the term, however, GIA Gem Trade Laboratory, Inc., does not use it on the GTL identification reports, treating it in the same manner as the trade grades "Burma ruby," "Kashmir sapphire," and "Siberian amethyst." Although this crystal was remarkable and many felt that it should be kept intact as a mineral specimen, everyone was curious as to what color of faceted gems it would yield, since it seemed inevitable that the crystal was going to be cut.

The crystal was indeed subsequently sold and cut. Because much of the crystal proved to be opaque, or too heavily included to facet, only four stones were reportedly fashioned from the 1,126-ct piece of rough. Three of these stones (16.92 ct, 23.55 ct, and 47.00 ct) were recently examined in the Los Angeles laboratory (figure 24). The fourth stone, which weighed just over 4 ct, was recently shown to the writer by Dr. E. Gübelin; it was similar in color to the 47.00-ct stone pictured here.

The 16.92-ct stone had been heat treated in an attempt to improve the appearance by reducing the dense concentration of intersecting stringers of minute particles (presumably rutile) that were oriented in planes throughout all three stones. This stone was reportedly treated in Sri Lanka using four blow pipes, in contrast to the furnaces that are usually used to heat treat sapphire. Although the treatment did improve the transparency of the stone, it also produced an unnatural-appearing intense orange color. However, the flu-

Figure 23. A 1,126-ct pinkish orange sapphire crystal from Sri Lanka.

Figure 24. The crystal shown in figure 23 yielded these 23.55-ct, 47.00-ct, and 16.92-ct cut stones. The stone on the far right has been heat treated.

orescence and absorption spectrum of this stone were quite different from those typically observed in heat-treated sapphires of this color. This stone showed a strong slightly reddish orange (tangerine color) when exposed to long-wave ultraviolet radiation and the same color, but weaker, with short-wave ultraviolet radiation. Most heat-treated yellow-to-orange sapphires show either a weak reaction or are inert. Interestingly, the other two untreated stones exhibited the same general color of fluorescence of a slightly greater intensity. The difference in fluorescence between this heat-treated sapphire and most others of this color may be because the original material is usually very light yellow to "milky white" and lacks the amount of chromium that causes the fluorescence in naturally colored yellow to orange sapphires. All three stones faceted from the pinkish orange crystal also exhibited absorption lines in the red portion of the visible spectrum, which are attributed to chromium. Again, yellow-to-orange heat-treated sapphires generally do not show chromium absorption due to the nature of the starting material. *RK*

YTTRIUM ALUMINUM GALLIUM GARNET

Several years ago, a new man-made product appeared that has occasionally been referred to as "synthetic tsavorite." Recently, the Los Angeles laboratory had the opportunity to examine a few samples of this material. At first glance, the round-brilliant-cut stones, each weighing approximately 1 ct, resembled in color and luster deep green vanadium grossularite, which is known in the trade as tsavorite. However, examination with the microscope revealed prominent reddish brown flux-melt inclusions and fine unmelted flux in wispy veils, which proved that the stones were of synthetic origin. The refractive index was determined to be 1.885, singly refractive, on a cubic zirconia refractometer. This figure is considerably higher than the range for tsavorite. The absorption spectrum showed a broad band at 570–620 nm and also distinct lines at 660, 670, and 690 nm, an absorption pattern that is similar to green "YAG." All sample stones transmitted red and showed red fluorescence, which was stronger to long-wave than to short-wave radiation. Using the hydrostatic method, we determined the specific gravity to be 5.05. On the basis of these properties, we concluded that the stones were another man-made product with a garnet structure, grown by a flux-melt method. A nonquantitative X-ray fluorescence analysis showed the major constituents to be yttrium, gallium, and lesser amounts of aluminum, chromium, and nickel, thus identifying the product as "yttrium aluminum gallium garnet." This type of synthetic is also grown by the Czochralski pulling technique. *KH*

FIGURE CREDITS

Dave Hargett supplied the photos used in figures 1, 6, and 19. Shane McClure furnished figures 2–4, 7–9, 12–14, 16, and 24. Karin Hurwit prepared figure 5. Bob Kane produced figures 10 and 15. John Koivula took figure 11. Robert Crowningshield did the X-radiographs for figures 17, 18, 20, and 22, and Richard Cardenas took figure 21. Figure 23 is © Tino Hammid.

GEM NEWS

John I. Koivula, *Editor*
Elise Misiorowski, *Contributing Editor*

DIAMONDS

India

New deposits discovered. Diamonds have been found in the Tanna and Chatarpur districts of India by the Geological Survey of India. No information has yet been released about the quality of the diamonds or the size of these previously unknown deposits. (*Diamond Intelligence Briefs*, October 18, 1985)

Japan

World's largest synthetic industrial diamond? A synthetic 3.50-ct industrial diamond was produced by the National Institute for Research at Tsukuba, Japan, in their Inorganic Materials Research Laboratory. This is reputed to be the largest man-made diamond in the world. The diamond was made by placing 2 grams of carbon and small amounts of iron, nickel, salt, and diamond seed crystals in a cylinder measuring 5 cm high × 7.5 cm in diameter. The mixture was heated at 1550°C for 200 hours under a 14,000-ton press at 8.9 million pounds per square inch.

The Tsukuba Institute is also working on a technique for depositing a layer of synthetic diamond on a substrate, to be used by the electronics industry for semiconductors that need to withstand high temperatures and by the machine-tool industry for harder cutting edges. The process involves directing a flow of methane and hydrogen through a microwave source at 300 atmospheres of pressure against a substrate (e.g., silicon) that is heated to a temperature of up to 1000°C. Under these conditions, the gases undergo a reaction whereby they decompose and deposit a layer of diamond on the substrate. (*Diamond World Review*, Autumn 1985; *Indiaqua*, No. 40, 1985)

South Africa

Diamond inclusions in pyrope. While at the Pasadena Gem and Mineral Show in Pasadena, California, last November, the Gem News editor was shown a small but exciting group of rough pyrope garnets. These stones contained numerous inclusions of diamond, which made them exceedingly unusual. These garnets were found in an unnamed kimberlite 96 km (60 mi.) north to northeast of Kimberley, in the Republic of South Africa. Although geologists, mineralogists, and gemologists are all familiar with inclusions of pyrope in diamond, or diamond in diamond, this is the first report of diamond in pyrope. Perhaps more of these highly unusual garnets will be discovered as geologists begin to examine inclusions in upper-mantle minerals more closely.

Sri Lanka

Geological exploration planned. The Geological Survey of Sri Lanka plans to undertake exploratory geological and geophysical studies with subsequent deep drilling in an effort to locate diamond occurrences. The department will focus on the Koslanda, Ratnapura, Sinharaja Forest, Eppawela, Elahera, Welipatanwila, and Embilipitiya areas. (*Mining Journal*, October 18, 1985)

COLORED STONES

Fade testing yellow sapphire—a caution. Dr. Kurt Nassau has informed *Gem News* that one excellent method to test some gemstones for color stability is to heat them for one hour at approximately 200°C (approximately 400°F). He cautions, however, that this type of fade test should *not* be done on yellow sapphires because a complicated reaction occurs and the gems will lose their color. Dr. Nassau has promised to detail the color stability reaction of yellow sapphire to both heat and light in an upcoming issue of *Gems & Gemology*.

Pala in Sri Lanka. In addition to operating the historic Himalaya tourmaline mine in San Diego County, California, Pala International has begun a dredging operation in Sri Lanka. Once recovered, the Sri Lankan gem rough, primarily corundum and garnet, is presently cut at Pala's lapidary workshop in Fallbrook, California. According to Josh Hall, Pala International anticipates that the Sri Lankan operation will also yield spinel, chrysoberyl, zircon, and tourmaline, and that only the larger rough will be cut in the United States. The rest will be fashioned in Sri Lanka. (*Gem Spectrum*, October-November 1985)

Unusual Sri Lankan sapphires. Mr. Ben Hoo, of C. T. Hoo Pte. Ltd. in Singapore, recently sent the Gem News editor two very strongly bi-colored blue-and-orange oval mixed-cut Sri Lankan sapphires (2.79 and 3.00 ct) for examination. These sapphires showed all of the gemological properties typical of sapphire, except for their reaction to ultraviolet radiation and their weak absorption spectrum. The two stones displayed a very weak, unevenly distributed, orangy fluorescence when ex-

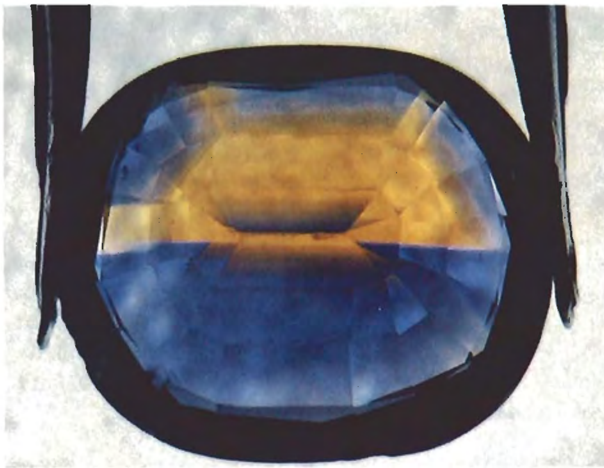


Figure 1. This unusual, strongly bi-colored, Sri Lankan sapphire weighs 2.79 ct. Photo by John I. Koivula.

posed to short-wave ultraviolet radiation. Exposure to long-wave ultraviolet radiation produced a strong orange fluorescence in the orange areas of the stones, but the blue portions remained inert. Under the spectroscope, the lighter colored stone showed no visible light absorption, while the dark blue portion of the darker colored stone (figure 1) showed a very weak iron line near 450 nm. When examined with the microscope, both stones showed evenly disseminated clouds of fine particulate matter (rutile dust?) confined exclusively to the straight-angular color zones. The darker stone also contained a small fingerprint, an angular white included crystal, and several tiny inclusions surrounded by halos.

Such strongly bicolored stones are rare; their appearance indicates their natural origin.

SYNTHETICS

Synthetic "watermelon" beryl. A very unusual, and heretofore unreported, form of synthetic beryl is now being grown and marketed by Adachi Shin Industrial Company, Ltd., in Osaka, Japan. Known as watermelon beryl, the material consists of a synthetic pink beryl core with a synthetic emerald rind (figure 2). Although this synthetic has been grown experimentally since 1979, it has only recently become available commercially.

At first glance, the synthetic watermelon beryl resembles watermelon tourmaline. However, a routine check of gemological properties easily distinguishes the two. The Gem News editor recently examined three polished slices of this material, ranging from 0.61 to 0.80 ct. As expected, the test slices were uniaxial negative. Using a sodium vapor light and a Duplex II refractometer, he found refractive indices of 1.559 and 1.564. The specific gravity was uniform at 2.66. When examined with a Beck prism spectroscope, the green portions displayed spectral lines at 660, 620, and 477 nm, while the pink centers showed no visible-light spectrum. The pink cores were inert to both long- and short-wave ultraviolet radiation, while the green rinds reacted with a weak dull-red fluorescence; no phosphorescence was observed. Examination with a microscope revealed numerous tiny monophase fluid inclusions restricted to the pink, distinctly growth-zoned core.

Details concerning the general method of synthesis of this and other synthetic beryls were kindly provided by Mr. Naosuke Adachi and Mr. Isao Yagi, of the Osaka Vacuum Chemical Company Ltd. These beryls are grown by a new method of beryl synthesis, whereby fluorine and oxygen react at higher (but undisclosed) temperatures with crystalline or amorphous beryllium oxide, silicon dioxide, and aluminum oxide together with the appropriate coloring dopants. This mixture then migrates to a cooler zone, where crystallization of the desired product takes place on seeds. With this method, beryl crystals larger than 1 cm have been grown in a wide range of hues including brown, reddish brown, pink, colorless, purple, sky blue, yellowish green, and emerald green, as well as the watermelon material. To obtain these colors, a variety of single-element dopants and combinations are employed, including cobalt, manganese, copper, nickel, titanium, iron, and chromium. The primary dopants that appear to be responsible for the coloration of the watermelon beryl are manganese in the pink core and chromium in the emerald rind.

Figure 2. This slice of synthetic watermelon beryl (6.9 × 4.7 × 2.5 mm) was grown by Adachi Shin Industrial Company in Osaka, Japan. The tiny inclusions in the pink core zone were identified as primary monophase inclusions. Photo by John I. Koivula.

The Lizzadro Museum of Lapidary Art, located in Elmhurst, Illinois, contains one of the finest collections of Chinese and Chinese-style hardstone carvings on public display in the United States today. In addition to antique jadeite pieces, the museum features vases, urns, bowls, and other historical and contemporary objects carved from nephrite, rock crystal quartz, agate, and other ornamental materials. For further information, contact Judy Greene at (312) 833-1616.

The 23rd World Diamond Congress will be held in Tel Aviv, Israel, June 29–July 3, 1986. It is sponsored by the World Federation of Diamond Bourses and the International Diamond Manufacturers Association. For further information, contact The Secretariat, 23rd World Diamond Congress, P.O. Box 50006, Tel Aviv 61500, Israel; Tel.: (03)654571; Telex: 341171 KENS IL.

The Colorado Chapter of Friends of Mineralogy is sponsoring the Colorado Pegmatite Symposium from May 30 to June 2, 1986, at the Denver Museum of Natural History. The symposium will include two days of lectures and two days of field trips to Colorado pegmatite localities. A volume of abstracts and a field trip guide will be published and distributed at the symposium. For registration and further information, contact the Denver Museum of Natural History, c/o Geology Department, City Park, Denver, CO 80205.

IN MEMORIAM: LAZARE KAPLAN, 1883–1986 AND LEO KAPLAN, 1913–1986

It is with great sadness that we record the passing of Lazare Kaplan, renowned diamond cutter and founder of Lazare Kaplan International, at the age of 102; and of his elder son, Leo Kaplan, former chief executive officer of Lazare Kaplan International, at the age of 72.

Born in Russia on July 17, 1883, Lazare Kaplan began his career at age 13 as an apprentice in his uncle's diamond-cutting factory in Antwerp. There he built his skills as a cutter and developed a reputation for getting the maximum yield from odd-shaped rough. By the age of 20, he had his own diamond-cutting factory. When the outbreak of war forced him to move to New York with his wife and infant son in 1914, he quickly rebuilt his business and by 1917 had established one of the first diamond-cutting factories in Puerto Rico. Kaplan himself continued to cut, however, and added to his accomplishments the 287-ct Pohl diamond, the 726-ct Jonker diamond, and the development of the oval brilliant cut. His talent was legendary.

Lazare Kaplan is survived by his younger son, George, Executive Chairman of the Board of the Gemological Institute of America.

Leo Kaplan, who preceded his father in passing after a long illness, was one of the best-known and best-liked figures in the jewelry industry. For many years, he was treasurer of the Jewelers Vigilance Committee and served on the board of the Jewelers Mutual Insurance Company. From 1967 to 1969, he was president of the American Gem Society, and in 1977 he was the recipient of the Shipley Award. Leo Kaplan also served as an officer of the Jewelers Security Alliance, the Jewelry Industry Council, and the 24-Karat Club of New York.

Leo Kaplan's career was devoted to the family business; at the time of his death, he was vice-chairman of the board of Lazare Kaplan International. He is survived by his sons, Peter and Paul, and by his wife Janet.

GEMOLOGICAL ABSTRACTS

Dona M. Dirlam, Editor

COLORED STONES AND ORGANIC MATERIALS

'Arteries' in opal? R. K. Mitchell, *Journal of Gemmology*, Vol. 19, No. 7, 1985, pp. 584–585.

After reviewing the general appearance of Mexican opal and listing some of the inclusions noted in them to date, the author reports on an unusual specimen. This flat cabochon had a "blood-red" color with a reticulated pattern; Mr. Mitchell compares it to a medical picture of a circulatory system. He notes that whereas iron contamination is commonly assumed to cause such colors in porous gems, in this specimen the cellular patterning may have been caused by colorant solutions penetrating and flowing in wisps during the opal's early stages of formation—when it was a somewhat plastic gel. *RCK*

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

Green phantoms. E. R. Swoboda, *Lapidary Journal*, Vol. 39, No. 11, 1986, p. 24.

The author provides a concise, well-written historical account of the early discovery of Brazilian quartz crystals containing phantoms of minerals such as pyrite and chlorite. Much of the information in this article is a recounting of the author's own experiences as a long-time explorer and dealer in Brazilian minerals. A number of descriptions of important specimens are given. Two of these specimens, one a crystal containing 26 pyrites and the other a beautiful chlorite phantom, influenced the author to locate and reopen the old mines that had yielded these two inclusion-filled pieces. Mr. Swoboda describes the reopening of the mines and the new discoveries made. Because the mine producing the chlorite phantoms is currently active, the author is able to provide a great amount of detail concerning this locality.

The minerals noted by the author as inclusions in these crystals are chiefly green chlorite phantoms, carbonate crystals, limonite, hematite, rutile as stubby needles, white phantoms of unknown mineral(s), and montmorillonite clay-like inclusions in shades of pink, orange, brown, red, and black.

The crystals and gems cut from them are quite striking and make excellent decorative specimens and jewelry. The article is illustrated with scenes from the mine, and with a color plate showing five phantom crystals and six faceted gems. *John I. Koivula*

The solid solution chemistry of vesuvianite. T. D. Hoisch, *Contributions to Mineralogy and Petrology*, Vol. 89, 1985, pp. 205–214.

Vesuvianite, or idocrase, is a lesser-known gem mineral that is typically brown or green, but is also found in a very broad range of colors. Faceted stones up to 15 ct have been reported. This material has a wide range of refractive-index and specific-gravity values that result from its complex chemistry and varied geologic occurrence. As with such gemstones as garnet and tourmaline, extensive solid solution, or the substitution of one chemical element for another, occurs in idocrase. This article is a detailed study of the crystal chemistry of idocrase, that is, the relationship between its physical properties, chemistry, and crystal structure. *JES*

The tourmaline group: a résumé. R. V. Dietrich, *Mineralogical Record*, Vol. 16, No. 5, 1985, pp. 339–351.

This article summarizes the mineralogical and gemological properties presented in Dietrich's new book, *The Tourmaline Group.* This group of minerals contains some of the most attractive and interesting species known, differing widely in their complex chemical compositions and occurring at a vast number of deposits worldwide. Tourmaline is today among the most popular of colored gemstones because of its availability in a wide range of color hues and saturations, including multicolored stones. This article provides information on the nomenclature, crystallography, chemical and physical properties, uses, and occurrence of tourmaline. Accompanied by a number of superb color photographs and other interesting illustrations, the article is an excellent introduction to Dietrich's more detailed book on the tourmaline mineral group. *JES*

DIAMONDS

Diamonds and the Holocaust. D. Federman, *Modern Jeweler*, Vol. 84, No. 5, 1985, pp. 39–46, and 72.

"For 300 years European Jews had been cutting and selling the bulk of the world's polished diamonds in Belgium and Holland. On May 10, 1940, when Nazi Germany invaded both these countries, the world stood to lose more than 80% of its supply of polished diamonds." This is the central premise of Federman's article, which outlines the history of the European diamond-cutting industry before World War II, and then tells the story, purportedly for the first time, of "how the diamond industry survived the Nazi nightmare."

Situated as they were in the Low Countries, Europe's diamond-cutting capitals—Amsterdam and Antwerp—were caught off guard by the Nazi invasion, and the Jewish-dominated industry was frozen at a standstill. Federman traces various escape routes that some diamond dealers used to flee the Nazis—routes that ultimately led to the establishment of interim cutting centers in London, Brazil, Palestine, and Cuba. These "refugee" cutting locations prevented the world's diamond supply from suffering from the far graver enormities of the Holocaust.

Though it runs the risk, ironically, of trivializing the Holocaust itself, Federman's article is an important historical contribution to the understanding of today's diamond-cutting industry. It tells us how, for example, some of the alternative cutting locations became viable centers in their own right—notably Israel, but also India, whose meager output of 700 ct in 1945 was, as Federman tells us, "a harbinger of post-war expansion and eventual Third World emergence" in the field. This was the true legacy of the Holocaust to the diamond-cutting industry, he concludes. MB

On the rocks? C. Cummings, *Canadian Jeweller*, Vol. 107, No. 1, 1986, pp. 30–35.

The author gives us a rare look into Antwerp's struggle to retain its preeminence as a diamond cutting and trading center.

Antwerp's woes are numerous: a decline of some 11,500 workers in the trade over the past decade, huge bad debts assumed by trade lending organizations, several bankruptcies among large diamond companies, and, most serious of all, the slump in worldwide diamond sales as a result of the recession of the early 1980s. Further problems include Russian "dumping" of polished goods (and perhaps some rough) whenever they need foreign currency and reduced Arab spending in the wake of the current oil glut.

Antwerp's four bourses are also discussed, revealing some interesting facts and historical perspectives. The Antwerp Bourse, for example, was the world's first, having been established in 1893. Over the years the ethnic makeup of the bourse membership (which had been predominantly Jewish) has shifted to a majority of members coming from eastern Mediterranean countries or from Belgium itself. The four Antwerp bourses together handle more diamond transactions than all the rest of the world's 15 bourses! About 70% of the world's rough diamonds pass through Antwerp. Belgian law gives final authority in some disciplinary decisions to the bourses—not the courts.

Leaders in the Antwerp market also note some bright spots, one of which is automation. Semiautomatic polishing machines have greatly reduced training time and increased productivity. Antwerp manufacturers also place considerable value on their excellent reputation for "old-world" craftsmanship. The Diamond High Council of Antwerp is promoting the Antwerp diamond industry worldwide and generally raising the profile of this most important diamond city. *James R. Lucey*

GEM LOCALITIES

Gem pegmatites of the Shingus-Dusso area, Gilgit, Pakistan. A. H. Kazmi, J. J. Peters, H. P. Obodda, *Mineralogical Record,* Vol. 16, No. 5, 1985, pp. 393–411.

Pegmatites in the Gilgit region of northern Pakistan have yielded exceptionally fine specimens of multicolored tourmaline as well as aquamarine, topaz, and almandine-spessartine garnet. This region lies in the rugged Karakoram range along the northern border of the Himalayas. The gem pegmatites occur in a series of regionally metamorphosed igneous and sedimentary rocks that represent the suture zone between the Indo-Pakistan and Asian crustal plates. In addition to the gem materials, the pegmatites contain a variety of other minerals such as feldspars, apatite, hambergite, micas, and zircon. Details of the geology and mineralogy of these pegmatites are accompanied by photographs of many aesthetic crystal specimens. *JES*

Maine tourmaline. C. A. Francis, *Mineralogical Record,* Vol. 16, No. 5, 1985, pp. 365–388.

Since their discovery in the early 1800s as some of the earliest known gem localities in North America, the gem pegmatites of Maine have produced an astonishing array of specimens of gem tourmaline and other minerals. This review article describes the occurrence of tourmaline and other pegmatite gem minerals in Maine, especially in Androscoggin, Oxford, and Sagadahoc counties. The history of mining at a number of famous localities, including Mount Mica, Mount Rubellite, Newry, Mount Apatite, and others, is summarized with interesting details on tourmaline specimens and on noted individuals who were associated with their discovery. Twelve color photographs of spectacular tourmaline crystals from this area highlight the article. *JES*

Minerals of the Elba pegmatites. P. Orlandi and P. B. Scortecci, *Mineralogical Record,* Vol. 16, No. 5, 1985, pp. 353–363.

The small island of Elba, lying between Italy and Corsica, has been mined (principally for iron ores) for the past two millennia. While long noted as a source of mineral specimens, the granitic pegmatites that dot the western half of the island have been worked for gem material only within the last hundred years.

This article briefly describes the geology and mineralogy of the Elba pegmatites. These pegmatites occur in narrow dikes or veins that are associated with the Monte Capanne granodiorite stock. They range up to 1 m in thickness and may exhibit well-developed internal zonation. Common minerals include quartz, orthoclase, albite, and schorl, while more interesting species (tourmaline, garnet, petalite, and beryl) are found in pockets in the cores of zoned pegmatites. Details of the minerals found in the pegmatites, along with attractive color photographs of many of them, are provided. This area is likely to remain best known for its mineral specimens rather than as a source of gem material. *JES*

Minerals of the Pikes Peak granite. B. L. Muntyan and J. R. Muntyan, *Mineralogical Record,* Vol. 16, No. 3, 1985, pp. 217–230.

Amazonite is an attractive blue-green variety of microcline feldspar that is commonly used as a gem material in cabochon form. One of the most important sources of gem-quality amazonite and smoky quartz are the granitic pegmatites in the vicinity of Pikes Peak, Colorado. This article summarizes the geology and mineralogy of this remarkable region. The pegmatites occur in granites of the Pikes Peak batholith, which covers an area of about 2,800 km^2 in central Colorado. Consisting mainly of quartz and microcline, the pegmatites are seen as small dikes running in all directions within the granite. Amazonite, smoky quartz, topaz, and a number of other minerals are found within small pockets in the granite.

Photographs of various minerals noted from this area are included in the article. The small size and random distribution of the pockets has limited most commercial mining for pegmatite minerals in this area. While a large number of pockets have been excavated over the years, it is likely that the pegmatites of the Pikes Peak region will continue to be a source of fine mineral specimens. *JES*

Move over Brazil, here comes East Africa. D. Federman, *Modern Jeweler,* Vol. 85, No. 1, 1986, pp. 40–45.

This is the most comprehensive article on East Africa since Campbell Bridges wrote "Gems of East Africa" for the *G.I.A. International Gemological Symposium Proceedings* in 1982. Federman emphasizes the marketing of East Africa's colored stones, concentrating on tanzanites and green grossular garnets (tsavorites). He argues that a new generation of dealers and retailers, many from California, created a niche with East African gems. As a result, a thriving gemstone industry has developed on the West Coast of the U.S.

Federman traces the involvement of Tiffany in promoting East African gems beginning in 1969, when Tiffany christened blue zoisite "tanzanite." Then, in 1974, Tiffany introduced the term *tsavorite* for green grossular garnet. He suggests that as a result of Tiffany's marketing efforts, gem dealers began to take Kenya and Tanzania more seriously as sources of fine gemstones.

Interviews with gem dealers who concentrate on East African stones are an interesting feature of the article, as Federman touches on other gems including rubies, chrome tourmalines, fancy-colored sapphires, and change-of-color garnets. Many gemstones from this area have properties that are "breaking all the rules" and causing gemologists to re-examine established concepts.

Federman concludes with a discussion of how East Africa has changed the colored stone trade. *DMD*

Recent work at the Himalaya mine. C. R. Marcusson, *Mineralogical Record,* Vol. 16, No. 5, 1985, pp. 419–424.

The Himalaya pegmatite mine in the Mesa Grande district, San Diego County, California, was for a period the world's leading supplier of gem tourmaline. Prior to its closure in 1914, the Himalaya mine produced more than 100 metric tons of marketable tourmaline, valued at over $750,000. In 1977, mining of this remarkable pegmatite was renewed with the excavation of new underground workings to reach lower, untapped portions of the pegmatite dike. During the past few years, mining has yielded some exceptional specimens of gem tourmaline and other minerals. This article summarizes the recent mining operations at this famous locality. *JES*

The tourmalines of Nepal. A. M. Bassett, *Mineralogical Record,* Vol. 16, No. 5, 1985, pp. 413–418.

Gem tourmaline has recently been mined from pegmatites at Hyakule and Phakuwa in the Sankhuwa Subha district of Nepal, 60 km south-southeast of Mount Everest. The pegmatite dikes outcrop at an altitude of 2,150 m in a metamorphic sequence of marbles, dolomites, and schists of the Khitya Khola formation. The geology of this region is not completely known. The gem tourmalines are predominantly pink with yellow, colorless, green, or orange bands, and are particularly dichroic. They are found as well-terminated crystals ranging up to 20 cm (8 in.). Details of the chemical and physical properties of these tourmalines are provided. *JES*

INSTRUMENTS AND TECHNIQUES

Colour filters and gemmological colorimetry. J. B. Nelson, *Journal of Gemmology,* Vol. 19, No. 7, 1985, pp. 597–624.

Dr. Nelson's article goes beyond the subject of its title and discusses current attitudes among gemologists toward color science and why the subject should be taught routinely as part of gemological curricula. The article then proceeds with the description of a set of color filters designed for use with a hand spectroscope and to assist the teaching of color science and spectroscopy in gemology.

The 38 filters included in the set are accompanied by spectrophotometer graphs of their transmission spectra so that the student can learn the relationship between a spectrum as seen with a hand spectroscope and that displayed graphically by a spectrophotometer. Also provided for each filter are its dominant wavelength, excitation purity, and metric luminance. Two of the filters fit on the light source of a spectroscope unit so that the resulting illumination approximates CIE source A. (Unfortunately, the light sources used with the spectroscopes vary somewhat in composition, so the illumination obtained by using these filters may or may not actually approach that of CIE illuminant A. The actual significance of this possibility needs to be tested.)

CIE diagrams that display the coordinates of the 38 color filters are provided, but these include a number of mysterious entries, with no key whatsoever provided to assist in the interpretation of the figures. Moreover, projections of the dominant wavelengths of various filters are shown as straight lines, where they should be curved lines in most cases. This suggests an incomplete knowledge of the CIE system on the author's part that undermines an otherwise convincing plea for adoption of CIE-based techniques in gemology.

A discussion follows of specific applications of several of the filters, to provide examples of their uses. Also included in the article is a brief description of a new "comparison prism spectroscope" that displays two spectra simultaneously. This aside seems out of place, and the potential value of such a spectroscope merits the attention of a separate paper. The article concludes with a general appeal for standardized color description and a peremptory mention of ongoing experiments in the field.

Perhaps the oddest thing about this article is the apparent omission of a section of the conclusions that must at least have mentioned the GIA's appreciable efforts at measuring and describing gemstone colors. This is apparent because the text is missing two references that are included in the numbered bibliography. Thirty references are cited, but numbers 27 and 28 (on the ColorMaster and on GIA's color description of gemstones, respectively) are nowhere to be found in the text or illustrations.

Although somewhat lengthy and wandering, this article manages to convey the very real need for education in color science in gemology, and the color filters—or some similar system—sound as if they could be of assistance in such an educational effort. Unfortunately, Dr. Nelson uses many terms throughout his article that may be unfamiliar to those not versed in color science. The time certainly has come for better understanding and description of gemstone color. *CMS*

JEWELRY ARTS

The amazing Mr. Evans. S. Hale, *Connoisseur,* Vol. 215, No. 887, 1985, pp. 116–119.

A profile of the noted British artist-goldsmith Edward Evans, this article focuses on one of Evans's most elaborate productions—a "peacock" pistol encased in gold, enameled, and studded with sapphires and diamonds. The author relates how Evans, while employed by the eminent firm of Garrard in London (crown jewelers to the British monarchs since 1843), was asked to design a necklace to accommodate a 60-ct cushion-shaped diamond that Garrard's jewelry director felt was too "chunky" for a ring. Evans, revered mainly for his necklace designs, surprised many by coming up with another vehicle for the diamond: a .38 special Smith & Wesson revolver.

With the diamond set in the butt of the gun, Evans built a golden case around it, set a pair of golden peacocks along the handle, and created an engine-turned barrel of blue enamel. Ironically, during the course of his work the very diamond that had inspired it was sold, so Evans perforce replaced the stone with a citrine of similar size (the gemmy firearm was subsequently sold to an Arab prince).

The peacock pistol is used to illustrate Evans's range of talent and skills. Noting that most expensive jewelry is now produced by teams of specialized artisans, the author singles out Evans as a Renaissance man in the field of commercial jewelry, creating as he does "all of his pieces without assistance, from the first rough sketch to the final polish, using traditional hand tools." The author goes on to cite recurrent motifs in Evans's work, including peacocks, swans, dragonflies, and snakes, although he adds that the artist nonetheless avoids creating a definitive Evans "look." Other trademarks of Evans's craft are described, such as his "crisp and sweet" jeweled and enameled bow ties. The text includes a short but interesting biography of the artist, whose more select creations are brightly illustrated in the photographs by Kenro Izu. *JMB*

The golden art of El Dorado. S. Voynick, *Gems and Minerals,* No. 577, 1985, pp. 10–13 and 53.

Mr. Voynick reveals the abundant splendor of gold artifacts fashioned by pre-Columbian Indians of Central and South America. Although they possessed neither iron tools nor sophisticated smelting furnaces, these people created gold treasures that rival and even surpass those of the early Egyptians.

The Indians developed many ingenious goldworking processes and techniques. They created a refining process whereby common salt was added to the raw, molten gold in order to vaporize the undesirable metals, leaving behind a very pure form of gold. Ironically, this basic process may have prevented the art from reaching its full potential, because the best and most prolific artisans died prematurely as a result of poisoning and lung disease caused by the metal chloride vapors. Indian goldsmiths also used a basic molecular-fusion welding process and were experts at lost wax casting. Much of their work was actually done in *tumbaga,* a 2:1 copper-gold alloy. The finished tumbaga piece was heated until it glowed, thus converting the surface copper content to copper oxide. The piece was then washed in acetic acid, which dissolved the copper oxide, leaving a surface of pure, bright, yellow gold.

The arrival of the Spanish in the 1500s triggered hundreds of years of ruthless exploitation. The conquistadors soon realized that the Indians had buried a wealth of golden objects with their dead. Between 1533 and 1537, about 655 lbs. of pure gold and 229 lbs. of tumbaga were taken from Indian graves. By the early 1800s, grave robbing had become a lucrative business: In 1859, half a ton of gold was dug from graves in the Chiriquí region alone.

Despite strict governmental prohibitions, grave robbing is still a serious problem in South and Central America. During the 1960s, a government bank made a bold, and desperate, move to keep Colombia's gold artifacts inside the country by offering to buy them from the *huaqueros* ("tombers") with no questions asked. The Museo de Oro in Bogotá now contains over 26,000 golden pieces; nearly all of them were acquired from *huaqueros.* Many modern grave robbers operate from organized fronts, probing the earth with advanced electronic underground-utility locators. It is a dangerous but extremely profitable business, one with almost negligible penalties for the native *huaquero* but catastrophic consequences for foreigners. Anthropologists believe that far more gold than has yet been recovered remains hidden in jungle graves. It can only be hoped that some of these cultural treasures will remain inside their native lands. *SAT*

Italy's dazzling city of gold. P. Dragadze, *Town & Country,* Vol. 139, No. 5059, 1985, pp. 114, 116, 119, and 121.

On the banks of the Po River in northern Italy lies a "city of gold" named Valenza. The city is steeped in the history of goldsmithing, as recorded by Pliny the Elder in the first century A.D.: "The important military post of Valentium has a river port on the Po. The inhabitants believe in the cult of the god Urano, who dominates fire and makes models with rare metals, inspiring the people also in this trade .... Just outside the city confines are places where, by simple washing of gold-bearing sands, a diligent man can earn a day's wages with ease."

Today, Valenza produces some of the highest quality jewelry in the world, catering to an elite international clientele. The modest town houses more than 1,000 jewelry-related firms and 10,000 employees. Most of the companies are extremely small, consisting of the owner, his wife, their son, and one or two others. The fine craftsmanship produced under these conditions is especially appreciated by wealthy Americans.

The author interviews several owners and master-craftsmen from Valenza, revealing a world of fantastic fortunes and commissions for pieces that dreams are made of. However, despite its billion-dollar reputation, Valenza remains a quiet, unpretentious town, truly one of Italy's finest treasures. *SAT*

Natural affinities. C. Seebohm, *Connoisseur,* Vol. 215, No. 885, 1985, pp. 120–127.

There are several keys to the secret of jewelry designer Angela Cummings's success. First, she has tapped her own affinity for natural shapes, colors, and patterns and translated it into beautiful, ultimately wearable jewelry. Much of her inspiration comes from her garden: a powdery butterfly wing, the cool geometry of snakeskin, the graceful twisting of a bittersweet vine. " 'I don't ever want to make a flower or otherwise duplicate nature,' she cautions. 'I am inspired by natural forms, but the shape that I finally create is not really natural.' "

Beneath, or perhaps parallel to, this pastoral tranquility is a fine sense of business savvy and self-confidence. She received a rigorous education in jewelry design, gemology, and goldsmithing, and took her talent—and her considerable charm—straight to Tiffany's in New York. Within an amazingly short time she became recognized as one of today's top jewelry designers. However, when the situation at Tiffany's changed with the arrival of Avon, Angela and her husband Bruce were undaunted, forging a highly successful business outside the comfortable womb of a large company. Created only one year ago, Angela Cummings Inc. now employs at least 50 multinational craftsmen to execute her designs. The husband and wife team seem to be unbeatable, with Bruce contributing keen management techniques and an in-depth knowledge of gemstones. The company has produced elegant flatware and fine porcelain plates, and is even contemplating a select line of designer scarves.

Angela Cummings's star is definitely rising, and promises to cut a meteoric path across the industry. *SAT*

RETAILING

Sting! Baiting the trap with jewelry. M. Schwartz, *Jewelers' Circular-Keystone,* Vol. 155, No. 11, 1985, pp. 96–100, 102–105.

The shadowy undercover world of jewelry fencing is revealed in this account of Operation Greenthumb, "the biggest law enforcement assault in history against interstate jewelry fencing." Between 1979 and 1981, soaring precious metals prices prompted a record number of burglaries and robberies in Washington, D.C. and its affluent suburbs. People were accosted in the streets, and their homes were ransacked. As their fear increased, retail jewelry sales plummeted.

Operating behind a thin façade of respectability, the kingpin fences employed a gang of petty crooks and desperate junkies to do the dirty work, paying them only 10% maximum of the stolen items' precious metal value. Stolen items ranging from simple gold chains to a \$175,000 snuff box that had belonged to Catherine the Great were sent to legitimate out-of-state refineries to be melted into scrap. It was a lucrative racket: one of the fences boasted a net worth of \$1 million, with an annual income of \$500,000.

The fences toyed brazenly with the authorities, playing an intricate game of cat-and-mouse. A network of local jewelers, the District of Columbia metropolitan and the Virginia and Maryland suburban police forces, and FBI investigators pooled their resources to gather evidence against the fences. During the eight-month probe, they set up sophisticated surveillance equipment, sifted through garbage, faked a break-in, and planted a specially trained double agent inside the fencing operation. Finally, on April 22, 1981, Operation Greenthumb closed in. A spectacular eight-site raid recovered more than \$2 million of stolen merchandise, with the kingpins later convicted on both state and federal charges. More than 70 crime suspects were identified, and 430 burglaries solved. Best of all, after news of the triumphant sting hit the press, the number of burglaries dropped dramatically, and reassured customers returned once more to patronize D.C. jewelry stores. *SAT*

SYNTHETICS AND SIMULANTS

The composition of the lapis lazuli imitation of Gilson. K. Schmetzer, *Journal of Gemmology,* Vol. 29, No. 7, 1985, pp. 571–578.

Beginning with a brief description of natural lazurite and lazurite-containing rocks (i.e., lapis lazuli), the author proceeds to describe his investigation of the lapis substitute produced by Gilson.

The strongest lines in the X-ray powder diffraction pattern of the Gilson material were identical to those in the pattern of natural lazurite, with some weak pyrite lines also present. Additional weak lines, not attributable to either lazurite or pyrite, were also noted. Qualitative (EDX) chemical analysis by electron microprobe showed major elements typical of lazurite, plus substantial quantities of F, Zn, and Fe; quantitative analysis by "classical chemical methods" (wet chemical analysis) revealed that Zn and F percentages were in the range of the main constituents of the synthetic ultramarine.

Further examination consisted of thermogravimetric analysis, a chemical water determination, and analysis of the X-ray diffraction pattern after heat treatment, followed by a re-examination of the original diffraction pattern. This led to the determination that the Gilson product consists of ultramarine, pyrite, and two crystalline hydrous zinc phosphates. Because the zinc phosphates are main components, the author concludes that the Gilson product should be described as an imitation rather than as a synthetic. *RCK*

Nakazumi synthetic star corundum. J. Snow, J. Sanders, and G. Brown, *Australian Gemmologist,* Vol. 15, No. 11, 1985, pp. 410–412.

This Gemmology Study Club Report summarizes the results of an examination of inclusions in synthetic star rubies and star sapphires manufactured by Nakazumi Earth Crystals.

Initial macroscopic examination revealed sharp, six-rayed stars with relatively straight arms that tapered toward the girdle of the cabochons but that were somewhat less distinct than those usually observed on synthetic star corundum. Also noted were irregular, whitish masses scattered randomly on the cabochon surfaces. The flat polished bases showed distinct curved color banding, with occasional bands displaying darker color than the rest.

Microscopic examination at 30× revealed rounded gas bubbles of various sizes. It was also determined that the whitish splotches seen on the surfaces of the cabochons were caused by light being reflected from masses of gas bubbles located just below the surface. Short oriented needles were seen at very high magnification (800×). A pattern to the distribution of the gas bubbles was also noted: The darker curved color bands contained a predominance of large, stretched bubbles, whereas the lighter-colored bands contained a much greater number of smaller, rounded bubbles.

Communication with the manufacturer revealed that these synthetic star corundums are produced by the Verneuil process, with low-purity hydrogen gas partly fueling the inverted blow-torches. The rutile content was reported as 0.11%, with the asterism induced by annealing first in a gas flame and then in an electric furnace.

The authors hypothesize that the elongated gas bubbles could be generated by temperature variations in either the melt or the flow rate of the gaseous fuels. They conclude that production of these synthetic star corundums is by a relatively unsophisticated Verneuil process, with asterism being induced by either a relatively short or a relatively low-temperature annealing step.

RCK

A re-examination of Slocum Stone—with particular emphasis on inclusions. C. R. Burch, *Journal of Gemmology,* Vol. 19, No. 7, 1985, pp. 586–596.

This article reviews the literature on Slocum Stone and reports the results of the author's microscopic investigation of six specimens.

The most prevalent inclusions noted were tinsel-like flakes—flat, extremely thin, and of varying sizes. Most had angular outlines and featureless surfaces. These flakes appeared bluish or purple in the black and white opal imitations, and were predominantly yellow, green, and orange in the fire opal imitations. When viewed with polarized illumination, the flakes exhibited strong interference colors. The edges of adjacent flakes suggested that many of these were once part of larger structures, perhaps continuous sheets.

Bubble inclusions were also common in all specimens. Their shapes ranged from those typical of glass imitations (e.g., spheres and "torpedoes") to many very unusual ones. In one specimen there was a close association between some of the unusual bubbles and the tinsel-like flakes. The author speculates that the unusual bubble shapes and the fragment-like nature of the flakes may be the result of agitation and mixing at some point in the production process.

The optical effects were also examined. In transmitted light the specimens showed very few, if any, color flashes. With overhead (reflected) light, however, they displayed a very strong effect; this changed with the angle of observation. The color effect was strongest when the specimens were viewed directly from above, due apparently to the fact that the material is cut so that the largest surfaces of most of the flakes are parallel to the base of the cabochon.

This report is illustrated with 17 fine photomicrographs.

RCK

BOOK REVIEWS

Jeffrey M. Burbank, Editor

CARTIER: JEWELERS EXTRAORDINARY

*By Hans Nadelhoffer, 312 pp., illus., publ. by Harry N. Abrams, New York, NY, 1984. US$50.00**

This book is essentially a biography of the great Cartier jewelry house, and as such it is an important work. The author traces Cartier's evolution from 1847 to the present, focusing primarily on the late 19th through the early 20th centuries—Cartier's period of greatest expansion and growth.

Three brothers, Louis, Pierre, and Jacques—the fourth generation of Cartier jewelers—brought the firm to its pinnacle of international recognition and acclaim during this period. Eighteen chapters cover specific aspects that were instrumental in the development under the three brothers of Cartier's signature style—Art Deco. In these chapters, Nadelhoffer examines each of the elements that influenced the birth of the Art Deco style. The discovery of Tutankhamen's tomb (1928) contributed ancient Egyptian motifs, while international trade with Japan, India, and the Arab nations lent ethnic overtones to Cartier's jewelry. The Ballets Russes also had a profound effect on the society of the time, which in turn had its effect on jewelry. Nadelhoffer does a superb job of demonstrating the impact that these factors had on Cartier's jewels, and brilliantly handles the colossal task of weaving this intricate tapestry of jewelry, people, places, and events.

Regrettably, this monumental work deserved a better final edit. Most of the numerous footnotes could have been incorporated into the text, which would have saved the reader from having to flip back and forth through the book. Furthermore, there are glaring omissions from the otherwise helpful chronology table (the murder of Czar Nicholas II and the coronation of Queen Elizabeth II are two of the more obviously absent events). Also, some of the references in the text to illustrations located elsewhere in the book give nonexistent page numbers, and a few of the illustrations are not captioned at all. Other than these few annoyances, however, the book is magnificent. The photographs and color plates are spectacular, and the text gives an insider's view into the world of the extremely wealthy upper classes at the turn of the last century. Overall, *Cartier: Jewelers Extraordinary* is a worthy addition to the reference literature currently available on jewelry.

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THE GREAT AMERICAN SAPPHIRE

By Stephen M. Voynick, 212 pp., illus., publ. by Mountain Press Publishing Co., Missoula, MT, 1985. US$16.95 cloth, $9.95 paper**

This is a remarkably complete history of the most important source of precious gems in North America, one that still contains far more sapphires than it has yet yielded. The first of seven chapters is an overview of gem discoveries in the United States, including inferior sapphires in Montana gold placers. In 1895, distinctly superior blue sapphires were found in Yogo Creek, about 100 miles east of Helena. These are the "great American sapphires" of the book's title.

Chapter 2 is a general discussion of sapphires that is appropriate for the layman, but not for the gem expert. Chapters 3 and 4 recount the rise and decline of the English syndicate that soon acquired Yogo and produced $25 million worth of cut sapphires. A series of 13 American owners subsequently failed to restore production. Most recently (chapter 5) American Yogo Sapphires, Ltd. (renamed Intergem in 1982) began a well-planned operation with "vertical integration" from mining through finished jewelry distribution. Intergem emphasizes the fine *natural* color of Yogo sapphires in its advertisements, and points out (chapter 6) that many other sapphires have undergone artificial color enhancement by heat treatment. The final chapter reports that Yogo sapphires are now sold in a thousand retail jewelry stores, and argues that the future importance of these gems is almost boundless.

Voynick gathered data from newspaper accounts, company sources, and "dusty geological reports" (one of which I prepared). Sources are quoted so abundantly that authenticity cannot be doubted, although rapid reading is impeded. Voynick's writing is mostly straightforward, not much given to flights of literary fancy, except in the introduction, where his florid account of the geological origin of the sapphires "born in the fiery womb of the earth" may make a geologist blush. The book is well organized, the dozen color photographs are excellent, and the other photos have historical value.

In 1946, I spent several weeks mapping the Yogo district as part of a U.S. Geological Survey appraisal of Montana corundum deposits. According to Voynick, my published report was optimistic enough to have been more useful to promoters than to geologists and mining men. Never mind, future speculators will find my appraisal vastly superseded by Voynick's statement that estimated reserves to a reasonable depth of 7,000 feet indicate "that Montana's Yogo dike contains more sapphires than the sum total of all the other known sapphire deposits in the world." True, perhaps, if you exclude other sapphires of less superb natural color, uniformity, and clarity. But Yogo sapphires are small (cut stones larger than a few carats are rare), and

**This book is available for purchase at the GIA Bookstore, 1660 Stewart Street, Santa Monica, CA 90404.*

Intergem's unique mining method is still largely unproven.

The paper, printing, editing, and binding of the book are excellent, and the price is reasonable. Anyone with an interest in minerals or Western Americana will enjoy reading it, and those who make a business of buying and selling sapphires anywhere in the world should own a copy.

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PEARLS—THEIR ORIGIN TREATMENT, AND IDENTIFICATION

*By Jean Taburiaux, 247 pp., illus., publ. by Chilton Publishing Co., Radnor, PA, 1985. US$24.95**

This is a welcome addition to the meager list of books available on the subject, and is doubly welcome because, in its four major sections, it covers the full scope of pearling: natural and cultured, saltwater and freshwater. The work is a translation from French into English, a fact that becomes obvious as the reader finds disparities in the spelling of names and places from one section to another, but this is a forgivable weakness because the overall continuity remains intact.

The author covers pearling from ancient times through the most recent developments, including the marketing and valuation of pearls, along with the very intricate method of pricing natural pearls. The one weakness in the work is the historical Part 1, "Natural Pearls." While the cited dates leave no question that the data are historical, it is still difficult to differentiate "then" from "now" in the reading, possibly a fault in the translation. This weakness is not distracting enough, however, to put the reader off.

The text is readable, and Mr. Taburiaux has tried to keep technicalities to a minimum in order to reach any audience with even a passing interest in pearls. The amount of material covered in the 247 pages is remarkable, both in terms of content and relevance. The text is generously illustrated with some 200 drawings and maps, but with only a meager 14 color plates. The overall quality of the book is high.

This work will help fill a void that has existed since 1908, when the last really comprehensive book on pearling was published—Kunz and Stevenson's classic *Book of the Pearl.* The great value in Taburiaux's book is that it couples the old with the new and covers pearl cultivation in all parts of the world more thoroughly than any book available today. It should be a welcome addition to the library of anyone interested in pearls.

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LAROUSSE DES PIERRES PRÉCIEUSES

*By Pierre Bariand and Jean-Paul Poirot, 264 pp., illus., publ. by Librairie Larousse, Paris, France. US$45.95**

Even if you cannot read French, this book is worth possessing. Of the 246 pages of text, 234 have at least one photograph. These photos—almost all of which were taken by Nelly Bariand—are of exceptional quality. Most have never before been published. Since gem and mineral names in French are either identical, or sufficiently similar, to their English equivalents, photo captions can be easily deciphered.

For those who read at least some French, however, Bariand and Poirot's book is of even greater value. The first 60 pages are devoted to a general introduction to gems and gem materials. It opens with a few pages on gem symbolism, including the gemstone's role in religion, society, medicine, trade, and personal adornment throughout history. A section then follows on the origin of gems, including some terminology and definitions, but primarily discussing where gems can be found, both in situ as well as in fashioned form, in state and private collections, and in commercial centers of the gem trade.

The bulk of the introductory section is entitled "The Substantive Qualities of Gems," and in it the authors thoroughly review various gemological properties, such as durability, color, phenomena, density, weight, inclusions, and cutting. Each of these subjects is treated with an awareness of the latest developments in gemology. For example, the segment on color includes comments on light, absorption, color centers, treatment of color (using ink, dyes, heat, and radiation), optical phenomena, color perception, and the effects of color on gemstone value.

The remainder of the introductory portion of the book presents an excellent review of imitations and synthetics, techniques of identification, and classification and nomenclature. A useful table summarizes the historic development of major gemstone treatments, imitations, and synthetics.

In French, the name "Larousse" connotes the word *dictionary*, just as "Webster" does in English. Given that association, this book rightly lives up to its dictionary image by describing 140 gems and gem materials in alphabetical order according to their species and variety names. The latter are cross-referenced to their mineral species as well. A number of trade names and obsolete terms are also listed, as are historically important forms of gem carving, such as the cameo and intaglio. While some of the classification departs from American standards, the information about each gem is impressive and largely correct.

For each gem material, the description generally includes the chemical nature, crystal form (if a mineral), basic optical and physical properties, locality information, history, etymology, and notable large specimens. Major gemstones such as diamond, ruby, emerald, sapphire, pearl, and "jade" are treated at length. At the same time, some materials rarely cut as gems (such as jeremejevite) are included for the benefit of collectors of the unusual. Toward the end of the book, the authors include a brief glossary, a bibliography, and a list of museums with major gem collections worldwide. The closing pages consist of a property chart for the gem materials mentioned in the text, ordered according to refractive index, with transparency, density, hardness, toughness, color, dichroism, luminescence, and chemical formula provided for each entry.

Given the encyclopedic scope of the book, errors are minimal (e.g., a photograph of what looks very much like maw-sit-sit is labeled "chloromelanite"). Perhaps the greatest problem that American-trained gemologists will encounter is the book's terminology; for example, the word *variety* is both loosely and liberally applied. Nonetheless, the photographic, historic, and descriptive information presented is of exceptional quality. While not technically complete enough to stand alone as a gem identification reference, the book does contain historic and very recent information not included in the standard texts and, as such, is likely to become an established supplemental text for those who read French. Finally, unlike the more technical gem references, this book will also appeal to non-gemologists. Unfortunately, this *Larousse* is not yet available in English. It is hoped that an English edition will be forthcoming.

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THE TOURMALINE GROUP

*By R. V. Dietrich, 300 pp., illus., publ. by Van Nostrand Reinhold, New York, NY, 1985. US$29.95**

Despite tourmaline's long and varied history as a mineral, gemstone, and crystalline material of scientific interest, no broad-based summary about tourmaline has appeared in recent years. Professor Dietrich's book fills this void by surveying the large and diverse literature on tourmaline and summarizing this information in a condensed but well-organized format. The book largely consists of a compilation of data and suggestions taken from more than 2,500 publications on tourmaline. Nearly 1,000 of the more important of these articles are included in the exhaustive bibliography. As such, the book represents a useful summary of the properties of tourmaline as well as a valuable guide to the scientific and popular literature on this mineral.

Today, tourmaline is used as the name of a group of minerals that includes species such as schorl and elbaite. In dealing with the literature on tourmaline, the book begins with chapters on nomenclature and crystallography. The name *tourmaline* appears to have been derived from the Sinhalese term *turmali*, a designation often applied by ancient Ceylonese merchants to mixed gemstones of unproved identity. Dietrich describes some 50 names that have been applied to tourmaline species and varieties, and identifies those names that are currently accepted. The crystallography chapters summarize information on the internal crystal structure of tourmaline and its external morphology, including data on crystal habits and a list of the largest recorded crystals.

The chemical and physical properties of tourmaline are discussed in the middle chapters of the book. There is a detailed summary of the complex chemistry of tourmaline, and how the chemistry is related to both tourmaline species nomenclature and the observed variation in its physical properties. Inclusions and other features seen with a microscope in tourmaline are covered in this section of the book. The wide variety of colors and color patterns in tourmaline has also long been of a subject of interest. The causes of color are discussed in some detail, as are other optical properties such as luminescence and pleochroism. Information is also provided on the effect of heat treatment and irradiation on tourmaline coloration. Lastly, data on a range of physical properties (e.g., density, hardness, etc.) are presented.

The latter chapters of the book cover a variety of topics, including the synthesis of tourmaline and the industrial uses of this mineral. An extended chapter on tourmaline as a gemstone describes the historical use of tourmaline in jewelry, the fashioning of gem tourmaline, and famous tourmaline gemstones.

The variability in chemical composition displayed by tourmaline is due in part to its occurrence in a wide range of geologic environments. The last chapter summarizes what is currently known about the occurrence of tourmaline in igneous, metamorphic, and sedimentary host rocks. An appendix to the book lists worldwide localities that have yielded noteworthy tourmalines as mineral specimens and/or gem material.

In many respects this is the best book available on tourmaline. It is well written, highly readable, and effectively organized. The major strength of the book is that the summarized information represents a compilation of data from the author's critical review of hundreds of publications on tourmaline. The one aspect of the book that lessens its appeal is the lack of a section describing specific tourmaline localities. Considering the voluminous literature on tourmaline, the inclusion of such information was perhaps technically or economically impossible. If this was the case, even annotating the list of tourmaline localities in the appendix with key references for each occurrence would have been helpful. With this sole criticism, however, *The Tourmaline Group* is the best reference on the subject and, at its modest cost, should be obtained by any gemologist interested in tourmaline.

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