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TABLE OF CONTENTS

ABOUT THE COVER: There are many different aspects to the study of diamonds: books, instruments, grading devices, the stones themselves, and the jewelry into which they are set. One aspect that has become as important to the gemologist as the technical study of the gems is an understanding of the economics of the very complex diamond industry. In the last decade in particular, fluctuations in demand and supply have had a powerful impact on the value and perception of diamonds worldwide. The economics of diamond during this decade is the subject of the lead article in this issue, by William Boyajian, which examines the many different factors that led to the "boom" period of the late 1970s, the subsequent recession, and the striking resurgence in recent years. Photo © Harold & Erica Van Pelt—Photographers, Los Angeles, CA. Jewelry courtesy of Larry Kane and Ballreich & Kantor, Los Angeles, CA; rough diamonds courtesy of Paul Kaplan, L. Kaplan, Inc., New York, NY.

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Gems & Gemology welcomes the submission of articles on all aspects of the field. Please see the Suggestions for Authors in this 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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GEMOLOGY TODAY

This current issue of *Gems & Gemology* contains an interesting review by GIA President William E. Boyajian of the economics of the diamond industry over the last decade, with its exceptional ups and downs in contrast to the relative stability of the preceding decades.

To those who view *Gems & Gemology* as purely a scientific journal, such an article may seem surprising. Today, however, the study of gemology is more than refractive indices and specific gravities; it goes beyond synthetics and simulants, localities and Leveridge gauges. Gemology is now a truly interdisciplinary profession, requiring a good balance of the technical, aesthetic, and commercial aspects of gems. Today's professional gemologist cannot function in a vacuum. A competent gemologist must be able not only to identify and evaluate gemstones, but also to judge the effectiveness of the design, workmanship, and quality of the jewelry in which the gems are set. Today's gemologist must know business management, salesmanship, and a variety of other subjects that are not strictly gemological in nature.

Most contemporary gemologists are not just scientists, but are deeply involved in the gem and jewelry industry as a business. To such individuals, knowledge of world economic conditions, currency relationships, trade balances, and other factors that impact the gem trade is essential if they are to succeed in this highly competitive field. To be fully effective in their vocation, modern gemologists must be well rounded—and well informed.

Like the management of the Gemological Institute of America, the editors of *Gems & Gemology* see among the journal's objectives the enhancement of the gemologist's effectiveness in all aspects of his or her business activities. The article by Mr. Boyajian is another step in our program to include articles dealing with these broader aspects of gemology.

Richard T. Liddicoat
Editor-in-Chief

AN ECONOMIC REVIEW OF THE PAST DECADE IN DIAMONDS

By William E. Boyajian

The diamond industry was buffeted by extreme price volatility during the last decade, unlike any encountered since the Great Depression of the 1930s. Although the industry is currently enjoying a resurgence of activity worldwide, particularly in the Far East, today's market differs significantly from what it was 10 years ago. This article reviews the factors that led to the enormous demand for diamonds in the late 1970s, examines the causes of recession in the early 1980s, and provides an analysis of the comeback of diamond in 1986. Inasmuch as events during this period ushered many changes into the diamond trade, an understanding of how economic forces affect the supply, demand, and value of diamond is critical to all gemologists. Factors such as inflation, recession, interest rates, and disposable income, as well as fluctuations in worldwide exchange rates, had, and undoubtedly will continue to have, an impact on the health of the diamond market.

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Mr. Boyajian is president of the Gemological Institute of America, Santa Monica, California.

Acknowledgments: The author thanks Dona Dirlam for her assistance in researching this article, Glenn Nord and Jim Lucey for their insight into the diamond market, Bryant Barnes for his help on economic issues, Richard T. Liddicoat for his advice on the original manuscript, Robin Walker for verifying information about the Central Selling Organisation, and Joyce Boyajian for her patience and understanding.

Although the market for gem diamonds has long enjoyed stability and gradual appreciation, it can nevertheless be sensitive to a variety of economic forces. At no time has this been more evident than in the period that spanned the late 1970s to the mid-1980s, when market demand and prices climbed to incredible highs—before falling precipitously to equally stunning lows.

In November 1973, the American economy entered its sixth post–World War II recession. In 1974 and 1975, De Beers's rough diamond sales declined by 5% and 15%, respectively. Consumer confidence and consumer spending in the United States bottomed out. The second half of the 1970s, however, heralded a period of rapid inflation, during which many investors sought tangible assets as a hedge. Diamonds, with a tradition of steady, rising value, became an obvious target for speculators. The diamond boom of 1976–1979 was followed by a collapse in 1980: The most durable of all gems (figure 1) became a victim of economic chaos.

During the first half of the 1980s, the diamond trade suffered one of its worst recessions in modern history. Although worldwide retail diamond sales increased during most of this period, prices at all levels dropped as the market sought to absorb the excess inventories built up during the late 1970s. By 1986, however, the diamond market had rebounded. The weakness of the U.S. dollar, and the consequent strength of other currencies, has accelerated demand for diamonds during the past three years, particularly in the Far East.

The diamond market has changed drastically since the mid-1970s. To prepare for future developments, every contemporary gemologist should understand the economic factors that altered the supply, demand, and value of diamond during this turbulent period. It is especially critical to know the forces that have influenced diamond's revival in the latter half of the 1980s. First among these is De Beers.

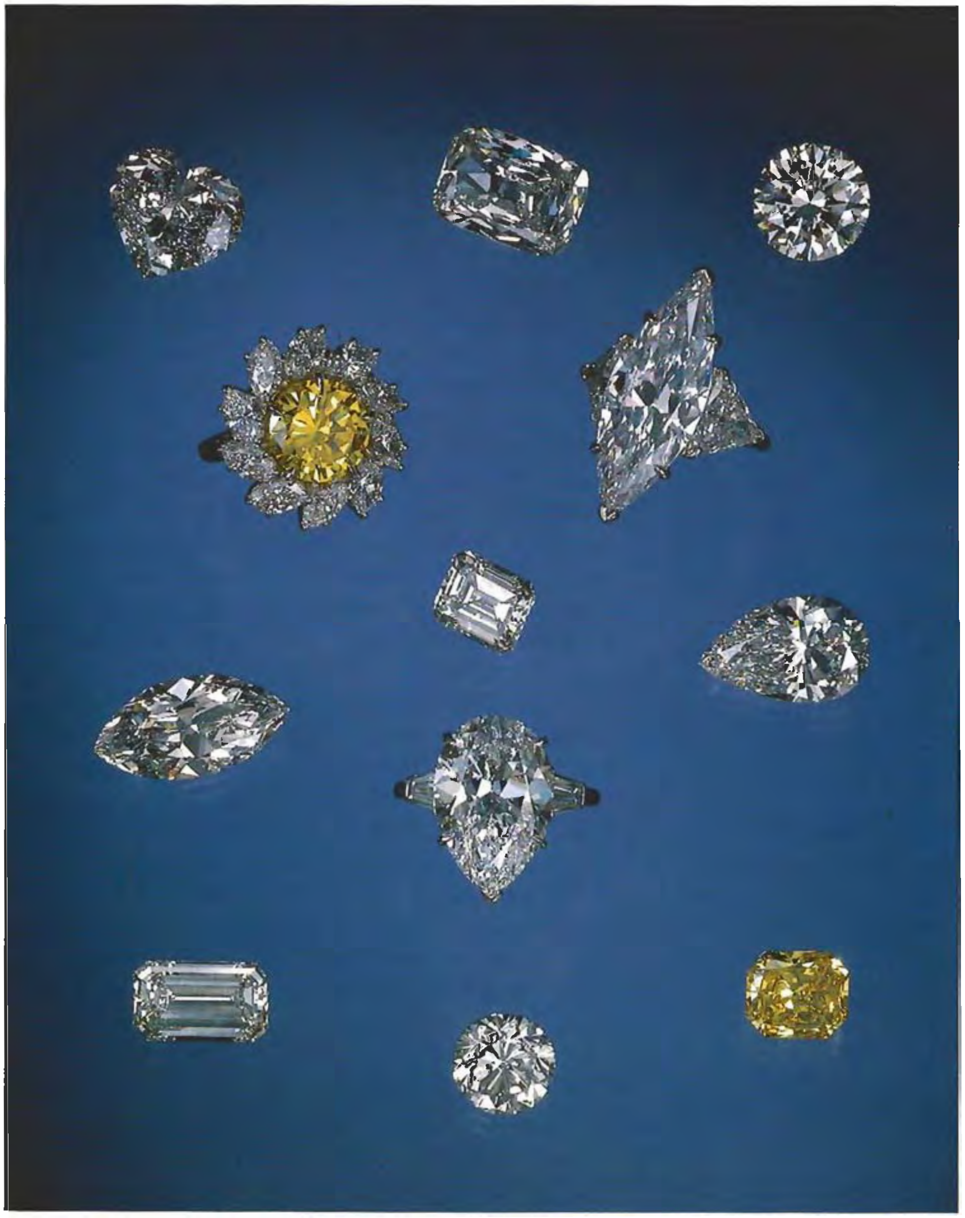


Figure 1. Diamond is the hardest substance known to man, which allows it to take the best polish among common gems. This, combined with its superb transparency and high refractive index, yields an adamantine luster. Although it can cleave, its toughness (resistance to chipping, breaking, and cracking) is good, while the exceptional hardness (resistance to scratching) and stability (resistance to dissolution by chemicals) also make it one of the most durable and eminently wearable gemstones. Physically, it is the best known conductor of heat. Optically, it is potentially the most transparent and the most brilliant gem. The robust dispersion it displays adds even more allure. The three rings, containing an 8.56-ct marquise, a 7.47-ct pear shape, and a 3.49-ct fancy yellow round brilliant, are courtesy of Harry Winston, Inc. Photo by Shane McClure and Robert E. Kane.

DE BEERS: HOW IT FUNCTIONS

The events of the past decade were capped in 1988 by the 100th anniversary of De Beers. Consider Chairman Julian Ogilvie Thompson's opening statement in the 1987 De Beers Annual Report: "It must be unique for a company which on its formation became the leader of an international business, indisputably still to hold that position at its centenary."

De Beers Consolidated Mines Limited is essentially a multinational financial, industrial, engineering, and mining conglomerate, governed by a board of directors headed by Chairman Ogilvie Thompson, who succeeded Harry Oppenheimer in 1984. De Beers owns diamond mines in South Africa and works in partnership with the independent state of Botswana. It also has close relationships with other governments and mining companies, in addition to owning an alluvial diamond producer, Consolidated Diamond Mines, in Namibia.

De Beers was founded in 1888, more than two decades after the discovery of diamonds in South Africa marked the birth of a new diamond era. Previously limited to depleting Indian and Brazilian sources, diamonds were too expensive for any but royalty or the very wealthy. Not so ironically, the large new diamond discovery of the 19th century coincided with the emergence of the modern middle class.

Figure 2. At No. 2 Charterhouse Street, London, the CSO markets about 80% of the world's diamond production. Photo courtesy of the CSO.

Today, De Beers no longer mines the lion's share of world diamond production. In particular, South Africa contributed only about 10% of the total quantity of diamonds mined in 1987. The four top diamond-producing countries (by production weight) in 1988 are Australia, Zaire, Botswana, and the USSR (table 1). Although De Beers continues to support extensive prospecting activities worldwide, it has maintained its position as the leading diamond organization through, among other efforts, the distribution, marketing, and research activities of the Central Selling Organisation (CSO), its London-based arm (figure 2).

The CSO functions as a quasi-producers' cooperative, selling to the world markets diamonds from the De Beers mines and from joint-venture partnerships, as well as those it obtains from other producers through contractual agreements and those it buys on the open market. The CSO purchases those quantities of rough diamonds necessary to balance the supply of diamonds with world demand; it is capitalized to the extent that it can hold such diamonds, in stock, for indefinite periods of time, thus fulfilling an important reserve function.

The CSO conducts rough diamond sales 10 times a year, every fifth Monday, in London, Lucerne, and Kimberley. The sales, called "sights," are handled through the Diamond Trading Company (DTC), an integral part of the CSO. The DTC currently has about 150 sightholders, half that of 1979, who comprise a carefully selected group of diamantaires (diamond manufacturers and dealers) that cover a wide spectrum of the world market for rough. Some own cutting and polishing factories;

TABLE 1. World rough diamond production, by country, for the years 1977–1987 (in millions of carats).[a]

Country	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Australia	—	—	—	0.480	0.205	0.457	6.200	5.692	7.070	29.211	30.333
Zaire	11.214	11.243	8.734	10.235	7.161	6.164	11.982	18.459	19.617	23.304	23.350
Botswana	2.691	2.799	4.394	5.101	4.961	7.769	10.731	12.914	12.635	13.110	13.207
USSR	10.300	10.550	10.700	10.850	10.600	10.600	10.700	10.700	10.800	10.800	12.000
S. Africa	7.643	7.727	8.384	8.520	9.526	9.154	10.311	10.143	10.202	10.300	9.053
Namibia	2.001	1.898	1.653	1.560	1.248	1.014	0.963	0.930	0.910	0.950	1.020
Brazil	0.620	0.620	0.620	0.667	1.089	0.530	0.530	0.750	0.450	0.550	0.645
Ghana	1.947	1.423	1.253	1.258	0.836	0.684	0.340	0.346	0.650	0.600	0.600
CAR	0.297	0.284	0.315	0.342	0.312	0.277	0.295	0.337	0.352	0.350	0.350
Indonesia	0.150	0.150	0.150	0.150	0.150	0.150	0.270	0.270	0.270	0.270	0.300
Sierra Leone	0.961	0.779	0.855	0.592	0.305	0.290	0.345	0.345	0.349	0.315	0.300
Liberia	0.326	0.308	0.302	0.298	0.336	0.433	0.330	0.240	0.138	0.252	0.250
Venezuela	0.687	0.820	0.803	0.721	0.490	0.493	0.279	0.272	0.215	0.235	0.250
Ivory Coast	0.390	0.450	0.480	—	—	—	—	—	—	0.100	0.200
Angola	0.353	0.650	0.841	1.480	1.400	1.225	1.034	0.902	0.714	0.250	0.190
Tanzania	0.408	0.282	0.314	0.274	0.217	0.220	0.261	0.277	0.296	0.300	0.190
Guinea	0.800	0.800	0.850	0.380	0.380	0.400	0.400	0.470	0.132	0.204	0.175
India	0.180	0.160	0.160	0.140	0.160	0.130	0.140	0.150	0.160	0.160	0.150
Guyana	0.170	0.170	0.160	0.100	0.100	0.110	0.100	0.140	0.110	0.900	0.110
Lesotho	0.420	0.670	0.520	0.540	0.530	0.420	—	—	—	—	—
TOTAL	41.558	41.783	41.488	44.688	40.006	40.520	55.211	63.337	65.070	92.161	92.673

[a]Source: U.S. Department of the Interior (1977–1987).

some supply other, smaller manufacturers. These buyers represent about 14 countries and/or cutting centers, although the vast majority have operations in the four major centers of New York, Antwerp, Tel Aviv, and Bombay. Purchases from the DTC are in cash and in U.S. dollars only. Transactions for sightholder boxes can range from hundreds of thousands of dollars to tens of millions and must be paid within seven days. Each sight box represents a "series," a selection of sizes and shapes that are tailored, as closely as possible, to the wishes, needs, and expertise of the individual sightholder (figure 3). CSO clients work through one of four brokerage firms that, for a commission, negotiate with the CSO on their behalf. Although rough diamonds are graded into some 5,000 categories within the CSO channel (figure 4), they are ultimately packaged into about 60 different types of series. Sightholders are free to question the grading or price of the goods in their allotment, but changes are seldom made. Prices on large rough (approximately 11 ct or more) may be negotiated individually.

De Beers is also heavily involved in the marketing and promotion of diamonds. For 1988 alone, De Beers stated that it would spend some $120 million to promote diamonds worldwide, nearly triple the expenditure it reported in 1980. Another $25 million will likely be spent in cooperative advertising with retailers.

In addition, De Beers has a major research facility in Johannesburg, South Africa, that investigates new techniques in diamond mining and recovery as well as develops new technical applications for diamond in science and industry. The CSO has a separate research facility in Maidenhead, England, which concentrates on improving techniques for sorting and cutting diamonds. Indeed, the new diamond cuts by Gabi Tolkowsky (Shor, 1988), which help maximize brilliance, color, and yield in rough that was previously difficult to manufacture, are a result of this research effort. De Beers also has subsidiaries devoted to the manufacture of synthetic diamond for industrial purposes.

The Marketing Liaison Department, formed in 1986, helps the CSO communicate with every level of the diamond pipeline: cutting, distribution of polished goods, jewelry manufacturing, and, ultimately, retailing. Through these and other activities within the industry, De Beers has played, and will undoubtedly continue to play, a major role in supporting the diamond trade.

Figure 3. Here, CSO clients examine part of their sight. Photo courtesy of the CSO.

THE DIAMOND BOOM: 1976–1979

For 30 years following World War II, the diamond industry enjoyed relative calm. Almost always stable, and usually growing, the market performed in an orderly manner, with goods supplied on the

Figure 4. Before they are sold, rough diamonds are sorted into some 5,000 categories. Photo courtesy of the CSO.

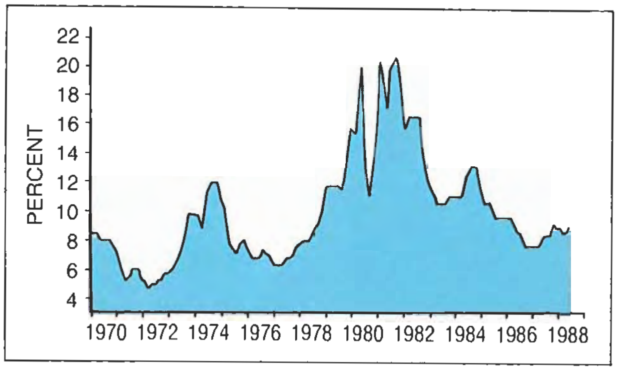


Figure 5. Prime interest rates in the U.S. from 1970 to mid-1988. Courtesy of Moody's Investors Service; artwork by Peter Johnston.

basis of global demand. Prices rose steadily, except for minor downturns during periods of recession.

By mid-1976, however, most world economies began to experience rising inflation with relatively low real interest rates (figure 5). While this should have boded well for diamonds, certain practices that started in Israel eventually led to a debacle that threatened the very core of the industry.

The Israeli Factor. In 1976, Israel was a relatively young but rapidly growing diamond center. The Israeli government was anxious to promote the diamond trade because of its contribution—both proven and potential—to the country's overall gross national product. To make things move even more quickly, the government supplied several Israeli banks with huge amounts of money at very low interest rates to be passed on to diamond manufacturers and dealers so they could build their inventories. The government also set up a system whereby the dollars that were brought into the country through the sale of diamonds received a more favorable exchange rate, which made speculating in rough diamonds even more lucrative. With Israel suffering from runaway inflation (400% at the peak), it is easy to see why many Israelis found diamonds, and this opportunity to speculate, too profitable to ignore (Green, 1981; Nord, 1982).

Typically, a diamantaire with a certain amount of rough diamonds would deposit his rough in a bank as collateral at a declared value, and get a loan from the bank for a similar amount at a very low interest rate. He would then buy more diamonds, deposit them in the bank, and, in turn, get another low-interest loan. In addition, according to Nord (1982), "at this same time there existed in Israel a unique system that allowed people with no money to enter the business. This system was referred to as the trust receipt. This would permit the bank to advance money to people to buy diamonds, which were then to be put up as collateral in the bank. But of course, the cutter had to have the goods to polish and manufacture. The bank would then issue a trust receipt, which, in turn, allowed the purchaser to take the goods out of the bank for a specified period of time for either sale or manufacture. In fact, the system was so liberal that the dealer was even able to ship the goods out of the country on approval to a foreign client. There was no question that this was one of the vehicles that kept the diamond industry moving in Israel. But it was another of the excesses that led to the speculative boom. . . ."

The easy money in Israel allowed manufacturers to obtain more and more rough from the CSO, which not only had to draw heavily on its stocks but also was compelled to increase production. In many cases, it was far more profitable for diamantaires to hold their rough, or sell it for a huge premium, rather than cut and polish it. In effect, manufacturers and dealers began to work totally on the bank's money, creating an apparent demand for diamonds that really did not exist, since many of the goods were not being cut and were not entering the market; it was not a true consumer demand. It is not surprising, then, that the price of rough rose much faster than the price of polished goods (Nord, 1982). And the banks were loaning money based on the value of the rough, rather than on the value of the polished. According to Rothschild (1982), unopened boxes of rough were being traded on the secondary markets for premiums up to, in extreme cases, double the cost of the rough from the CSO. In the end, the hoarding of boxes of rough created a shortage of goods in the marketplace, which drove speculation, and prices, higher and higher. By 1978, there was serious question whether control of the market would be wrested by the industry in Israel, where banks were holding hundreds of millions of dollars in overvalued rough diamonds. Soon, the speculative fever had spread to two other centers as well, New York and Antwerp.

Diamond "Investment" and "Certificate" Goods. During this same 1976–1979 period, a new dimension developed that also fueled the rise in prices. Almost overnight, diamonds (like other tangibles, such as gold and silver) became a fashionable "investment," and so-called diamond investment firms sprang up throughout the U.S. and Europe. These firms created high-powered promotional packages and presented cleverly designed seminars to tout the excellence of diamond as an investment vehicle, a hedge against inflation. They specialized in promoting one carat and larger diamonds, often with worthless buy-back agreements. Another lure was the premise that the diamond industry was controlled by an "omnipotent" cartel that never dropped its prices. Since credibility was a key to marketing such diamonds, these firms (typically managed by people from outside the industry who had little or no diamond experience) placed themselves in respectable positions by using diamond-grading reports issued by gemological laboratories (figure 6). Demand for "certificate" goods swelled as dealers, and the public, insisted that stones of large sizes and fine qualities have documentation by third parties (who may or may not have been impartial).

TABLE 2. Price increases and surcharges[a] levied by the CSO from November 1971 to May 1988.[b]

Year	Month	Overall price increase (%)	Surcharge (%)
1971	November	5.0	
1972	January	5.4	
	September	6.0	
1973	February	11.0	
	March	7.0	
	May	10.0	
	August	10.2	
1974	December	1.5	
1976	January	3.0	
	September	5.75	
1977	March	15.0	
	December	17.0	
1978	March		40.0
	May		25.0
	June		15.0
	July		10.0
	August	30.0	
1979	September	13.0	
1980	February	12.0[c]	
1982	September	2.5	
1983	April	3.5	
1986	April	7.5	
	November	7.0	
1987	October	10.0	
1988	May	13.5	

[a] Surcharges are one-time premiums charged by the CSO to offset "premiums" offered by the trade.
[b] Source: Jewelers' Circular-Keystone Directory (1988) and Rothschild (1982).
[c] On 1 ct and above.

Figure 6. During the "diamond investment era," diamond grading reports assumed a new level of importance that continues to the present day. Photo courtesy of Robert Lombardi Advertising.

Diamonds had long been viewed as portable wealth and a store of value, with a history of more than keeping pace with inflation, but never before had they been marketed on a broad scale as a truly "liquid investment." Too, seldom had the general public acquired them from other than the traditional retail jeweler, a situation that also changed. When price charts began to spring up, and publications like the *Wall Street Journal* started listing diamond prices on a weekly basis, public speculation escalated. The traditional retail jeweler, who had spent a lifetime building a reputation of integrity as a diamond merchant, saw much of his business for better-quality stones slip away.

De Beers Reacts. In the spring of 1978, in an attempt to bring order to an exploding market, the CSO began to impose huge surcharges on sightholder boxes (table 2). This, in effect, told the banks that they would be financing diamonds at greatly inflated values; it also told speculators that they could no longer broker sightboxes at huge premiums, without sharing these profits with the producing countries and De Beers. The first surcharge was 40% in March 1978, followed by 25% in May, 15% in June, and 10% in July. Over the same period, the CSO carefully reevaluated their existing sightholders and ultimately eliminated those who were taking premiums on unopened boxes or those who were no longer financially stable. The CSO then imposed an enormous overall price increase of 30% in August 1978, followed by 13% in September 1979.

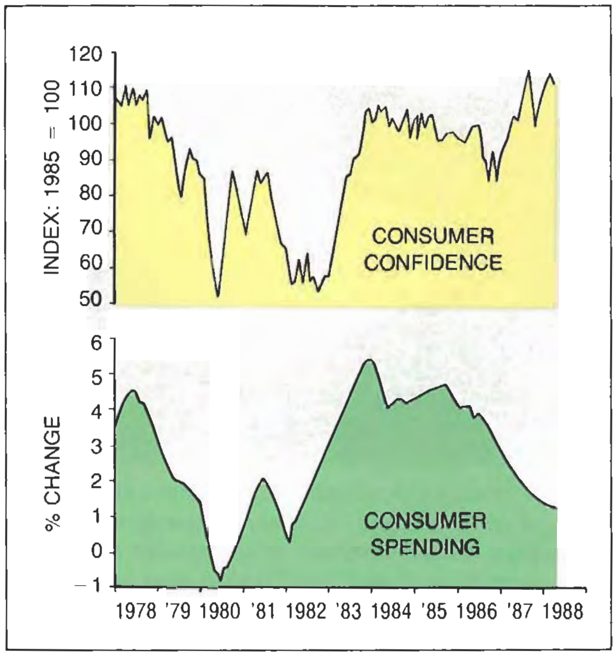


Figure 7. Both consumer confidence and consumer spending in the U.S. reached their lowest point for the past decade in 1980. The top graph covers consumer confidence (using 1985 as a benchmark, i.e., 100). The bottom graph covers variations in real consumer spending (year-to-year percentage change with a six-month moving average). Courtesy of the Consumer Research Center, The Conference Board (an independent, nonprofit economic and business research organization); artwork by Peter Johnston.

THE MARKET COLLAPSES: 1980

Crippling at the Dealer Level. After the huge surcharges of 1978 and the price increases of 1978 and 1979, the Israeli diamond market began to crumble. According to Green (1981), "for the first time in thirty years the value of Israel's diamond exports fell in 1979, and employment [in diamond manufacturing] declined by one-third. . . ." De Beers levied an additional 12% price hike in February 1980, which helped strike the final blow. All of these actions, together with rising interest rates (again, see figure 5), pushed up the cost of diamonds at every purchasing level. By the spring of 1980, prices had reached heights that exceeded consumer demand. At the same time, consumer confidence was dropping and, by June 1980, real consumer spending in the United States had fallen to near-record lows (figure 7). According to Rothschild (1982), retailers sold from stock, but were not restocking to the same levels. Suppliers weren't selling and therefore weren't buying. This affected the manufacturer's market which, in turn, affected the market for rough.

In a matter of several months, from March to September of 1980, the average sale price of the benchmark D-flawless, 1-ct diamond dropped dramatically (table 3). According to Ogilvie Thompson (1982, p. 10), "the price of a top-colour one carat flawless brilliant, which had risen steadily from $1,650 in 1971 to $16,000 in 1978, rose by 1980 to about $65,000 – even if very few genuine trades took place at that level – but has since fallen back and has even been traded at below $20,000." When the world recession hit by the second half of 1980, a great number of diamantaires were overextended at the banks. Manufacturers and dealers who had heavily invested in inventory at peak prices (often at huge – 20% + in the U.S. – interest rates), suddenly found themselves absorbing tremendous paper losses in their stock of goods. Forced to declare bankruptcy, many forfeited their

TABLE 3. Sample dealer prices for a D-flawless, 1-ct diamond (D-internally flawless after March 1978).[a]

Year	Month	Price/ct (US$)
1977	March	7,200
	September	7,925
1978	March	15,000
	September	20,000
1979	March	22,500
	September	32,000
1980	March	60,000
	September	54,000
1981	March	43,000
	September	30,000
1982	March	20,500
	September	18,200
1983	March	19,500
	September	18,500
1984	March	15,000
	September	14,700
1985	March	14,000
	September	12,600
1986	March	12,600
	September	15,500
1987	March	16,000
	September	17,000
1988	March	17,000
	September	17,800

[a] *Sources: March 1977–March 1978,* JC-K 1982 Directory; *September 1978–September 1988,* Rapaport Diamond Report, *for the last week of each month cited. Shaded areas represent the highs and lows for this period.*

diamond stockpiles to the banks, who were left holding enormous quantities of goods in a plummeting market. The glut of stones in dealer inventories, in private hands, and in the banks was so large that prices fell much faster than they had risen during the boom years. Instead of the CSO managing the world's stockpile (their stocks of larger, better-quality stones now essentially depleted), excess goods were spread into so many hands that the stability of the market, and that of diamond prices, was temporarily lost.

Diamond Investments Plummet. The same forces that were inflicting such heavy damage at the dealer level likewise wounded the diamond investment sector. On the one hand, the high interest rates made borrowing money to purchase diamonds almost prohibitive. On the other hand, the opportunity to invest money at these interest rates made speculating in tangibles such as diamond less attractive. The onset of the world recession ultimately killed diamond investment. From this investment activity, however, two important factors emerged that continue to influence the diamond industry: (1) the intrinsic value of diamond information and grading reports provided by gemological laboratories (although the GIA Gem Trade Laboratory actually began issuing diamond grading reports in 1955); and (2) the regular publication of diamond price lists, available to the public as well as the trade.

The Retailer Survives, even Thrives. Although the diamond industry at the supplier level was severely hurt by the fall of diamond in 1980 (and the slowdown through 1985), the effects in the retail sector in the U.S. were far less dramatic (figure 8). When prices escalated in the late 1970s, goods in the so-called investment qualities attained such artificially high prices that few, if any, legitimate retailers could market them. In addition, while the prices of better-quality diamonds rose astronomically, those of commercial goods – that is, stones of average quality under a carat – moved up, but less significantly.

U.S. Department of Commerce figures for rough and polished diamond imports from 1979 through 1983 clearly show how little the impact of the inflationary bubble for large, high-end goods was on sales volume at retail. According to Richard T. Liddicoat (pers. comm., 1988), the bulk of the rough (in value) imported into the United States consists of large, high-end stones that are cut in New York, generally finishing a carat or more in weight. Many of these are sold overseas. Most U.S. imports of polished diamonds, on the other hand, are less than a carat and are marketed in the U.S. While imports of rough dropped from $956 million in 1979 to $292 million in 1983, imports of polished diamonds during this same period rose from $903 million to $1.983 billion.

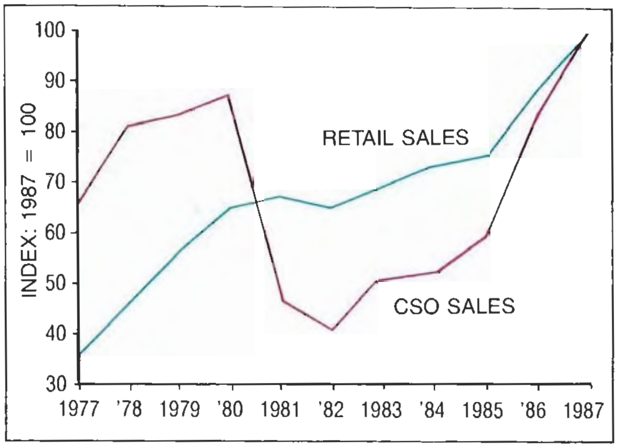


Figure 8. Using 1987 as a benchmark, this chart compares diamond sales by the CSO with sales at U.S. retail for the period 1977–1987. Although the 1980–1981 fall in prices dramatically affected the CSO, it had relatively little impact on the retail sector. Courtesy of the CSO, June 1988; artwork by Peter Johnston.

At this same time, retailers began to carry inventories that were often just high enough to service their customers, and began to operate on much stricter budgets. Although diamond sales are roughly half of most jewelry retailers' total business, retailers are able to diversify their product line to meet changes in the marketplace. Suppliers are not, and neither is the CSO.

SURVIVAL OF THE FITTEST: 1981–1985

For at least a year after the initial fall in diamond prices in mid-1980, the industry was in a state of confusion. The CSO's response was to reduce supplies of specific types of rough available in the markets by removing certain categories from the sights – in particular, the larger, higher quality stones (Rothschild, 1982) – and by cutting back on others. According to Rothschild (p. XXXII), "The range of rough diamonds sold to buyers was made more selective, and a completely new assortment with new categories, with prices reflecting these new categories, was presented in the November 1981 sight. . . . Sales [by the CSO] dropped to a figure of $1.472 billion – a decrease of 46% over the previous year."

A glance at the CSO's rough diamond sales for the years 1981–1985 (table 4) illustrates just how slow this period was. According to Miller (1987, p. 13), during "the diamond destocking process, which started in late 1980, . . . dealers, cutters and speculators disposed of around $5 billion worth of diamonds (often at very substantial financial losses). . . . To put this destocking by suppliers into perspective, by value it represented at least 30–40% of the annual global sales figures for uncut gem diamonds during the years of 1981–84."

With excess stock essentially disposed of by the second quarter of 1985 (Miller, 1987), many began to feel that a low point in diamond prices had been reached and that demand would start to build. Even before this, in late February 1985, a significant new economic factor entered the picture: The value of the U.S. dollar (the currency used by the CSO in the sale of all of its sights) began to slip against many other currencies, most notably the Japanese yen (see table 5). In addition, the resilient Israeli diamantaires, who were the first and perhaps the hardest hit by the rapid downturn, had successfully restructured their industry into smaller, more efficient manufacturing units. Their ability to respond immediately to changes in the marketplace would eventually help lead the industry out of recession.

TABLE 4. Annual sales of rough diamonds (gem and industrial) by the CSO from 1970 through June 1988.

Year	Total sales in millions of US$[a]	%Increase/ decrease over previous year	Total sales in millions of 1986 US$[b]
1970	529	−23	1,506.3
1971	625	+18	1,706.7
1972	849	+36	2,244.3
1973	1,322	+56	3,314.3
1974	1,254	− 5	2,811.7
1975	1,066	−15	2,190.3
1976	1,555	+46	3,020.6
1977	2,073	+33	3,782.8
1978	2,552	+23	4,325.4
1979	2,598	+ 2	3,960.4
1980	2,723	+ 5	3,654.1
1981	1,472	−46	1,788.7
1982	1,257	−15	1,440.2
1983	1,599	+27	1,774.9
1984	1,613	− 1	1,717.2
1985	1,823	+13	1,874.0
1986	2,557	+40	2,557.0
1987	3,075	+20	—
1988	2,201[c]	+41[d]	—

[a] *Sources: "Diamonds and Gemstones" (1988); De Beers Consolidated Mines, Ltd. (1977–1987).*

[b] *Source: Miller (1987).*

[c] *For January–June. Source: CSO press release, July 1988.*

[d] *Over January–June 1987.*

TABLE 5. Currency exchange rates for Japan, the United Kingdom, France, and Germany as compared to the U.S. dollar, 1977–September 1988.[a]

Year	Japan (¥/$)	United Kingdom ($/£)	France (FF/$)	Germany (DM/$)
1977	240.00	1.9060	4.7050	2.1050
1978	194.60	2.0345	4.1800	1.8280
1979	239.70	2.2240	4.0200	1.7315
1980	203.00	2.3850	4.5160	1.9590
1981	220.00	1.9150	5.7250	2.2480
1982	234.80	1.6180	6.7300	2.3750
1983	231.59	1.4515	8.3250	2.7220
1984	251.70	1.1587	9.6550	3.1530
1985	200.00	1.4455	7.5000	2.4400
1986	158.50	1.4815	6.4350	1.9255
1987	120.80	1.8860	5.3150	1.5695
1988[b]	134.40	1.6810	6.4065	1.8830

[a] *These figures represent the exchange rates applicable at the close of each year. Source for 1977–1987: Bank of America.*

[b] *Rates on September 29, 1988. Source:* Los Angeles Times, *September 30, 1988.*

Certainly, by late 1985, there was no doubt that the tide was turning. Demand for diamonds had risen markedly. Total sales for the CSO in 1985 rose 13.0% over those of 1984 (see again, table 4), and the number of GIA GTL diamond grading reports issued in the last quarter of 1985 increased by 8.3% over the same period in 1984.

DIAMONDS REBOUND WITH THE JAPANESE MARKET: 1986

With the declining strength of the U.S. dollar, Japan and other consuming nations with strong currencies began acquiring diamonds at, in effect, tremendous discounts. For example, 1986 diamond imports to Japan were up over those of 1985 by more than 50% in quantity (or dollars), but only 10% in yen (Jeremy Richdale, CSO, pers. comm., 1987). The CSO increased prices twice in 1986 – 7.5% in April and 7% in November – in response to heightened demand (in effect, an adjustment of the price in dollars to reflect the rising value of the yen and other currencies). Overall, rough diamond sales by the CSO were up 40% in 1986 over the previous year (see again, table 2).

Japan is De Beers's big success story in the past two decades. To illustrate, De Beers reports that only 6% of all Japanese brides in 1966 received

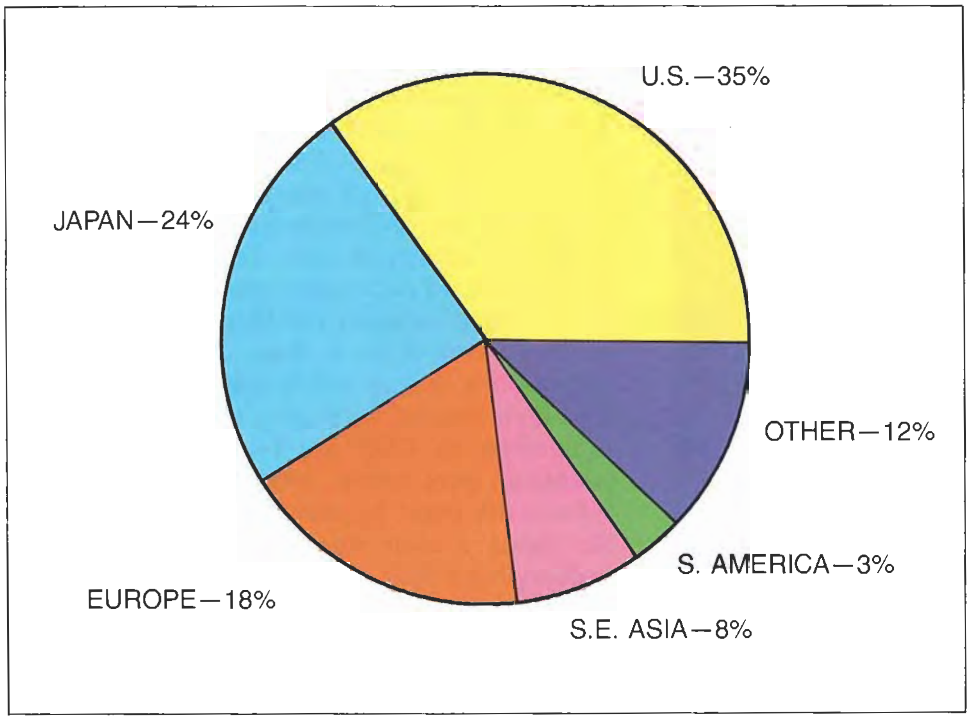


Figure 9. As this chart of worldwide retail sales of diamonds illustrates, Japan consumed almost one-quarter (by value) of the polished diamonds sold in 1987. The U.S. figure of 35% is down from 38% in 1986. The CSO expects Japan's share of the market to continue to expand, while that of the U.S. will get smaller. Courtesy of the CSO, June 1988; artwork by Peter Johnston.

diamond engagement rings, in contrast to 74% in 1987. In addition, according to the CSO's magazine *In-Sight* ("Consumer Market Trends," 1988), Japanese consumption of diamonds one carat and larger has tripled since the yen's most recent low in 1985. By the end of 1987, the Japanese market consumed 24% of all polished diamonds (in value terms) sold at retail (figure 9), up from 22% in 1986; in comparison, the U.S. share of the retail market dropped to 35% in 1987 from 38% the previous year (a long way from the 80% share it represented shortly after World War II). By the end of 1988, Japan is expected to be acquiring 27% annually of the world's total polished diamonds in dollar terms, with the U.S. share decreasing below 35% (Keith Ives, CSO, pers. comm., 1988). Considering that Japan has a lower per capita income than the U.S. and roughly half the population, these figures are even more astounding.

According to Ogilvie Thompson (1988), the diamond market was firm for the first eight sights of 1987, particularly in the larger sizes. The CSO's policy by early autumn of that year appeared to be one of cautious optimism. They knew that demand was up largely due to the strength of the yen. They also must have felt an element of worldwide speculation in the air, with a modest interest in tangible assets re-emerging. Nevertheless, the CSO raised prices again in October, at that time the single biggest sight in its history. Few could imagine what would happen next.

THE STOCK MARKET CRASHES: OCTOBER 19, 1987

Events on Wall Street. The Dow Jones Industrial Average rose to an all-time high of 2,722 on August 25, 1987, before dipping over the next seven weeks to 2,246 on Friday, October 16. Then the crash of Monday, October 19, rocked the world. Many stocks had been selling for far more than their earnings' value. Alternative investments were becoming, in effect, better (and safer) buys. As a number of investors began to get out of the market, modern computer trading, with automatic "sell" signals at specified price points, threw the U.S. stock exchanges into a selling frenzy on October 19th. Dubbed "Black Monday," this date saw the Dow Jones Industrial Average drop over 500 points, to 1,738, and the U.S. stock market incur a paper loss of some $1 trillion. Repercussions were quickly felt throughout the United States and on the Tokyo, Hong Kong, and London stock exchanges, which all experienced similar precipitous declines.

Following the CSO's October sight, just two weeks before the crash, some diamantaires speculated that De Beers had planned an even larger one for November. Instead, they cut it in half to tighten worldwide supply and firm up prices, undoubtedly in response to the uncertainty generated by events on the stock exchanges. By reacting quickly, the CSO maintained the confidence of their clients and the industry. Gradually, stocks began to re-

Figure 10. Current consumer interest in major diamonds is evidenced by this superb brooch designed and set by Tiffany & Co. in New York this past summer. The fancy yellow diamond weighs 128 ct; the largest pear shape, crowning the yellow stone, weighs approximately 20 ct. The additional 23 pear-shaped and marquise diamonds total approximately 160 ct. Photo by Josh Haskin; courtesy of Tiffany & Co.

bound as other economic indicators remained good. Consequently, the December sight was larger than that of November. Despite the crash, 1987 CSO sales of gem and industrial rough diamonds were $3.075 billion, the biggest year ever.

Renewed Demand by 1988. Worldwide demand for rough was so strong by early 1988 that the CSO's January sight was larger still. With reports of a good 1987 Christmas selling season, optimism abounded, and the February and March sights followed at even greater sizes. In response to continued strong demand, the then-record May sight was accompanied by an overall price hike of 13.5%. According to the *Rapaport Diamond Report* (April 29, 1988), because Japan is the power behind diamond buying today, this latest increase (in dollars) is really another attempt to stabilize diamond prices in yen. More important, prior to the price increase, premiums of 10%–15% had been offered in dealer-to-dealer trading for unopened boxes of rough from the CSO. Consequently, the May increase can also be thought of as an attempt by the CSO to ensure that they and the producing countries also benefited from the greater demand and higher prices.

De Beers followed the May 1988 sight with another record sight in June. Generally, a sight lasts a week, during which sightholders may discuss their "series" with the CSO at their option. According to CSO market liaison Michael Grantham (pers. comm., 1988), the June sight was "practically over" by Tuesday (the second day of the sight), a clear sign that sightholders were anxious to get their rough and manufacture or sell it right away. The July sight was a little smaller in comparison to June; whether this reflects a slowdown in Far East buying, due to a slightly stronger dollar and building inventories, is uncertain. The market for rough diamonds in late 1988, however, is still strong.

The period following the October 1987 stock market crash saw De Beers fulfilling its traditional role in the marketplace, balancing the supply of rough with demand in order to stabilize prices. According to the *Economist* ("Diamonds 1988," p. 25), "Indeed, during the week following 'Black Monday' on Wall Street, when prices in securities and commodities markets were gyrating wildly, diamond prices scarcely moved at all." De Beers's tightening of supplies after the October 1987 crash worked principally because there were few loose goods in dealer inventories. Although CSO officials felt that there had been some hoarding during the preceding year, it was nothing near the magnitude of the late 1970s.

RECENT EVENTS IN THE DIAMOND INDUSTRY

The May 1988 price increase was the CSO's biggest in nearly a decade. The pace set in 1988 indicates another record year for the CSO, with diamond sales in the first six months totaling $2.201 billion, up 41% over the same period in 1987 (see table 4).

In his April 26, 1988, address to the American Gem Society at their Toronto Conclave, the CSO's Michael Grantham claimed that the diamond industry is in better condition today than at perhaps any other time in history. The prodigious Far East demand stimulated by a weakened U.S. dollar is key. Moderate dealer inventories are also a

Figure 11. In 1988, sales at auction for diamonds and other gemstones have reached record levels. For example, sales at the April 1988 Christie's auction in New York—at which this ring and necklace were offered—totaled $24 million. As of September 1988, jewelry sales at Christie's had reached $77 million, more than 12 times the $5.3 million in jewelry they auctioned in all of 1977. The 18.56-ct pear-shaped diamond ring sold for $198,000; the garland necklace, with a 3.59-ct pear shape as the largest stone, sold for $143,000. Photo by Tino Hammid; courtesy of Christie's New York.

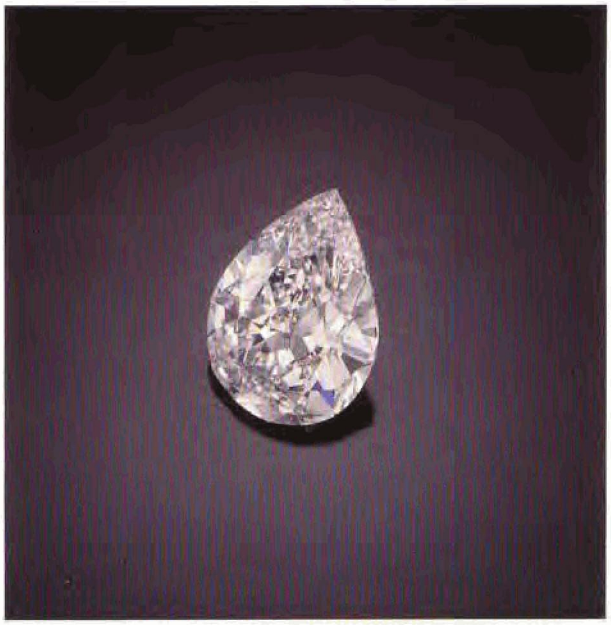
plus. After the stock market crash, the psychology of the diamond market shifted. Concerns about the possibility of a recession (or worse) and uncertainty about the stability of financial markets made dealers wary—not enough to curtail buying, but certainly enough to discourage excessive hoarding. At the same time, many wealthy people, who saw the volatility of the stock markets in October 1987, along with the rise (and firming) of diamond prices soon afterward, shifted some assets to major diamonds (figure 10). This contributed to an even stronger diamond market by mid-1988.

The renewed interest in large, fine-quality diamonds in the last few years is most evident in the increased activity at the auction houses (figure 11). During the diamond recession of 1981–1984, and through most of 1985, auction house activity was slow. Prices did not show signs of strengthening until the end of 1985. According to Moyersoen (1987, p. 111), "Generally auction prices are about 10% less than those prevailing on the wholesale market. Nevertheless, when the market starts to recover, precursory signs can be visible at auction houses where diamonds can command prices much higher than those prevailing on the wholesale market. For instance in December 1985, the beginning of the market recovery, we were able to observe much higher prices in New York auction houses than on the wholesale market."

Examples of these new price levels include the 0.95-ct fancy purplish red diamond that Christie's sold at their April 28, 1987, auction for a record-breaking $926,000 per carat. Two days after the stock market collapse, a 64.83-ct D–internally flawless stone sold at Christie's in New York for nearly $6.4 million (almost $100,000 per carat); just six months later, a 52.59-ct D–internally flawless emerald cut sold at Christie's for $7,480,000 – a record $142,000 per carat for a colorless diamond sold at auction (Moyersoen, 1988). Most recently, on October 19, 1988, a 59.00-ct D–internally flawless diamond (figure 12) sold at Christie's for $5,560,500. It is interesting to note that the second largest diamond in the world – a 407.48-ct fancy brownish yellow internally flawless "shield" cut (figure 13) – was offered at the same auction but was withdrawn when bidding ended at $12,000,000.

Another key factor in the stability of the market today is the more conservative distribution policy of the Soviets (Maillard, 1988). During the down times between 1982 and 1985, the USSR periodically flooded goods onto the market at depressed prices, presumably to raise foreign capital. According to Moyersoen (1988), an understanding between De Beers and the Soviets was reached in September 1985 whereby the USSR would cease "dumping" and would not increase its overall sales of diamonds, while De Beers would purchase Soviet polished goods over 0.25 ct as well as larger quantities of rough.

Figure 12. Several important colorless diamonds have come to auction in the last few years. This 59.00-ct D–internally flawless pear shape (shown here at actual size) was sold by Christie's New York on October 19, 1988. Photo by Tino Hammid; courtesy of Christie's New York.



WHERE DO WE GO FROM HERE?: PERSPECTIVES ON A CHANGING DIAMOND WORLD

The diamond industry has faced – and overcome – challenges throughout its history. There are, however, a number of key issues that can drastically affect the future economics of this industry. These include not only the traditional factors of supply and demand, but also an important, relatively recent variable: the impact of new technology.

On the Supply Side. Diamonds were originally discovered in India as early as the 3rd century B.C., with the next major discovery in Brazil in the 1700s. Just at the time of diminishing supplies worldwide, diamonds were found in South Africa in 1866. This discovery changed the diamond industry as the world then knew it. In the modern diamond era, major developments such as those in the USSR in the 1960s, Botswana in the 1970s, and Australia in the 1980s, have led to continued changes in the industry (see box on "World Diamond Production").

In his controversial 1982 book, *The Rise and Fall of Diamonds*, Epstein concluded that, "By the mid-1980s the avalanche of Australian diamonds will be pouring onto the market and unless the resourceful managers of De Beers can find a way in the interim to bring this plethora of diamonds under control, it will probably signal the final collapse of world diamond prices. Under these circumstances, the diamond invention will disintegrate and be remembered only as a historical curiosity, as brilliant in its way as the glittering, brittle, little stones it once made so valuable." Obviously, Epstein's scenario never took place.

To be sure, responsible members of the trade were concerned during the recession of the early 1980s about the market impact of the Australian finds and of Botswana's prolific Jwaneng mine (figure 14) on an already depressed market. The CSO, however, maintained a position from the outset that the Australian production would not adversely affect the market, and Botswana's production was already being marketed through CSO channels. Since then, the industry has seen this new production absorbed at a steady, increasing rate. Although worldwide exploration continues, there have been no reports of economically significant new mining sources on the horizon. Supply appears to be adequate, yet not excessive.

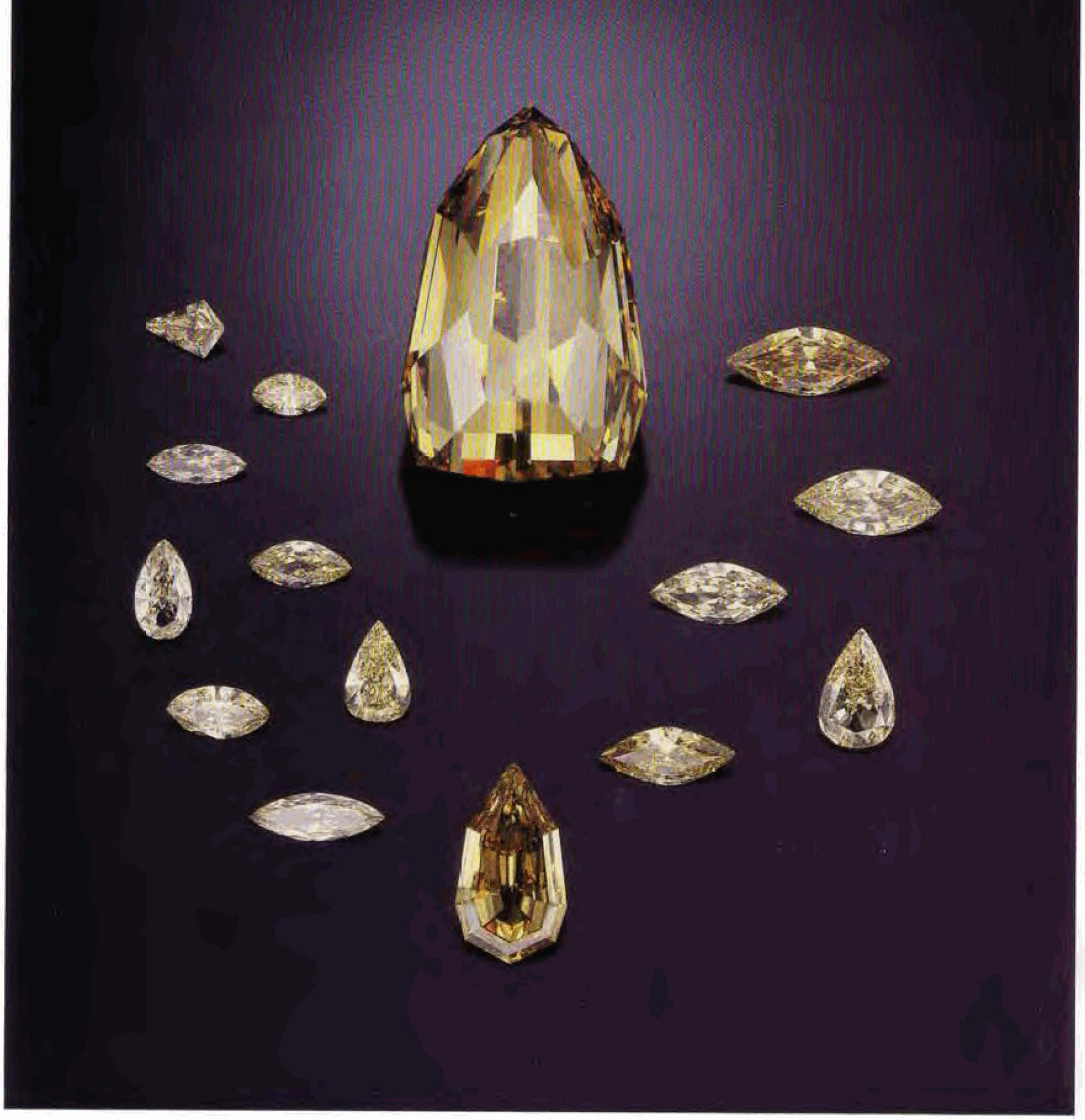


Figure 13. This 407.48-ct internally flawless diamond, the second largest diamond in the world (after the 530.20-ct Cullinan I), was offered at auction by Christie's New York on October 19, 1988 – ironically, one year to the day after the stock market crash of 1987. Even though the bidding reached $12,000,000, the stone was withdrawn. This and the satellite stones, which range from 1.33 ct to 15.66 ct, were faceted from an 890-ct piece of rough jointly owned by Marvin Samuels, Louis Glick, and the Zale Corp. Photo by Tino Hammid; courtesy of Christie's New York.

At the time that the Australian discoveries were made, India was developing as a major diamond-cutting center. The low labor costs in India and the specialization in small stones fit perfectly with the type of production Australia is offering the marketplace in the 1980s (figure 15). Concurrently, there has been a great expansion of retailing formats in mass merchandising throughout the world that has provided a broad market outlet for inexpensive, mass-produced diamond jewelry. Near-gem quality diamonds can now be affordably cut by labor-intensive India and developing Far East cutting operations, and sold at prices that attract a wider range of consumers.

Possible sanctions in the U.S. on the importation and sale of diamonds from South Africa (Comprehensive Anti-Apartheid Act of October 2, 1986) pose yet another apparent threat to the diamond industry. Because South Africa now contributes just about 10% of the world's total supply of rough diamonds by weight (though a higher percentage in gem qualities and in value terms) and the U.S. now accounts for only a little more than a third of world diamond consumption, it is doubtful that such sanctions would have a crippling effect on the diamond industry as a whole; they would, however, inevitably have an impact on the U.S. market and on U.S. sightholders in particular. Ironically, diamonds now contribute less than 3% of South Africa's total earnings from minerals, whereas Botswana, for example, earns 78% of its foreign exchange from diamonds (Oppenheimer, 1988).

Despite record sales for the CSO in 1987 and in the first half of 1988, stocks of uncut diamonds outside CSO control are still at moderate levels, although rising. In addition, prices of polished diamonds are relatively stable and increasing at a realistic pace. Supply appears to be in balance with demand. Japan's thirst for diamonds, however, has

WORLD DIAMOND PRODUCTION

Over 90 million carats of rough diamonds (gem and industrial) were mined worldwide in 1987 (see table 1); almost 90 years ago—in 1901—world diamond production was only about 1 million carats. Total production (in carats) has doubled over the last decade alone. About 40% of the rough yields cuttable qualities, half of which is considered gem, the other half near gem. In terms of total rough mined, the top four countries today are Australia, Zaire, Botswana, and the USSR. Each now surpasses the leader of decades past, South Africa. Several other areas are also active (see map).

Although the Argyle mine has given Australia the lead in total rough production today, for the most part the stones are small, with only about 5% of gem quality and 40%–45% considered near gem. Of the gem-quality crystals, many are browns and most are very difficult to cut because of the typically serrated and knotted nature of the rough. The first Australian production, in the early 1980s, was alluvial. The AK-1 pipe became fully operational in December 1985, and production since then has leaped from about 7 million carats in 1985 to 30 million carats in 1987, where projections indicate that annual output should level off. Australia is currently the world's major source of pink diamonds.

Zaire produces about 20 million carats of rough each year, mostly of industrial quality. For over 30 years, until 1986, Zaire was the world's largest producer of diamonds. Like Australia, only about 5% of Zaire's production is gem quality; 20%–25% is considered near gem. Zaire discontinued its 14-year exclusive selling contract with the CSO in 1981, only to negotiate a new one in 1983; this agreement has since been extended.

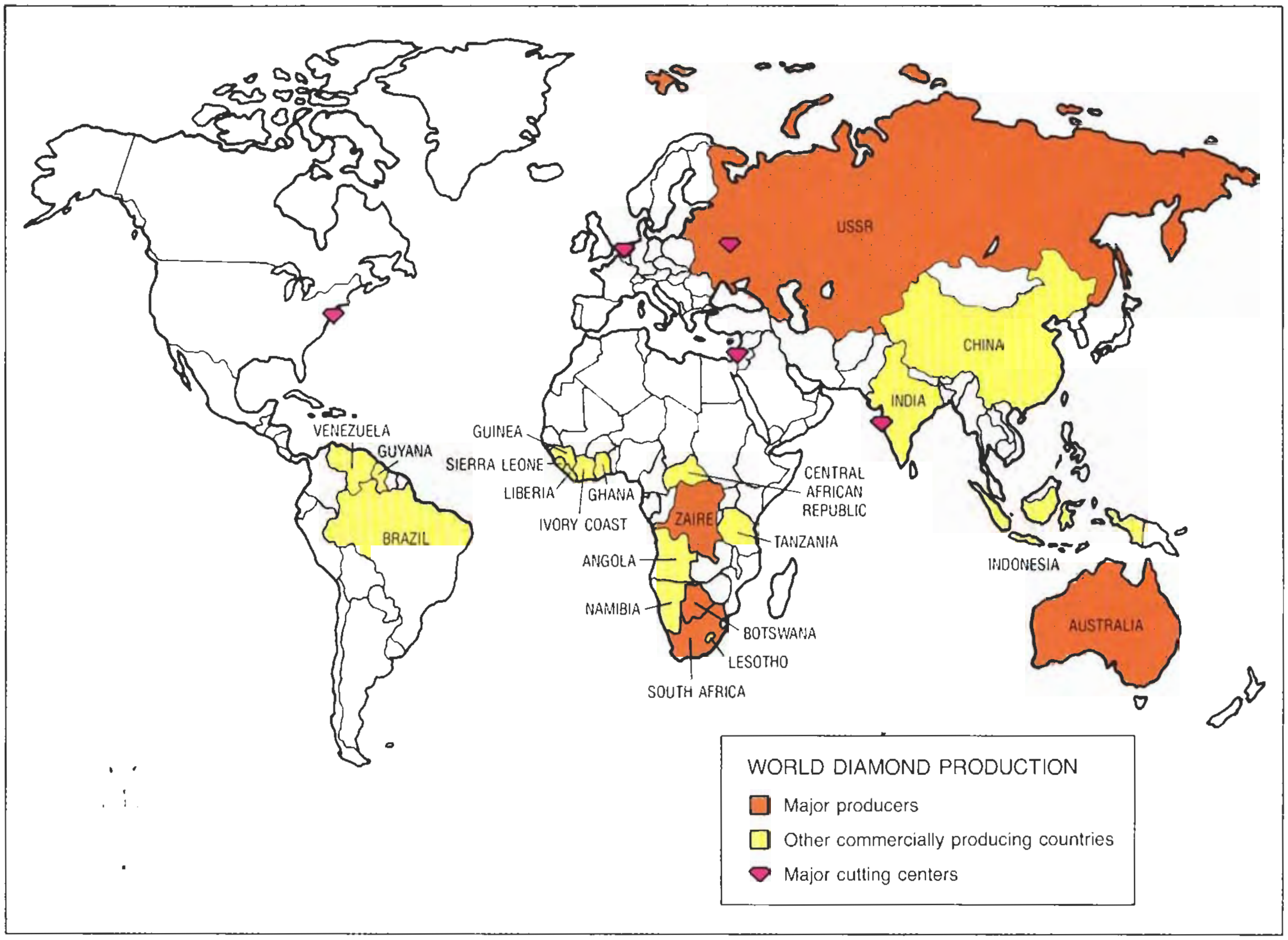
According to a July 2, 1987, press release issued by De Beers, Botswana—with its three mines of Orapa, Letlhakane, and Jwaneng—has, over the past decade, become one of the most significant diamond producers in value terms. More than half of the over 13 million carats of rough mined in Botswana in 1987 is cuttable. Jwaneng alone, which came into full production in 1982, yields over 7 million carats of rough per year. In terms of quantity, quality, and value, it is the most important mine to have gone into production in the past 100 years (Prins, 1987). To put the quality of Botswana's yield into perspective, this tiny country produces some $700 million of diamond rough per year—about three times more than the income earned by Argyle (Gibson, 1988).

Production is handled through a partnership between the Botswana government and De Beers known as Debswana. This 1987 agreement was a major achievement for both parties. According to the press release mentioned above, De Beers acquired the balance of Botswana's stockpile of diamonds, which accumulated during the 1981–1985 recessionary period, in exchange for 20 million newly issued ordinary shares of stock holdings in De Beers (which makes Botswana the company's third largest shareholder), an undisclosed cash payment, and two seats on the De Beers board. The Debswana agreement gave De Beers the supplies of rough necessary to meet rising diamond demand in the late 1980s (bringing De Beers's current diamond reserves to a total value of $2.3 billion), and gave Botswana an important interest in De Beers.

The major source of Soviet diamonds is in Siberia, where an estimated 12 million carats of rough was mined in 1987. The Soviet Union also has a substantial cutting industry that has become increasingly important during the past 15 years because of the quantity, quality, and uniformity of their polished goods.

Although most people probably believe that South Africa is the major source of diamonds today, it is now only fifth in total production by weight. However, nearly half of the 10 million carats South Africa produces annually are cuttable. Having selectively closed some mines in South Africa during the 1981–1985 recession, De Beers recently reactivated Annex Kleinzee ("Diamonds 1988") and Koffiefontein (Moyersoen, 1987), in response to improved market conditions and, in particular, the strong recovery of demand for large, fine-quality stones.

The Consolidated Diamond Mines (CDM) in Namibia once produced close to 2 million carats of rough diamonds annually, 95% of which were gem quality. This production has been dwindling over the last decade, to about 1 million carats in 1987.



Diamonds are found on virtually every continent, yet five countries contribute over 90% of the total production: Australia, Zaire, Botswana, the USSR, and South Africa (indicated in orange). Several other countries (indicated in yellow) produce small amounts of diamonds, totaling only 10% of world production. Each of the five major countries in which cutting centers are located—the U.S., Belgium, Israel, India, and the USSR—is indicated by a red diamond. Artwork by Robin Teraoka.

Mining is accomplished on raised beach terraces (in effect, ancient alluvial deposits) through the use of heavy earth-moving equipment and dredges. According to Ogilvie Thompson (1988), CDM No. 3 plant was recently reopened and modifications to the CDM No. 1 plant, for improved recovery, are well advanced.

Diamonds are also mined in smaller quantities in Brazil, Ghana, the Central African Republic, Indonesia, Sierra Leone, Liberia, Venezuela, the Ivory Coast, Angola, Tanzania, Guinea, India, Guyana, Lesotho, as well as China. Although production statistics for China are not available, the total production from these countries does not contribute even 10% of the total world rough mined each year.

Just as world diamond production has changed markedly over the past decade, so, too, have the centers that manufacture rough around the globe. Today, stones are cut in over 30 different countries, although the U.S. (New York City), Belgium (Antwerp), Israel (Tel Aviv), India (Bombay), and the USSR (Kiev, Moscow, Sverdlovsk, and Mirny) support the bulk of the business. Other noteworthy cutting centers are located in South Africa, Brazil, China, Sri Lanka, North and East Africa, Thailand, and elsewhere throughout Southeast Asia and the Far East (Prins, 1987).

Figure 14. The Jwaneng mine in Botswana is the most important diamond mine—in terms of quality and value—to have been brought into production during the last 100 years. This aerial view shows the vast open pit. Photo courtesy of the CSO.

created larger inventories of cut stones in that country than ever before. Although CSO officials attempt to closely monitor these stocks, there is some industry concern that excess inventories could be "dumped" on the market in the event of a downturn in the Japanese economy.

The concept of a futures market for diamond has been resurrected in the second half of the 1980s. Previously attempted by the Pacific Stock Exchange in the 1970s, and considered by the Chicago Mercantile Exchange, the London Commodity Exchange, and, most recently, by the New York Commodity Exchange (Comex), the development of a commodities market for diamond is another of the variables that could greatly affect the supply of fine-quality goods in the marketplace. Most in the trade are skeptical that a diamond futures market could succeed. Moreover, it would inevitably alter the traditional perception of diamond purely as an item of adornment and an expression of love, to one possessing the additional factors of hedging, speculation, and investment.

Demand and the Marketplace: A Case for Confidence. It is clear that world economic forces strongly influence the demand for diamond, since demand closely follows the worldwide business cycle. Among the more important factors to watch in the near future are the levels of disposable income and the real interest rates in the two major consuming markets, the United States and Japan. However, a number of other factors contribute to a case for optimism in the global diamond markets.

Consumer confidence in the value of diamond is rising again, and consumer demand for diamonds as objects of love and adornment is at an all-time high. With stock market uncertainty, there is also a renewed interest in tangible assets. This is especially strong in Japan, where recent changes in the tax laws provide further momentum for consumer spending. The self-purchase market (big and growing in the U.S.) is already bigger in Japan (Keith Ives, CSO, pers. comm., 1988); as Japanese women play an increasingly important role in the work force, their impact on the diamond market will also grow.

The strength of other currencies against the U.S. dollar, especially in Europe and the Pacific Rim, is also stimulating demand. Market activity in Hong Kong, Taiwan, and Singapore is particularly strong today. Unlike the speculative boom of the late 1970s, however, this latest fever appears to be mostly a product of actual consumer demand.

Retail jewelry markets in the U.S. continue to show overall growth (again, see figure 8), and worldwide demand at retail is rising. According to Ogilvie Thompson (1988), for each of the last five

Figure 15. Only 5% of the diamonds mined at Argyle are gem quality; 40%–45% are near gem. Most are brownish and small. The low labor costs in India and other emerging Far East cutting centers have made manufacturing near-gem material economically feasible. Photo by Brian Stevenson; courtesy of Argyle Mines Pty., Ltd.

years world retail sales of diamond jewelry established new records, principally as a result of increased consumer confidence and spending. Over $30 billion in diamond jewelry was sold in 1987, containing close to 300 million diamonds. Retail diamond sales in the U.S. alone were over $11.3 billion in 1987 (up 15% over 1986 levels), with over 19.8 million pieces of diamond jewelry sold ("Consumer Confidence in Diamonds High," 1988). De Beers's continued heavy promotion to consumers in some 28 countries worldwide further strengthens a view for confidence in diamond in at least the near future. There is consistent growth in the traditional market in the United States, where 66% of married women in the 25–44 age group and the top one-third income group expressed a strong interest in giving/receiving diamond jewelry (Ives, 1988); this is the highest percentage in history. Assuming that disposable incomes will rise in other consuming nations and in developing countries such as South Korea and perhaps even China, and that the diamond industry can attract some of that disposable income, worldwide demand should continue to grow. The diamond trade has had three good years in a row (1986–1988), and most firms are not overextended with the banks (by design) as in years past, which fosters even more confidence.

There are, however, a number of events in the global economy and in that of Japan in particular that could produce either excess supply or reduced demand. The *Rapaport Diamond Report* (April 29, 1988) points to "external economic forces such as a dramatic fall in the Japanese stock market, or a sharp drop in the yen" as possible scenarios that "could cause a collapse [in diamond demand]." A world recession would also undoubtedly reduce demand at all levels. Still, the diamond industry does appear to be in a better position to respond to such forces, if they should occur.

New Technology. Although it may not be obvious how scientific challenges can affect the economics of the diamond industry, the mere mention of synthetic gem diamonds is usually enough to upset any dealer. High technology will surely play a role in the diamond business in the 1990s and beyond.

Three major technological challenges now face the diamond industry: sophisticated color treatments, fracture-filling, and the availability of gem-quality synthetic diamonds. The treatment of diamond by heat and/or irradiation to induce or change color has created detection problems for gemologists worldwide. Identification of these sophisticated color treatments has already inspired extensive research (e.g., Walker, 1979; Collins, 1982) and is the subject of a major project that is now under way at GIA. The "filling" of cleavages and fractures to reduce their visibility in heavily flawed stones poses another challenge for the industry (Koivula, 1987).

Figure 16. Synthetic gem-quality diamonds may represent the most important technological development in the diamond world this century. These two faceted synthetic diamonds (0.30 ct and 0.27 ct) and their 1.03-ct-companion crystal were grown by De Beers for experimental purposes. Photo © Tino Hammid.

The greatest potential technological challenge, however, is that of gem-quality synthetic diamonds (see, e.g., Koivula and Fryer, 1984; Shigley et al., 1986 and 1987). Although not marketed specifically for the jewelry industry, small gem-quality yellow synthetic diamond rough can now be purchased from Sumitomo Corp. of Japan. In the course of its research, and for experimental purposes only, De Beers has grown gem-quality yellow synthetic diamonds as large as 11 ct (figure 16). Although the procedure continues to be expensive, the rising costs of natural diamonds could make the distribution of synthetic diamonds for jewelry, rather than purely industrial and technological purposes, an attractive option. All types of synthetic diamonds examined to date, however, can be readily identified by standard gemological tests.

The science of gemology must secure the knowledge necessary to insure stability in the marketplace, because public confidence in diamond is the key to its long-term success. The trade also needs more information and more absolute standards, such as the scientific nomenclature for grading fancy color diamonds that is currently a subject of research at GIA. Accurate information with standardized terminology, presented honestly, will help the industry because the consumer will be better equipped to buy diamonds confidently.

CONCLUSION

Economic forces have buffeted the diamond industry for much of the past decade. The unusually high demand generated by Israeli diamantaires (backed by low-interest/low-risk loans from the government-supported banking system) was further escalated by the heightened interest in investing in diamonds as a commodity during the inflationary spiral of 1976–1979. What started in Israel in 1976 ended in the U.S. and Europe in 1980. Higher interest rates from the banks, surcharges and sharp price increases by the CSO, and the onset of a world recession worked together to curb demand at both dealer and consumer levels. The diamond market plunged.

In the early 1980s, many manufacturers and dealers went out of business, as the large quantities of stones hoarded during the upward climb could not be absorbed by an already-saturated market. To help correct this imbalance in supply and demand, the CSO began to restrict the supply of specific categories of new diamonds that entered the system. Gradually, excess goods were absorbed at the consumer level and, by 1985, most of this stock had been disposed of. Despite the problems at the diamantaire level from 1980 to 1985, there were healthy increases in worldwide retail sales during most of this period. By 1986, the industry was feeling the full impact of the attractiveness of diamonds to a growing Japanese market as the U.S. dollar weakened against the yen. The diamond market rebounded.

Today, demand for diamonds is strong and prices are rising. Supplies of rough are healthy, but supply and demand appear to be in balance. The fact that diamond prices have continued to rise following the worldwide plummet in stock prices in October 1987 is further evidence of the strength of diamonds in the late 1980s.

The key to success in the 1990s and beyond, however, will be the ability of the diamond industry – the CSO, diamantaires, and retailers alike – to anticipate, and prepare for, the future. The appeal of diamond as an object of love and adornment continued strong throughout the past decade. The fact that so many Japanese women are now wearing diamond engagement rings indicates that the romance of diamond is still a major demand factor. This is echoed by the continued strength of diamonds at the retail level in the U.S. However, further changes in currency exchange rates, especially a weaker Japanese yen, would undoubtedly have some impact. Too, the economies of the developed nations worldwide have been very healthy in recent years. A recession of any duration, as in the early 1980s, would also affect demand for diamonds. Technology is another factor that undoubtedly will have an impact on the industry, but this will be minimized if the technology of gem identification can keep pace with the technology of treatments and synthesis.

The diamond industry has weathered the radical fluctuations of the past decade well. Every indication is that it will be able to face future challenges even more efficiently and effectively. As standards of living internationally continue to rise, as De Beers continues to promote to old and new markets alike, as supplies continue to be strong, the future for the diamond industry does indeed appear bright.

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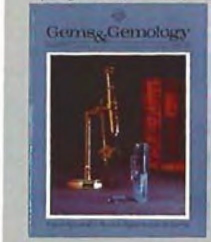

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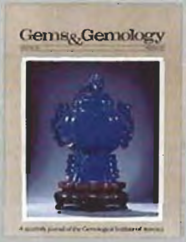

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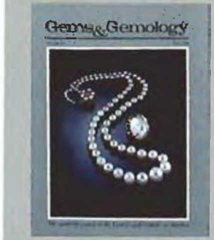

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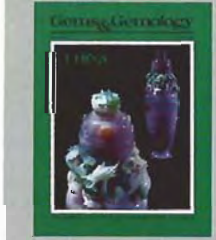

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NOTES
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NEW TECHNIQUES

THE SAPPHIRES OF PENGLAI, HAINAN ISLAND, CHINA

By Wang Furui

The sapphire deposit at Penglai, on Hainan Island, is potentially the largest in China. Gem-quality sapphires, at least one as large as 35.5 ct, have been found in alluvial gravels approximately 2 km southeast of the city of Penglai. Gem-quality zircon and a few pieces of what might be considered ruby have also been recovered in the course of the geologic study of this area, which has not yet been commercially developed. The average size of the sapphires is 2–5 mm. They are similar in appearance and gemological properties to sapphires from Australia, Thailand, and Kampuchea.

Sapphire is one of the greatest potential gem resources in China today. To date, several major occurrences have been identified, including Mingxi, Liuhe, and Jiangsu Province. However, the deposit at Penglai, on Hainan Island in Guangdong Province, appears to be the most promising (figure 1). Although the Penglai sapphire deposit is still in the exploration stage, local government and Bureau of Geology officials feel that it will develop into a major gem field. Already, gem dealers from abroad are coming to Penglai to buy sapphires.

During the spring of 1987, the author had the opportunity to visit and study the sapphire deposit at Penglai. The information provided in this article is based on the author's observations during this visit, as well as on interviews with Penglai residents, various geologists, and members of the local government.

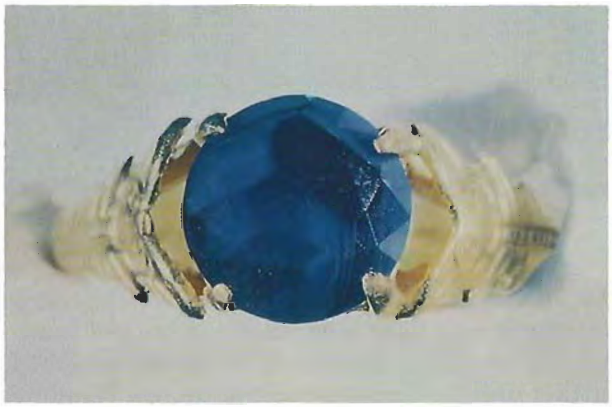

Figure 1. This 2.60-ct faceted blue sapphire is from the deposit near Penglai, on Hainan Island, People's Republic of China.

HISTORY

Sapphires were first discovered by a farmer named Zhang Changde (figure 2) near the town of Penglai in the early 1960s. He found a beautiful stone on

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Acknowledgments: Robert E. Kane, of the GIA Gem Trade Laboratory in Los Angeles, kindly provided the gemological information in table 1 and the photomicrographs.

Figure 2. Farmer Zhang Changde, who was the first to discover sapphire near Penglai, continues to search the alluvium for these valuable gemstones.

the ground near where his animals were grazing. The stone was light blue, transparent, and luminous in sunlight. He picked it up and searched further until he found more blue stones. Handing them over to the local geologic team, he received one yuan and sixty fens (approximately US$1.00) as a reward. In 1982, a special exploration team was sent to the area to determine the extent of the gem field.

LOCATION AND ACCESS

The Penglai mine lies approximately 2 km southeast of the town of Penglai, 30 km southwest of Wenchang, in the northeast part of Hainan Island. Access to Penglai requires a three-hour bus ride from Haikou, the capital of the island (figure 3). Although vehicles can easily reach the mining area during the dry season, heavy rains can make the roads impassable. The mine field covers about 25 km^2 in an area near the villages of Gaojin and Xinan.

The town of Penglai is an important hub in Hainan Island, with more than 40,000 inhabitants. The climate in this area is tropical, with considerable rainfall, and rice paddies represent the dominant agriculture. Penglai is famous for pineapples and produces much natural rubber and pepper.

GEOLOGY AND OCCURRENCE

Detailed geologic study of the new mine field is still being done by a geologic team. The region's tropical climate has led to deep chemical weathering and massive erosion. Rock outcrops of any type are very rare, and the sapphires have been found only in alluvial gravels in the rice paddies and on nearby hillsides.

By examining the composition of the alluvium in which the sapphires have been found, geologists have determined that alkali basalt is the basic rock unit, with more than 10 alluvial strata of various thicknesses (Shi Guihua and Li Zhaosong, pers. comm, 1987). The basalt consists mainly of olivine basalt, dolerite, and pyroclastics, of Cenozoic age. The gravels also contain abundant pyrope garnet, black spinel, pyroxene, olivine, and zircon. A few pieces that might be considered ruby have also been recovered.

Field exploration indicates that the sapphire deposits extend to a depth of 1.5–3 m and are scattered in several layers. The sapphire occurrences in this area are similar to the sapphire deposits in Chanthaburi, Thailand (Keller, 1982), the New England district of New South Wales, Australia (Coldham, 1985), and the Mingxi beds in Fujian Province, China (Keller and Keller, 1986). These areas are also deeply weathered and have similar mineral associations. The corundum is either alluvial or eluvial.

MINING AND PROCESSING

Although the deposit has not been extensively developed thus far, the geologic team has dug a number of trenches 30 × 15 m and up to 3 m deep, from which specimens of sapphire and other gems have been gathered. In addition, local residents sporadically dig for the gemstones in their fields, in ditches, and on the hillside. After a heavy rain, farmers and even government personnel go to the fields to look for gemstones. To process the gem gravels removed by the geologic team, a facility has been set up at the western edge of the mining area, next to the road. First, the gem gravel is poured into a pool and washed. The large pieces are removed by hand, while the smaller gravels are sieved with a mesh and the fine sand is thrown away. Next, the smaller pieces are placed on a driving belt which carries them to a big trough in which they are sorted into several different sizes by means of different meshes (in a manner similar to that used at the Mingxi sapphire deposit, described by Keller and Keller, 1986). Last, the various groups of gravels are sent to a separation room, where the gemstones are removed from the gravels by hand.

DESCRIPTION OF THE GEM MATERIALS

The Penglai sapphires occur as small- to medium-sized hexagonal prisms and irregularly shaped pieces. The average size observed is 2–5 mm, although the geologic team working the deposit reports that gem-quality pieces as large as 35 × 33 × 32 mm (35.5 ct) have been found.

The sapphires range in color (in order of abundance) from dark blue (figures 1 and 4), blue, and greenish blue, to bluish green, green, and yellow-green, with the smallest quantity found in

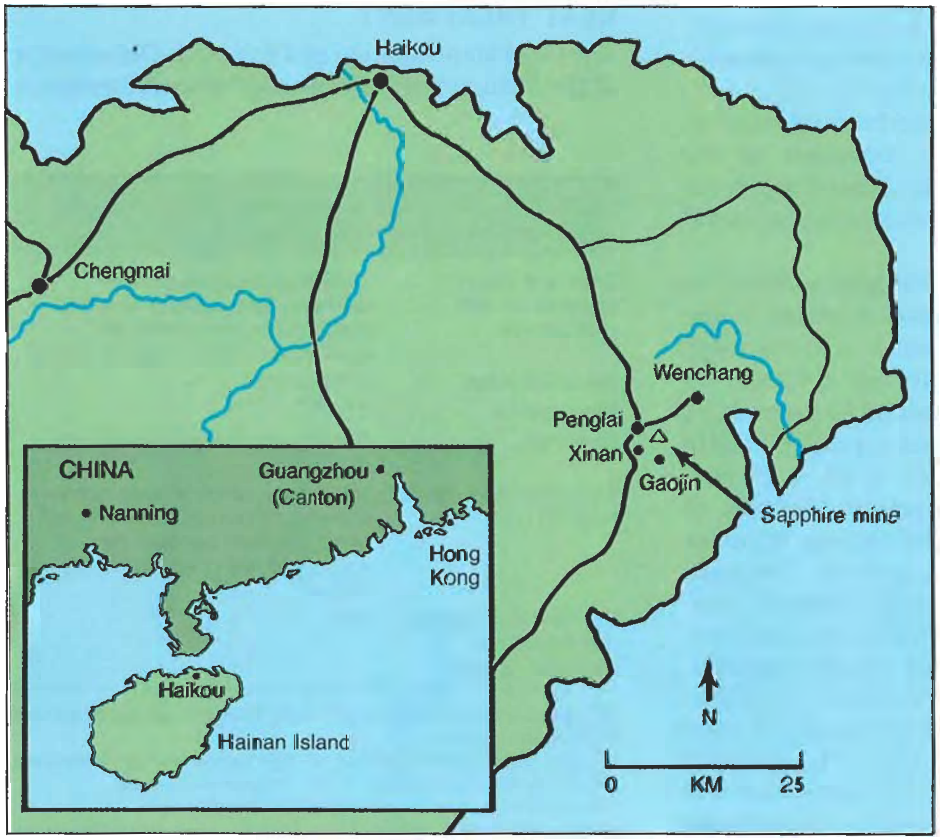

Figure 3. The Penglai sapphire deposits cover an area approximately 25 km² that begins about 2 km southeast of the town of Penglai. Artwork by Peter Johnston.

Figure 4. This dark blue sapphire crystal found at Penglai weighs 13.69 ct. Photo by Shane McClure.

light bluish green and purplish blue to blue-gray. Most of the sapphires are very dark and appear to contain large amounts of iron (Fe^{3+}).

Although no statistics have been released on the production to date, the consensus of the geologic community is that the Penglai sapphires are superior in quality and quantity to those found at Mingxi.

Zircon is another important gem material in this deposit. It appears to equal sapphire in the number of pieces found, although most of these pieces are smaller than the average observed for sapphires. The largest zircon found to date at this deposit, a brown-red tetragonal crystal (partially gem quality) that measures 42 × 20 × 12 mm (41.8 ct), is now at the Geological Museum of China, in Beijing. The Penglai zircons occur in purple, purple-red, brown-red, and red. The commercial potential of the zircons is limited, however, because most of the stones are very small and even the larger ones are usually heavily included.

Government geologist Shi Guihua reports that small amounts of what might be considered ruby have also been found at Penglai. The rounded pieces examined to date are approximately 2–3 mm and "rose" red. Unfortunately, insufficient material is available to draw any conclusions about the potential of the deposit for this variety of corundum.

GEMOLOGICAL PROPERTIES

I was able to obtain seven gem-quality sapphires from the Penglai mine for examination. Although four were small, three weighed in the 10–15 ct range. Tests on these seven crystals, which ranged in color from purplish blue to blue-gray, revealed a specific gravity of 3.99–4.02, a refractive index of 1.761–1.769, and strong pleochroism. These properties are very similar to those reported for gem corundum found in Australia, Thailand, and Kampuchea. The properties for the 13.69-ct crystal shown in figure 4, as determined by Robert Kane of the GIA Gem Trade Laboratory in Los Angeles, are given in table 1. When Mr. Kane examined this stone for inclusions he found very strong color zoning and dense concentrations of "silk" (both in a hexagonal arrangement following the original crystallographic growth of the sapphire crystal), as evidenced in figure 5. There are also two distinctive types of solid crystal inclusions, illustrated here in figures 6 and 7.

HEAT TREATMENT

The Gem Identification and Research Department of the Ministry of Geology and Mineral Resources

TABLE 1. Gemological properties of a sapphire from Penglai, Hainan Island, China.[a]

Color and visual appearance with unaided eye	Dark blue, nearly opaque in overhead light; areas of blue and bluish green, transparent to semitransparent in transmitted light[b]
Refractive index	1.762–1.771
Birefringence	0.009
Dichroism	Distinct yellowish green and dark blue
Absorption spectrum[c] (400–700 nm)	Very strong bands at approximately 450 and 460 nm that nearly merge, and a separate narrower band of strong intensity at approximately 470 nm
Reaction to long-wave and short-wave ultraviolet radiation	Inert

[a] *Properties listed were obtained from one 13.69-ct rough crystal with two large polished faces.*

[b] *Degree of transparency as well as color appearance is dramatically affected by the rough surfaces of the partly polished crystal.*

[c] *As observed through a hand-held type of spectroscope.*

Figure 5. A view of the base of the Penglai blue sapphire crystal shown in figure 4 (after it had been partially polished) reveals prominent angular growth zoning as well as "fingerprints" and stringers of rutile "comet tails." The growth zoning, evidence of the changes that took place in the chemical environment as the sapphire crystal grew, represents a combination of color zoning and varied concentrations of fine particles of rutile. Fiber-optic illumination; magnified 15×. Photomicrograph by Robert E. Kane.

Figure 6. The Penglai blue sapphire shown in figure 4 also contained a small brown crystal surrounded by a tension halo and trailed by a "comet tail." Oblique illumination; magnified 40×. Photomicrograph by Robert E. Kane.

Figure 7. This white crystal, set against a backdrop of dense rutile particles and color zoning, was also observed in the Penglai blue sapphire shown in figure 4. Oblique illumination; magnified 40×. Photomicrograph by Robert E. Kane.

and the Laboratory of the Bureau of Geology and Mineral Resources in Guangdong Province have been experimenting with heat treatment to lighten these sapphires. Both laboratories obtained favorable results. On October 10, 1986, the newspaper *China Geology* reported that "the treated sapphires acquired a good medium indigo-blue color, good transparency, and generally were free of color banding. The chemical and physical characteristics of the treated sapphires are the same as the untreated sapphires." No precise details of the heat treatment method used have been revealed to date.

PROSPECTS FOR THE FUTURE

Current operations at the Penglai mine are mainly for exploration and research. However, the Bureau of Geology and local government officials hope to establish an economic operation, including mining, treatment, faceting, and selling, in the near future. Chinese gemologists are enthusiastic about the results of prospecting efforts and the heat treatment of the gems.

For the Penglai mine to achieve its potential, I believe that a regular mining effort is needed. Efficient mining methods, such as a high-power water cannon to break up the alluvial material, would help increase production. The future prospects for sapphire (and zircon) mining at Penglai appear to be excellent.

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CONGRATULATIONS!

The following readers received a perfect score (100%) on the second annual *Gems & Gemology* Challenge, which appeared in the Spring 1988 issue.

Joseph N. Autore, West Paterson, NJ; Bernice Backler, Pinetown, South Africa; Linda Anne Bateley, Kent, England; Rebecca Ann Bell, Joshua Tree, CA; Ernesto J. Belmont-Moreno, Mexico City, Mexico; Maria Lourdes Berre, Coral Gables, FL; Susan Bickford, San Francisco, CA; Linda Blum-Barton, Aiken, SC; R. F. Brightman, Fraser, Queensland, Australia; Arline E. Broad, Thames, New Zealand; Kim L. Brown, Overland Park, KS; Patricia A. Brozovic, Fairfax, VA; John Patrick Bugara, São José Dos Campos, S.P., Brazil; Ned Burns, Phoenix, AZ; Richard H. Cartier, Toronto, Ont., Canada; JoAnne Chisholm, Thornhill, Ont., Canada; Alice J. Christianson, St. Catharines, Ont., Canada; Yale Chussil, West Hartford, CT; Peggy Sue Clark, Bethesda, MD; Ron Conde, Santa Monica, CA; Fontaine F. Cope, Lamesa, TX; Patricia Corbett, Toronto, Ont., Canada; Robert Cotellesse, Cibolo, TX; Elizabeth Cressey-Plummer, Tucson, AZ; Florence May Davenport, West Paterson, NJ; Ellen J. Dean, Cambridge, England; Shane Denney, Jacksonville, IL; Mario Detrano, Canton, OH; Don Devenney, Victoria, B.C., Canada; Lorraine D. Dodds, Greensboro, NC; J. H. Eigenbauch, York, PA; Sandra Rose Engeberg, Los Angeles, CA; Michael T. Evans, Huntington Beach, CA; Ed Fasnacht, Logansport, IN; Roberto Filippi, Lucca, Italy; Danielle M. Finney, Palm Springs, CA; Wayne Neal Fleischer, Oxnard, CA; John R. Fuhrbach, Amarillo, TX; Rhoda Gheen, Foster, OR; Raymond Giroux, Dollard Des Ormeaux, Que., Canada; Elaine A. Gregory, Choctaw, OK; Sharon Griffith, Eagan, MN; Phyllis M. Gunn, Spokane, WA; Loreen N. Haas, Sherman Oaks, CA; Brian Halawith, Phoenix, AZ; William D. Hannah, Louisville, KY; Joop G. Heetman, Rotterdam, Netherlands; Graziella Hess, Marina del Rey, CA; Harold E. Holzer, Cape Coral, FL; Robert P. Hord, Laguna Park, TX; Alan R. Howarth, Braintree, MA; R. Fred Ingram, Tampa, FL; Mary Margaret Jackson, Dallas, TX; Michael A. Jaegel, Mountain Home, AR; Joyce G. Jessen, Western Springs, IL; Chris Johnson, Capistrano Beach, CA; Felicitas Johnson, Boulder Creek, CA; Mark. A. Kaufman, San Diego, CA; Elmer E. Kitchell, Tulsa, OK; Neil A. Kitzmiller, Columbus OH; Helen Klages, Orlando, FL; Kay Koeppel, Green Bay, WI; Charles M. Koslow, Phoenix, AZ; Jim J. Kovacs, Dartmouth, N.S., Canada; Peggy J. Kramer, Austin, TX; Don O. Kuehn, New Braunfels, TX; Ingrid Langdon, Corpus Christi, TX; Richard Larson, Drummond, MT; Bert J. Last, Sydney, N.S.W., Australia; Robert S. LeFevre, Jr., Virginia Beach, VA; Sandra MacKenzie-Graham, Burlingame, CA; Brent Malgarin, Bellevue, WA; Janet Rae Malgarin, Bellevue, WA; George F. Martin, Woodstock, VT; Warner J. May, Ozark, AL; Brenda Meier, Victoria, B.C., Canada; Daniel Meier, Victoria, B.C., Canada; Betty Sue Melton, Macomb, IL; Paul B. Merkel, Rochester, NY; Grenville Millington, Birmingham, England; Richard Moreno, Calabasas, CA; Richard L. Murray, Santa Clara, CA; Morris D. Neuman, Atlanta, GA; Ben Nibert, Mission, TX; Mary Olsen, Salt Lake City, UT; Mary D. O'Mara, Quincy, MA; Mark Osborn, Bothell, WA; James O'Sullivan, Boca Raton, FL; Philip L. Papeman, Chico, CA; Carole S. Parker, Portland, OR; Graeme Petersen, Wellington, New Zealand; Mike Peterson, Santa Monica, CA; Mary M. Poche, New Orleans, LA; Janice A. Prudhoe, Paris, France; Renee M. Pypiak, Monmouth Junction, NJ; Elizabeth L. Ralls, Spokane, WA; Michael W. Rinehart, Walnut Creek, CA; Morton Samson, New Haven, CT; Vora Sarju, Los Angeles, CA; Jack Schatzley, Toledo, OH; Pinchas Schechter, Miami Beach, FL; David A. Schultz, New York, NY; Corey Lee Shaughnessy, Sun City, AZ; Kathleen A. Smith, Toronto, Ont., Canada; Peter R. Stadelmeier, Levittown, PA; John Stennett, Temple, TX; John R. Swallow, Stratford, NJ; J. Brian Swirk, Kansas City, MO; Milan Tankosic, St. Catherines, Ont., Canada; Alice Rhodes Thie, Mediapolis, IA; Blair Tredwell, Advance, NC; Starla Turner, Redwood City, CA; Bruce William Upperman, Decatur, IL; Barbara J. Wallace, Lynnwood, WA; Joe C. Weng, Capitola, CA; P. A. Westrich, St. Louis, MO; Joseph R. White, Bessemer, AL; Colleen Witthoeft-Nayuki, Montreal, Que., Canada; Charles C. F. Yen, Taipei, Taiwan; Geraldine M. Zwack, San Francisco, CA.

Answers to the *Gems & Gemology* Challenge (see pp. 54 and 56 of the Spring 1988 issue for the questions) are as follows: (1) C, (2) C, (3) C, (4) C, (5) D, (6) A, (7) A, (8) D, (9) D, (10) C, (11) C, (12) A, (13) B, (14) B, (15) D, (16) C, (17) B, (18) D, (19) D, (20) B, (21) B, (22) A, (23) C, (24) D, (25) D.

Once again, the response to the Challenge was excellent. Congratulations also to the literally hundreds who received a passing grade on the exam. For those of you who were reluctant to try this time (and those who did), we will offer another opportunity (covering the 1988 issues) in the Spring 1989 issue.

A GEM-QUALITY IRIDESCENT ORTHOAMPHIBOLE FROM WYOMING

By R. V. Dietrich, John Sampson White, Joseph E. Nelen, and Kwo-Ling Chyi

A gem-quality iridescent orthoamphibole from Wyoming, similar to that described from Greenland, has been identified. This ornamental material occurs in a weathered gneiss-schist, near its contact with a peridotite mass. Most of the individual iridescent grains that constitute this rock are golden or dark brown, but a few are rose red or silvery gray. They consist principally of goethite and/or opaline silica, which probably was derived directly from the original ferroanthophyllite as a result of weathering. Economic amounts of this material are not available at this time, although it is likely that the deposit has the potential to produce significant quantities.

Appel and Jensen's 1987 *Gems & Gemology* article on an "iridescent orthoamphibole" from Greenland reminded one of us (RVD) of a rock specimen and some cabochons (NMNH #120539) of Wyoming origin that were sent to the U.S. National Museum of Natural History (Smithsonian Institution) in the early 1960s. In 1987, we obtained additional hand specimens from this same locality. In total, three cabochons and six hand specimens, together with a couple of thin sections and several grain-mounts made from those specimens, were studied for this report (figure 1).*

All specimens are from exposures about 11 miles (18 km) southwest of Douglas, in Converse County, Wyoming. Currently, there is little, if any, of the gem-quality material still exposed, but there may be significant amounts underground. If our hypothesized origin for the gem-quality material is correct, however, it probably occurs only in the upper few feet or, at maximum, few tens of feet of bedrock. In any case, additional material could probably be collected with permission of the owner of the mineral rights, whose identity can be found by consulting records in the office of the county clerk in Douglas (R. B. Berry, pers. comm., 1987).

GEOLOGIC SKETCH

Mr. R. B. Berry, who collected and supplied us with the specimens studied, noted that the rock occurs as irregular masses within a weathered gneiss-schist, near its contact with a peridotite mass. This concurs with the geologic data of George L. Snyder, of the U.S. Geological Survey, who has mapped within the region (part of the Precambrian [Late Archean] metamorphic terrain of the northern Laramie Mountains). After examining one of our study specimens, Snyder wrote that he has seen similar amphibole-rich rocks associated with both amphibolite-grade iron-formation and calc-silicate rock in the Laramie Mountains. In addition, he suggested that "an iron-formation or a very impure carbonate rock may have been the metasedimentary wallrock progenitor that the reported peridotite intruded" (pers. comm., 1987).

DESCRIPTION

Like the iridescent orthoamphibole from Greenland, the material we examined (figure 2) is far from homogeneous. Rather, it consists for the most part of diversely oriented, nearly equidimensional amphibole(±) grains that average about 1 cm across. Although most of the grains are golden or dark brown in color, a few are rose red; nearly all are iridescent (figures 1 and 3). A few sporadic silvery gray iridescent grains are also evident in some of the polished pieces (again, see figure 1).

The "amphibole(±)" designation is given be-

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R. V. Dietrich is professor emeritus of geology at Central Michigan University, Mt. Pleasant, Michigan; J. S. White is curator-in-charge of gems and minerals, and J. E. Nelen is chemist, at the U.S. National Museum, Washington, DC; and K.-L. Chyi is assistant professor of geology at Central Michigan University.

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* *After this report was submitted to* Gems & Gemology, *a similar-appearing material was sent to the GIA Gem Trade Laboratory by Mr. Bill Martinek, of Martinek Jewelers, Traverse City, Michigan, for identification. Chemical analyses by energy-dispersive X-ray fluorescence (performed by Carol Stockton, of the GIA Research Department), proved that this material—also purportedly from Wyoming (V. Hobe, pers. comm., 1988)—was the same as that we examined. A photo of Mr. Martinek's specimen is included here as well (figure 3).*

Figure 1. These are two of the cabochons of iridescent orthoamphibole from Wyoming that were examined for this report. The larger stone is 0.6 × 2.5 cm. Note especially the variety of colors in which the iridescent grains may appear. The larger specimen is courtesy of the U.S. National Museum of Natural History; photo by Robert Weldon.

cause the individual grains range from partially to completely dissociated to a mixture of goethite and opaline silica. The rock also contains small percentages of a few other minerals. The most common is garnet, which occurs as small grains, most of which are 0.1–0.2 mm across. Some of these garnet grains are discrete, whereas others constitute irregular aggregates that typically include 20 to 50 grains. Quartz veins, dense black goethite veins, and fracture surface coatings of white calcite are also common.

Some cabochons fashioned from this rock exhibit extremely attractive hologram-like effects. That is, some of the grains seem to be floating in an overall dark brown milieu.

GEMOLOGICAL AND OTHER PROPERTIES

Because this gem material is a rock rather than a mineral, gemological properties of practical use differ from those usually reported. Essentially, they consist of data for individual mineral constituents rather than for the material as a whole; these data are given in the succeeding paragraphs of this section. Furthermore, because of the variability of constituents, the density (usually reported as specific gravity) is not given here. For this rock, as for many mixtures of minerals, the density varies over so wide a range that it is of little significance. In fact, two essentially identical appearing specimens of this rock may have specific gravities that differ by as much as 0.5 in larger samples to 1.5 in smaller pieces.

None of this material fluoresces when exposed to long-wave ultraviolet radiation. It does, however, exhibit a dull, hardly detectable, orange to rusty red fluorescence to short-wave U.V.

Optical examinations indicate that the Wyoming rock once consisted largely of an orthorhombic amphibole (biaxial, (+), R.I.$-\gamma = 1.667$; the small size and discoloration of the individual units of pure amphibole precluded determination of the lower α and β refractive indices). Today, nearly all of the grains contain noteworthy percentages of goethite and opaline silica, and some are essentially all goethite and opal. The different phases occur as interdigitated mixtures with interrelations that resemble those exhibited by microperthites usually termed mesoperthites with shadow textures (see, for example, figures 19-2 and 19-17 in Smith, 1974). Typically, elongate masses of goethite and opal are essentially parallel to the *c* crystallographic axes of the original amphibole grains. As viewed through a microscope, the goethite is golden to rusty brown in color, and is essentially opaque; the opacity makes determination of definitive optical properties impossible. The opal is optically isotropic and has a refractive index of 1.422 ± 0.001, which indicates that it probably has a relatively high H_2O content.

X-ray powder diffraction patterns corroborate the optical data. The amphibole generates good peaks, from which we calculated the following cell dimensions (in angstroms): $\underline{a} = 18.82(5)$, $\underline{b} = 18.23(7)$, $\underline{c} = 5.29(1)$. (These dimensions were calculated by a least-squares refinement of nine indexed peaks; Charles W. Burnham's LCLSQ-MARK VI program was used.) This cell is significantly larger than that recorded by Appel and Jensen (1987) for the orthoamphibole from Greenland. The major goethite peaks from the Wyoming material—those with d(I) values of 4.18(100) and 2.69(30)—are distinct. We have observed no reflections that can be attributed to the opaline silica; however, the likelihood of its presence is indicated by, and probably responsible for, the rather high background present on X-ray patterns of the other minerals and mineral combinations.

Microprobe analyses[**] indicate that the Wyoming amphibole is ferroanthophyllite with the approximate formula $(Fe_{6.23}Mn_{0.42}Mg_{0.35})Si_8O_{22}(OH)_2$, but also containing minor Al(0.02–0.97 wt.% Al_2O_3), Ca(0.29–1.12 wt.% CaO), K(0.01–0.11 wt.% K_2O), Na(0.03–0.25 wt.% Na_2O), and Ti(0.06–0.11 wt.% TiO_2). This composition contrasts in several ways with the range of compositions recorded by Appel and Jensen (1987) for the Greenland orthoamphibole: $Na_{0.17}(Mg,Fe)_{6.3}Al_{0.7}(Al_{0.9}Si_{7.1})O_{22}(OH)_2$ to $Na_{0.29}(Mg,Fe)_{6.3}Al_{0.7}(Al_{1.0}Si_{7.0})O_{22}(OH)_2$. For the record, microprobe analyses indicate the garnets in the Wyoming material to be Ca-bearing almandine-spessartine. Their composition is approximately $(Fe_{1.41}Mn_{1.09}Ca_{0.50})Al_2(SiO_4)_3$ with 0.66–1.17 wt.% MgO, 0.0–0.04 wt.% K_2O, 0.04–0.07 wt.% Na_2O, and 0.05–0.09 wt.% TiO_2.

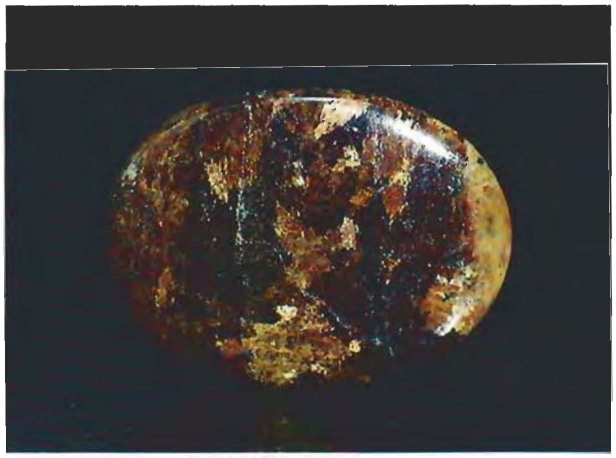
Microprobe reconnaissance traverses across the composite amphibole(±) grains corroborate the optical data. That is, they show that these grains comprise thin (submicroscopic to about 0.1 mm) bands of hairlike domains that consist primarily of iron and silica in near-ferroanthophyllite proportions, with alternate bands having excess amounts of either iron (goethite) or silica (opal) or both, plus a few bands that are almost wholly silica.

Figure 2. Unlike the material from Greenland, the iridescence of the Wyoming amphibole(±) rock is exhibited well in some hand specimens. Longest dimension is 9.5 cm (approximately 3³/₄ in.). Photo by Robert Weldon.

CAUSE OF THE IRIDESCENCE

The iridescence of this gem material appears to depend on diffraction of light by the intricate, more or less parallel arrangement of the extremely small masses of the diverse constituents of the amphibole(±). The alternative that it might depend on

Figure 3. Typically, most of the grains in the iridescent orthoamphibole from Wyoming are golden or dark brown. Specimen (1.1 × 2.4 cm) courtesy of Bill Martinek, Martinek Jewelers; photo by Robert Weldon.



[**] *ARL-SEMQ with six fixed spectrometers (Si, Al, Fe, Mg, Ca, and K) and three scanning spectrometers, which were tuned for Ti, Mn, and Na; operating voltage—15kV, sample current—0.025 μamp on brass; all analyses were done with a focused beam and corrected for matrix effects using a Bence-Albee correction program; on-peak backgrounds were measured on corundum for Si and on quartz for other elements. Hornblende from Kakanui, New Zealand (NMNH #143965) was the primary standard used for amphibole analyses, and garnet from the Roberts Victor Mine, South Africa (NMNH #87375) was the primary standard used for garnet analyses (see Jarosewich et al., 1980).*

the presence of opal can be ruled out. Not only are most of the constituent masses of opal extremely small, but the silica spheres that constitute the opal also lack a regular arrangement such as that responsible for the diffraction of light that causes play-of-color in gem opal.

ORIGIN OF THE BANDING

The interrelationships among the mineral constituents indicate that the goethite and opal were very likely derived directly from the original ferroanthophyllite. The dissociation could have been a two-step process that involved, for example, a breakdown of the ferroanthophyllite to quartz and olivine, plus or minus magnetite, at elevated temperatures and pressures (Gilbert et al., 1982), followed by processes that resulted in the alteration of those minerals to the opaline silica plus goethite. We consider it more likely, however, that the dissociation was direct, that is, that the ferroanthophyllite was converted into opaline silica plus goethite, probably in response to near-surface, low-temperature/low-pressure weathering and weathering-associated processes. Geologic relations and considerations, along with the occurrence of ferroanthophyllite grains that are only partially dissociated close to grains that are largely opaline silica and goethite, have led us to this conclusion.

This possible derivation of goethite and silica – opal, in this case – as the result of the breakdown of an amphibole raised another question: Could some tiger's-eye consist of goethite and quartz derived as the result of a similar breakdown of its precursor asbestiform amphibole? In seeking a tentative answer to this question, we examined several tiger's-eye specimens. We found that some do indeed consist of alternate fibers of goethite and silica (quartz) rather than almost wholly of silica (quartz), as usually reported. Thus, it would seem that different tiger's-eye materials may be of different origins, and that some may be the result of an alteration similar to that hypothesized for the Wyoming material described in this article.

SUMMARY AND CONCLUSIONS

The gem material described herein was collected near Douglas, in Converse County, Wyoming. It is an altered amphibole-rich rock now made up largely of diversely oriented grains comprising intimately intermixed lamellae or hair-like units of goethite and opal plus or minus some of the original amphibole (ferroanthophyllite). The alteration is probably a result of weathering or weathering-associated processes. While this material is somewhat similar in appearance to the iridescent amphibole reported from Greenland, there are a number of differences in diffraction patterns and chemical composition.

The Wyoming rock has been cut and polished to make attractive cabochons that are predominantly golden to dark brown, with some of the stones also containing sporadic grains that are rose red or silvery gray. Grains of each of the colors are typically iridescent. The diffraction of light responsible for the iridescence appears to be caused by the extremely thin bands and/or hair-like masses of the constituent goethite and opal plus or minus the original ferroanthophyllite.

The amount of this material still available for recovery can only be guessed. Based on the hypothesized origin, we think that it may be significant, although it is very likely restricted to the relatively thin zone of weathering.

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DETECTION OF TREATMENT IN TWO UNUSUAL GREEN DIAMONDS

By Emmanuel Fritsch, James E. Shigley, Carol M. Stockton, and John I. Koivula

A pair of sharp absorption bands in the near-infrared region, referred to as H1b and H1c, have been detected in one (and the H1b band in the other) of two green diamonds known to have been treated. Until now, these bands have been associated with the annealing of yellow to brown laboratory-irradiated diamonds. This is the first reported observation of these bands in green treated diamonds. Although these two diamonds may represent a special case, in that they are believed to have been irradiated, annealed, and then re-irradiated, the presence of one or both of these bands in a green diamond is one of the few reliable characteristics that identify that the stone has been treated in a laboratory.

Distinguishing diamonds of natural color from those colored by treatment is one of the greatest challenges facing the gemologist today (see, e.g., Collins, 1982; Nassau, 1984), and green diamonds present some of the most serious difficulties. This arises from the fact that the green color in diamond is usually the result of irradiation only (whether in nature or in the laboratory), while most of the gemological criteria used to separate natural- from treated-color diamonds are based on features related to the annealing step in the treatment process. Recently, it was reported that two sharp bands in the near-infrared region (referred to as H1b and H1c) are characteristic of annealing of laboratory-irradiated type Ia diamonds in the yellow to brown range (Woods, 1984; Woods and Collins, 1986). This article is the first report of the observation of the H1b and H1c lines in treated green diamonds (figure 1).

BACKGROUND

Green coloration is produced in diamonds when high-energy radiation (e.g., electrons, neutrons, gamma or alpha rays, etc.) removes carbon atoms from their original positions in the diamond crystal structure, thereby creating vacancies (called the GR1 [General Radiation] center, with a sharp absorption band at 741 nm). These vacancies absorb light in the red portion of the spectrum. Inasmuch as most nitrogen-containing diamonds already absorb in the violet end of the spectrum, this leaves a transmission "window" in the green. The GR1 center can be created by irradiation either in nature or in the laboratory. Thus, its presence is not proof of laboratory treatment.

Gemologists have used various criteria in the past to separate natural- from treated-color green diamonds. Recent observations have shown these criteria to be wrong in some cases, although they may be correct in others.

Specifically, many gemologists have noted that treated green diamonds commonly have an unattractive brownish or grayish ("olive" or "tourmaline") green hue, in contrast to the purer, more attractive green of the natural stones (G. R. Crowningshield, 1957 and pers. comm., 1987). In 1957, Crowningshield stated that "unless green *naturals* are present on a dark-green diamond . . . few dealers today accept as natural any dark-green stones." At that time, dark green in diamonds was associated with treatment, and only the few pale green stones with green naturals encountered were believed to be of natural color. Today, however, it appears that more light green stones are available on the market. This may be due to the fact that treaters are currently using electron and other irradiation technologies which may produce a greater proportion of stones that are light green, as compared to the darker green associated with the older method of treatment in a nuclear reactor

ABOUT THE AUTHORS

Dr. Fritsch is research scientist, Dr. Shigley is director of research, and Ms. Stockton is former senior research gemologist in the Research Department of the Gemological Institute of America, Santa Monica, California. Mr. Koivula is chief gemologist at GIA, Santa Monica.

Acknowledgments: The authors are indebted to Mr. Marcus Fuchs, president of Chromagem, Inc., for the loan of the treated green diamonds.

Figure 1. The two treated green diamonds described in this article weigh 0.17 ct (left) and 0.19 ct (right). Photo by Robert Weldon.

(R. T. Liddicoat, pers. comm., 1988). In the course of our study of colored diamonds, we have observed sufficient overlap in color between the two groups to suggest that color alone is not a reliable separation criterion.

In addition, except for cases of cyclotron and radium treatment (see, e.g., Nassau, 1984), where the green color is concentrated in lines or spots, the color of treated green diamonds is generally homogeneous throughout the stone. This is not always the case for natural diamonds (some of which have only a green outer "skin"). Again, though, this characteristic cannot serve as conclusive evidence.

Green or brown spots, thought to be the result of α-radiation bombardment (Vance and Milledge, 1972), may also be present on the surface of a natural green diamond crystal. Called "irradiation stains" by gemologists, they are sometimes observed at the girdle or culet of a faceted stone, close to the original surface of the diamond. To our knowledge, they cannot be induced by laboratory irradiation (except by exposure to radium salts, a process that is easy to detect because of the remnant radioactivity). Therefore, these spots have suggested to some gemologists that the green body color of the diamond is also of natural origin. However, some near-colorless diamonds also have (natural) brown or green irradiation stains, and these stones, too, may be turned green by irradiation in the laboratory.

The presence of a prominent 595-nm absorption line (traditionally called the "5920"), first reported by Dugdale (1953), has been associated with the treatment of yellow diamonds (Crowningshield, 1957). In some rare cases, this line has even been observed in the spectra of treated green diamonds (G. R. Crowningshield, pers. comm., 1988). However, this line has been observed in a number of natural-color diamonds as well, including some green stones (Crowningshield, 1957; Anderson, 1963; Scarratt, 1979; Cottrant and Calas, 1981; Collins, 1982; Guo et al., 1986). From these observations on color, color distribution, irradiation stains, and spectral bands, one can readily understand why it may be difficult to determine whether the color in a diamond is natural or the result of treatment.

However, a breakthrough in the separation of some natural-color from treated-color diamonds was achieved recently (Woods, 1984; Woods and Collins, 1986; Collins et al., 1986). In particular, two sharp absorption bands in the near-infrared region at about 4935 cm^{-1} (2026 nm) and 5165 cm^{-1} (1936 nm), called respectively H1b and H1c, have been associated with the annealing of known laboratory-irradiated type Ia diamonds in the yellow to brown color range. Neither band has ever been observed in natural-color diamonds. We report here the first observation of either of these infrared bands in green diamonds known to be treated (as stated by M. Fuchs, pers. comm., 1987).

MATERIALS AND METHODS

The treated diamonds loaned to us for study are two dark grayish green round brilliants that weigh 0.17 and 0.19 ct (figure 1). The optical absorption spectra of the two stones were obtained with a Pye-Unicam 8800 spectrophotometer (at low temperature, 120K) as well as a Beck prism spectroscope mounted on a GIA GEM Instruments spectroscope base. The infrared absorption data were obtained with a Nicolet 60SX Fourier Transform infrared spectrometer, covering the energy range from 400 to 25,000 cm^{-1} (see Fritsch and Stockton, 1987, for more details on this instrument).

RESULTS

The gemological properties of the two stones are summarized in table 1, but they are not sufficient to provide a useful conclusion. The color of each of these stones falls within the range that has been observed for treated green diamonds (as mentioned above). The larger stone displays an internal planar brown graining and an otherwise homogeneous green body color (figure 2), which suggests that this stone was brownish before irradiation. The smaller stone does not exhibit such colored graining. The optical absorption spectra of both stones (as observed with the Pye-Unicam 8800) display a strong to moderate GR1 (figure 3), a moderate 595 nm, and moderate H3 (503 nm) and H4 (496 nm) lines (which are sometimes referred to collectively by gemologists as the "4980–5040 pair"). Both stones are "green transmitters"; that is, they fluoresce green to a concentrated beam of visible light transmitted through the stone. This property has been noted in natural and treated diamonds of various colors, and our observations suggest that it is associated with the defect that gives rise to the H3 band. The near-infrared spectrum shows a weak but definite H1b band for the larger stone, and moderately intense, sharp, H1b and H1c bands for the smaller one (figure 4). Both are type Ia diamonds (containing aggregated nitrogen atoms).

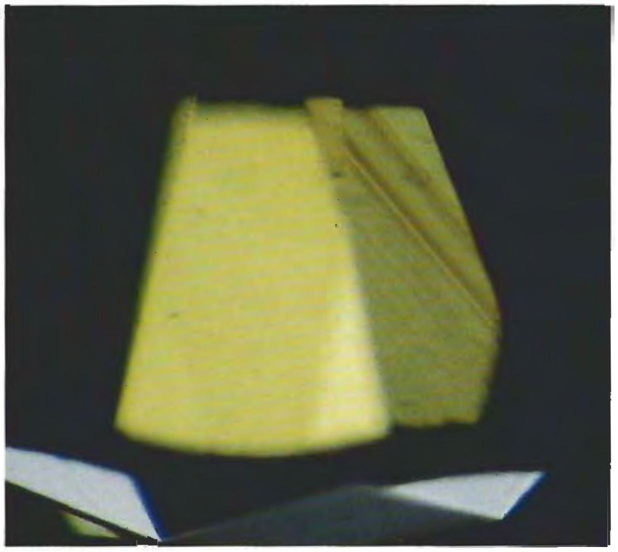

Figure 2. Brown planar graining in the otherwise homogeneous green 0.19-ct diamond indicates that the stone was brownish in color before it was irradiated. Magnified 10×; photomicrograph by John Koivula.

TABLE 1. Gemological and spectral properties of the two treated dark grayish green diamonds.

Property	0.19 ct stone	0.17 ct stone
Gemological		
Fluorescence to U.V. radiation:		
Long-wave	Strong yellowish green	Weak green
Short-wave	Very weak green	Very weak green
Fluorescence to transmitted visible light	Strong green	Moderate to strong bluish green
Internal graining	Moderate to strong brown planar	None observed
Optical absorption spectrum, hand spectroscope (nm)	Moderate sharp 496–503 nm, weak sharp 595	Strong 415, weak 478, moderate sharp 496–503
Advanced Spectroscopy		
Low-temperature optical absorption spectrum (nm)	Moderate 496 (H4) and 503 (H3), moderate 595, strong 741 (GR1)	Moderate 415, weak 478, moderate sharp 496 (H4) and 503 (H3), weak 595, moderate 741 (GR1)
Type	IaA + B (moderate nitrogen content)	IaA + B (high nitrogen content)
Near-infrared absorption	H1b	H1b, H1c

DISCUSSION AND CONCLUSION

Woods and Collins (1986) demonstrated that the H1b and H1c bands are related to the intense annealing (at least 650°–700°C) of irradiated diamonds. Thus, it is most unexpected to find these bands in green diamonds, because the green color usually is changed to yellow by such annealing. Although Mr. Fuchs does not know the exact details of the treatment these stones received, he indicated that it is likely that they were originally irradiated and heat treated in an attempt to get a "canary" yellow color; then, when the new color was deemed unsatisfactory, the stones were subsequently re-irradiated to green. So far, there has been no evidence of the H1b and/or H1c lines appearing in any colored diamonds other than

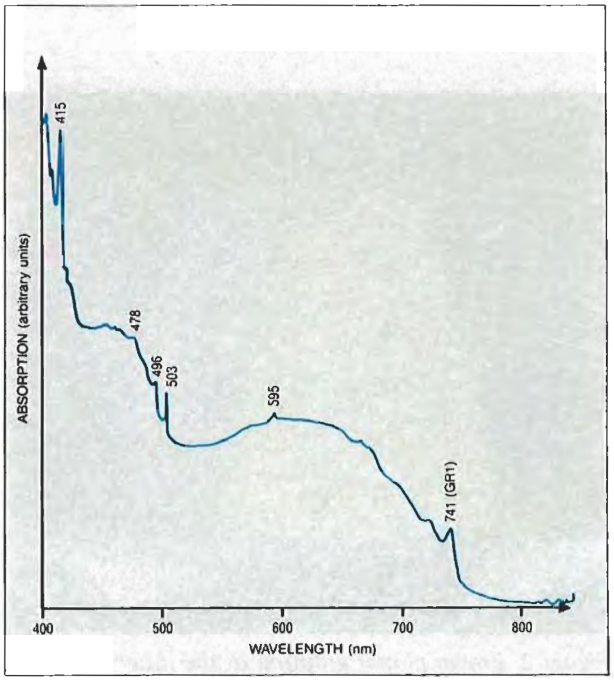

Figure 3. This optical absorption spectrum of the 0.17-ct treated green diamond was taken at 120 K (−243°F).

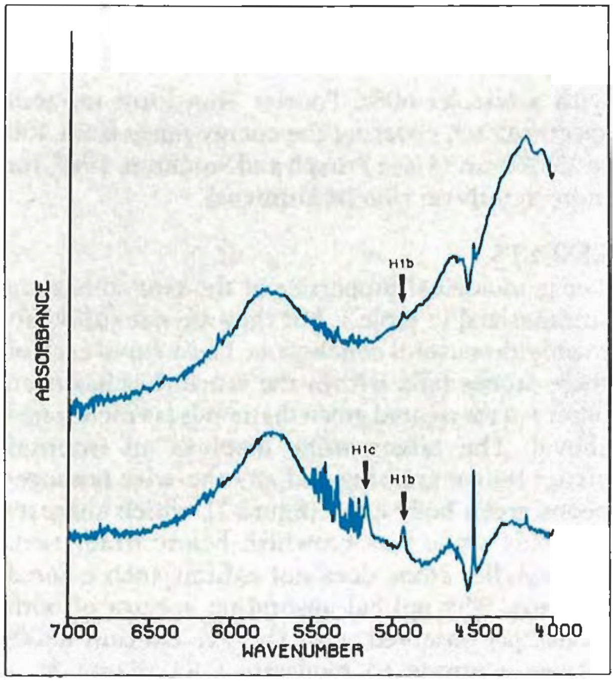

Figure 4. The near-infrared absorption spectra of the two treated diamonds (top = 0.19 ct stone, bottom = 0.17 ct stone) show the presence of the H1b and H1c lines (arrows).

those treated in a laboratory. Thus, the observation of the H1b and/or H1c lines seems to be one of the few reliable means at this time to identify treatment in a green diamond, although it may be applicable only in rare instances as represented by the two stones we studied.

Note added in proof: Shortly after the H1b and/or H1c bands were observed in the two treated green diamonds discussed here, we observed these bands in another green diamond, which had been submitted to the East Coast Gem Trade Laboratory. This 0.58-ct grayish yellow-green stone exhibited a strong green fluorescence to transmitted light, a greenish yellow fluorescence to ultraviolet radiation, a weak 595-nm line in the visible range, and both the H1b and H1c lines in the near infrared. We concluded, therefore, that the green color of the stone was the result of treatment.

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Gem Trade LAB NOTES

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Unusual Inclusions in a Synthetic ALEXANDRITE

The West Coast laboratory recently examined a 3-ct stone with a very distinct change of color from green with purplish overtones in fluorescent light (daylight equivalent) to reddish purple in incandescent light. Because of its strong red fluorescence (strong red to long-wave and slightly weaker red to short-wave U.V.), this stone displayed the "oily" appearance frequently seen in synthetic alexandrites. These and other standard gemological tests indicated that it was synthetic alexandrite.

This stone, however, did not contain the flux inclusions that we commonly see in most synthetic alexandrites. Rather, minute, white-appearing pinpoint inclusions were scattered throughout. In addition, there were a few transparent rounded crystals with high relief (figure 1). Since we had not encountered these types of inclusion in synthetic alexandrites before, we asked the GIA Research Department to examine the stone by infrared spectroscopy. The spectrum obtained matched that of synthetic flux-grown alexandrites, thus proving the identity of the stone. The identity of the inclusions in this stone could not be ascertained. *KH*

Figure 1. The transparent rounded crystals seen in this 3-ct flux-grown synthetic alexandrite are very unusual for this material. Magnified 45×.

Dyed Spangled AMBER

Although the Gem Trade Laboratory occasionally encounters "spangled" amber, we had never before seen spangled amber that was dyed both red and green in the same piece. Although the result is quite striking (figure 2), it in no way appears natural.

Figure 2. This bracelet is set with dyed "spangled" amber.

The spangling procedure is quite simple: First, the amber is heated in oil until cracks ("spangles") appear, and then dye is drawn into the spangles. In the material we examined, some of the spangles contain red dye while others contain green; some even contain both colors (figure 3). Perhaps the dyeing process was halted prematurely, so that some fissures were only partially filled with one color; then the process was resumed, using a different color to fill the rest of the spangles.

David Hargett

Figure 3. Some of the stress cracks in the "spangled" amber shown in figure 2 are dyed both red and green. Magnified 15×.

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

AUGITE, Chinese "Onyx"

The West Coast laboratory recently tested three opaque black stones that had been purchased in China, where they were represented as Chinese "onyx." On all three stones, the base was cabochon cut, while the top was faceted like the crown of an oval brilliant cut (figure 4). The stones were well polished, showing a very high luster.

Figure 4. This 1.5-ct augite was purchased in China as Chinese "onyx."

Unlike dyed chalcedony "onyx," which in some cases may transmit some light and may even reveal parallel banding when examined with a strong transmitted light source (such as a fiber-optic illuminator), these black stones were completely opaque. Therefore, we were limited in the testing methods we could use. The refractive index was determined on the Duplex II refractometer to be 1.702–1.728, and the specific gravity was estimated with heavy liquids to be approximately 3.35. Although these properties suggested augite, we used X-ray diffraction analysis to prove the identity. The pattern obtained did indeed match that of the mineral augite, a type of monoclinic pyroxene that is common in igneous rocks. *KH*

CALCAREOUS CONCRETION

Our West Coast laboratory received another unusual nacreless concretion for examination. The translucent, white, oval-shaped concretion (approximately 10 × 8 × 7 mm) showed a sheen-like effect over its entire surface. Also, at one end it had a prominent conchiolin spot. When the stone was examined with low magnification, we readily noted the alveolar (honeycomb) structure that is frequently seen in concretions from various mollusks. Figure 5 shows both this structure and the conchiolin spot. Unfortunately, we were not able to determine which clam or oyster produced this particular concretion. *KH*

Figure 5. This calcareous concretion (10 × 8 × 7 mm) shows the honeycomb structure typical of this material, as well as a conchiolin spot on the end.

DIAMONDS, Treated green

The West Coast laboratory recently examined the three green round brilliant-cut diamonds illustrated in figure 6. Although all were reported to be treated, each exhibited distinct gemological properties. Because so little has appeared in the literature on the gemological properties of treated green diamonds, we are reporting the findings on these three stones below.

When the 0.93-ct dark green diamond was placed table down over a strong light source, we observed a strong blue transmission luminescence. Using a Beck prism spectroscope on a GIA GEM Instruments base, we examined the visible spectrum (400–700 nm) both at room temperature and with the stone cooled by an aerosol refrigerant. In both cases, we observed a Cape series of moderate intensity, with lines located at 415.5, 423, 435, 452, 465, and 478.5 nm.

Exposure to long-wave ultraviolet radiation produced a slightly chalky blue fluorescence of moderate intensity. When the radiation was turned off, there was a very weak yellow phosphorescence. Short-wave U.V. produced a similar, but weaker reaction.

Examination with magnification in diffused lighting revealed faint geometric color zoning. Observation with polarized light showed a strong mottled strain pattern, which correlated with the color zoning.

Using the same techniques described above, we observed a strong bluish green transmission (with more blue in some areas) in the 1.02-ct dark yellowish green stone. Examination of the spectrum at room temperature revealed a strong 415.5-nm line, general absorption up to about 490, a strong pair of lines at 498/504, and a strong 594-nm line, proving treatment. Cooling caused the spectral features to be stronger and sharper.

Long-wave U.V. radiation revealed a strong, very slightly greenish yellow fluorescence, followed by a very weak yellow phosphorescence. Short-wave U.V. produced a moderate chalky green-yellow fluorescence and a very weak yellow phosphorescence. No distinct color zoning was seen with magnification under diffused lighting. A weak radial strain pattern near the center of the stone was observed with polarized light.

The 0.45-ct dark blue-green diamond had no transmission luminescence, other than a hazy colorless transmission that is often referred to as the "cathedral" effect. This stone showed no lines or bands at all in the spectrum at room temperature, with just a suggestion of a very weak smudge centered at 500 nm when cooled.

The stone fluoresced a very

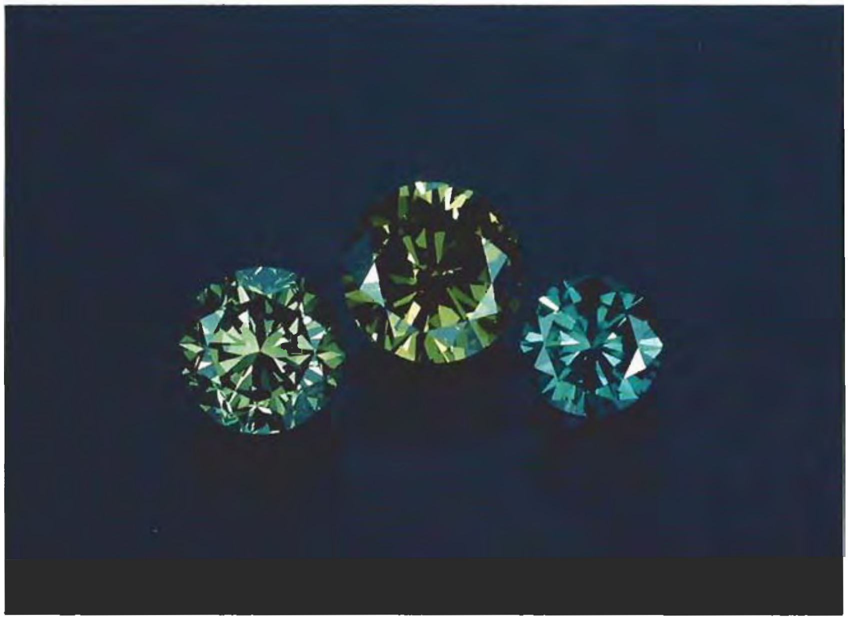


Figure 6. Each of the treated green diamonds shown here—weighing, from left to right, 0.93 ct, 1.02 ct, and 0.45 ct—revealed different gemological properties.

weak, slightly chalky, greenish blue to long-wave U.V., with no phosphorescence. Exposure to short-wave U.V. produced an even weaker reaction, but with a similar color.

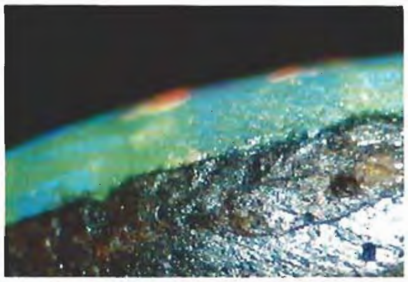
The microscope revealed surface graining on both the crown and the pavilion, and a fairly even coloration to diffused lighting. Polarized light showed a strong mottled strain pattern. Because of the strong blue component to the color, this diamond was tested for electrical conductivity; it was found to be nonconductive. *RK*

Assembled Ironstone OPAL

A black opal is usually submitted to the lab with the request that we determine whether the stone is natural or treated color, or an assembled stone. If the stone is assembled, the backing is commonly attached to the top with a black cement; the separation plane is frequently flat, so that the two pieces can be joined smoothly. Natural opals, however, almost always have a wavy or uneven interface between the more transparent top and the potch or ironstone matrix on the bottom. In fact, careful observation will often reveal areas of the natural potch or matrix back that grow up into (sometimes even through) the more transparent top.

The East Coast laboratory recently examined an opal triplet with an uneven, wavy separation plane. The uneven surface of the top, natural material was reasonably flat. The ironstone backing was joined to this surface with a cement that was carefully tinted to duplicate the color and appearance of the ironstone, as seen in figure 7. This cement filled the uneven contact surface of the opal top, so that the stone appeared to be one piece, not assembled. It should also be noted that the joining material melted when lightly touched with the thermal reaction tester. *David Hargett*

Figure 7. The contact surface of the opal top on this 1.73-ct opal triplet was left uneven, and then the cement layer was dyed the same color as the ironstone backing in an attempt to disguise the fact that it is an assembled stone. Magnified 45×.



Opaline "ROCK"

A very interesting 5-ct oval cabochon, represented to be "golden jade," came into the West Coast laboratory for identification. The staff was told that this material came from a deposit in Wyoming, and it resembles the material described in this issue by Dietrich et al. (see figure 3, p. 163). Microscopic examination revealed that the material consisted primarily of yellow iridescent grains that were quite irregular in shape. These grains seemed to form a pattern resembling the mosaic appearance commonly seen in opal.

We were able to determine one vague refractive index of 1.44 and another that appeared to be over the limit (1.81) of the refractometer. There was a decided variability in the surface luster from almost metallic to vitreous. While testing for specific gravity in the heavy liquids, we noticed that the stone remained almost suspended in the 2.57 liquid, but one end was consistently heavier than the other end. All of these observations indicated that the material was a rock consisting of two or more different minerals.

An EDXRF chemical analysis performed by the GIA Research Department showed appreciable Si and Fe, with lesser amounts of Mn and Ca. An X-ray diffraction pattern from material in the heavier end (as indicated by the specific gravity test) showed that goethite and hematite were present. Another from the lighter end of the cabochon revealed a spessartite garnet pattern. We concluded that the stone is a rock consisting primarily of opal with goethite and hematite present throughout the stone. Except for the hematite, this is consistent with the findings reported by Dietrich et al. (pp. 161–164 of this issue). *KH*

South Seas Cultured PEARL

The West Coast laboratory recently received for identification the 13.25 × 14.65 mm cultured pearl shown in figure 8, which has very good color and luster. Figure 9 shows the large area of conchiolin that was deposited in one spot on the nucleus and thus caused the ovoid shape. Notice also the thick nacre (2.5 mm) that is typical of growth in the warmer waters of the South Seas. Figure 10, looking directly down the end of the pearl, shows how the orientation of the X-ray beam can affect the appearance of the radiograph; the conchiolin is much less apparent in this view than in figure 9.

Figure 8. This ovoid South Seas–type cultured pearl, which measures 13.25 × 14.65 mm, has good color and luster.

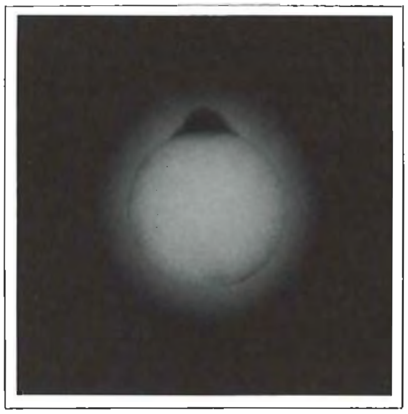


Figure 9. The thickness of the nacre layer and the conchiolin spot responsible for the out-of-round growth are evident in this X-radiograph of the cultured pearl shown in figure 8.

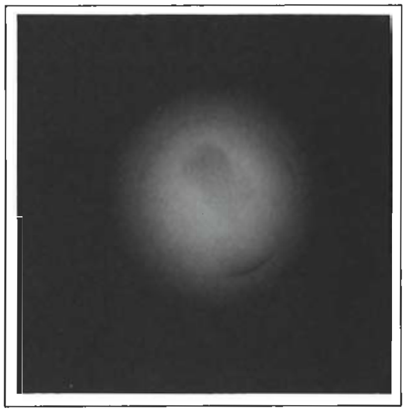


Figure 10. Another X-radiograph, taken from a different angle, illustrates how different the pearl appears when the orientation of the X-ray beam is changed.

Saltwater cultured pearls fluoresce to X-radiation because of the traces of manganese in the freshwater mother-of-pearl bead nucleus. Therefore, the thinner the nacre, the stronger the fluorescence. Many of today's cultured pearls fluoresce very strongly when exposed to X-rays for only a few tenths of a second; this is particularly true of most of the material grown in Japan, which may have nacre coatings as thin as 0.2 mm. When we checked this South Seas–type pearl for X-ray fluorescence, we observed only an extremely weak yellowish green glow during a relatively long two-second exposure. This weak reaction is to be expected for a cultured pearl with such thick nacre. *RK*

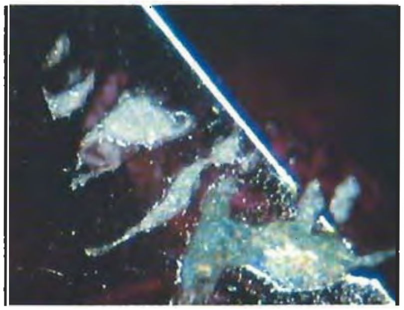
Flux at the Surface of a Synthetic RUBY

Flux is used in the growth process of certain synthetics because the synthetic material will dissolve in the molten flux at a temperature significantly lower than its melting point. This enables crystallization of the synthetics under more easily obtainable conditions. Although the flux material is frequently trapped in the crystals as they grow, it seldom breaks the surface of the crystal. Gemologists describe these flux inclusions (as seen through the host material) variously as wispy veils, high relief white (or sometimes colored) "fingerprints," or fine parallel stringers of tiny droplets called "rain."

A 2.65-ct synthetic ruby tested by the East Coast laboratory had two patches of flux, each about 1 mm, that did reach the surface (figure 11). They were grayish white and had a dense, flaky appearance. It is unfortunate that we did not have the time to send the stone to the GIA Research Department for chemical analysis of the inclusions to determine which flux was used.

David Hargett

Figure 11. Flux inclusions break the surface of this 2.65-ct synthetic ruby. Magnified 20×.



SAGENITIC Stones

A pair of near-colorless sagenitic stones (figure 12) were loaned to the East Coast laboratory for examination. A sagenitic material is one that contains long acicular inclusions, usually tourmaline but sometimes other minerals, such as actinolite. The crystal habit, extreme dichroism, and refractive index (measured where they reached the surface) of the coarse needles in these stones proved that they were indeed tourmaline.

Although the two stones are similar in appearance, except for a slight difference in luster (exaggerated in this photograph), routine gemological testing proved that the oval stone is quartz, while the antique cushion cut is fluorite. Not only is sagenitic fluorite unusual, but the fact that the appearance of this specimen resembles quartz, despite its low hardness and refractive index, is also a testament to the careful faceting of this stone and its subsequent lack of wear.

Clayton Welch

Figure 12. These two sagenitic stones contain prominent tourmaline inclusions. The quartz, on the right, weighs 15.68 ct; the fluorite weighs 24.49 ct.

Abraded SAPPHIRE

The East Coast laboratory recently examined a natural sapphire that had three shallow pits on the pavilion (figure 13). Although such pits are frequently a side effect of heat treatment, they usually occur on the girdle. The unusual symmetry of the pits in this stone also suggests a different explanation. We surmised that the previous owner wore the sapphire in a ring alongside and in contact with a ring containing three diamonds, which caused the abrasions on the softer sapphire.

Clayton Welch

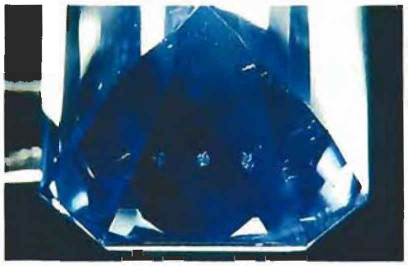


Figure 13. The abrasions on this approximately 11-ct natural sapphire are unusual for their occurrence on the pavilion and their symmetry.

Synthetic Brown STAR SAPPHIRE

The West Coast laboratory recently received for identification the synthetic brown star sapphire ring illustrated in figure 14. Although synthetic star sapphires of this color are known (the GIA collection has some samples that were produced by Linde more than 20 years ago; similar material is also illustrated in K. Nassau's *Gems Made by Man*, Chilton Book Co., Radnor, PA, 1980), this is the first one that we recall having received at this laboratory for identification.

Although this stone is basically opaque, it has some semitranslucent areas near the surface. The stone has an R.I. of 1.76 (determined by the spot method), is inert to both long- and short-wave ultraviolet radiation, and shows no absorption lines or bands in the visible spectrum (400–700 nm). When the stone was viewed with the unaided eye, widely spaced curved color bands were visible, as well as the sharp star. These bands, which are medium brown and dark yellow-brown, could be followed around the top of the cabochon in a concentric pattern; they were only faintly visible on the base of the stone. With magnification, we observed tiny spherical gas bubbles just under the surface, as well as irregular veins and dark brown shallow cracks (figure 15). *RK*

Figure 14. This synthetic brown star sapphire, which measures 13.00 × 10.70 × 5.65 mm, was set in a white metal man's ring.

Figure 15. Dark brown irregular veins and cracks are evident in the stone shown in figure 14 when examined with oblique lighting at 25× magnification.

TAAFFEITE with Unusual Fluorescence

A transparent, light purple, oval mixed-cut stone was tested in our West Coast laboratory. It was so light in tone that, face-up, it appeared almost colorless. Standard gemological testing methods revealed it to be taaffeite. However, this particular 5-ct stone was quite remarkable because of its unusual reaction to ultraviolet radiation. When exposed to long-wave U.V., it fluoresced a weak red; but to short-wave U.V., it fluoresced a chalky yellowish green. Even though our laboratory has identified numerous taaffeites, we had never before noticed this type of fluorescence in this gem material, even in the lighter tones. Rather, such a fluorescent reaction is most commonly seen in colorless synthetic spinel. Because this fluorescence is so typical of synthetic spinel, this stone served as a good reminder that it can be dangerous to base an identification on only one test. *KH*

TRIPHYLITE

A long-time friend of the West Coast laboratory sent us two 0.65-ct cut stones and two small pieces of rough that he thought (and correctly so) we would be interested in seeing. The material proved to be triphylite, a lithium, iron, manganese phosphate mineral not previously encountered by the laboratory in either cut or rough form.

The transparent grayish brown cut stones were tested and found to have the following gemological properties. The material is biaxial negative, with R.I.'s of $\alpha = 1.689$, $\beta = 1.691$, and $\gamma = 1.695$, giving it a birefringence of 0.006. The specific gravity was determined to be approximately 3.40 by the heavy liquids method. There was no reaction to either long- or short-wave ultraviolet radiation. Examination with a GIA GEM spectroscope unit revealed a strong line at 410, a weak one at 425, a moderate band at 450–460, another strong line at 470, a moderate band from 485 to 498 (with a moderately strong line within this band), and a weak band from 540 to 590 nm. The only inclusion seen was the fine-grained fingerprint shown in figure 16. X-ray diffraction analysis confirmed the identity as triphylite. Although we do not test for hardness, it is reported to be $4-4^{1}/_{2}$ for this material. *John I. Koivula*

Figure 16. A very fine-grained fingerprint inclusion was observed in one of the triphylite specimens at 35× magnification.

FIGURE CREDITS

The photos used in figures 1, 5, and 16 were taken by John I. Koivula. David Hargett took figures 2, 3, 7, and 11. Robert Weldon supplied figure 4. Shane McClure furnished figures 6, 8, 14, and 15. Robert Kane is responsible for figures 9 and 10. Clayton Welch did figures 12 and 13. Mike Havstad took the photos of the 32.69-ct alexandrite; Andrew Quinlan took the photo of the damaged diamond in the "Historical Note".

A HISTORICAL NOTE

Highlights from the Gem Trade Lab 25, 15, and five years ago

FALL 1963

In this issue, the New York lab reported on its examination and testing of several different color-treated diamonds, as well as the opportunity they had to study the De Beers collection of 150 natural fancy-color diamonds. They also reported on several unusual collector stones seen: brown danburite, red sphalerite, rhodizite, natrolite, colemanite, boracite, and a true hiddenite.

The use of scheelite to separate synthetic from natural emeralds (by determining the transparency of the material to short-wave U.V. radiation) was discussed by the Los Angeles lab. They also described an interesting imitation staurolite "fairy cross." Rough staurolites are frequently encountered as twins with one crystal penetrating the other at right angles to form a natural cross; this imitation was formed by filing a soft talcose material into the appropriate shape and then dipping it into a substance similar to paraffin so that it more closely resembled the darker color that is associated with staurolite.

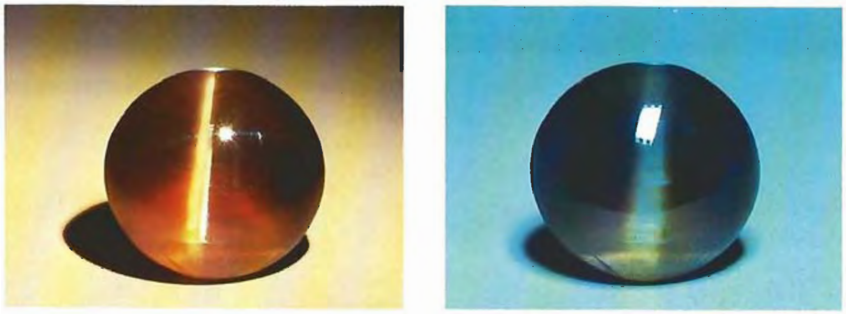
FALL 1973

The results of fade tests carried out on irradiated brown topaz and smoky quartz were enumerated by the New York laboratory. The possibility of improving yellow topaz to "imperial" color was discounted when it was found that the color faded back to the original in sunlight.

Another discussion from New York concerned the "lavender" jade situation. Because not all stones show definite evidence of dye, the origin of color of certain stones cannot be determined.

A number of different reflection problems in diamonds were illustrated in the Los Angeles column. One of the most striking "reflectors" was a round brilliant cut with a large diopside crystal located very near the culet; the image of this inclusion was reflected at least once in almost every crown facet.

Two unusual cameos, one of green beryl and the other carved from a tridacna shell, were examined and illustrated in the column. Another item of interest was a partly silicified coral cabochon. We easily discerned the quartz grains because of the difference in hardness, even before we observed a slight etching around them when a small drop of acid was applied to an inconspicuous spot on the back.

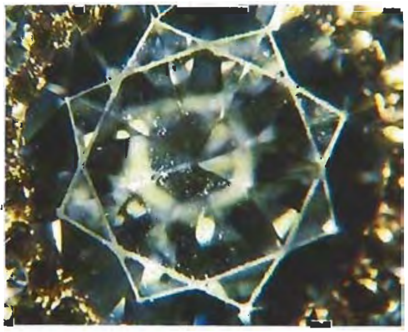


This unusually fine cat's-eye alexandrite weighs 32.69 ct and is 17 mm in diameter. The color under incandescent lighting is shown on the left; that seen with fluorescent (daylight equivalent) lighting is on the right.

FALL 1983

The most spectacular item mentioned in the Gem Trade Lab Notes column in this issue was a 32.69-ct cat's-eye alexandrite. The stone had a very good color change and very few inclusions, other than the needles that cause the chatoyancy.

The severely abraded facet junctions of the diamond shown here prove that just as you shouldn't judge a book by its cover, the hardness of a stone shouldn't be judged by its appearance. This stone was submitted by a dealer who could not believe that a diamond could show such wear, and thus felt it must be a softer stone, perhaps zircon. We can only speculate that the ring containing this stone was stored in contact with other diamonds.



The facet junctions of this large center diamond were badly abraded.

GEM NEWS

John I. Koivula and Robert C. Kammerling, *Editors*

DIAMONDS

Angola. The guerilla leaders of the Angolan UNITA movement have announced the discovery of huge deposits of diamonds in the areas of Cuando and Cubango in Angola, which are firmly under their control. They plan to start developing these properties as soon as possible.

Large Chinese diamond discovered. A 32.79-ct diamond crystal has been found at the Mengyin mine in Shandong province, People's Republic of China. It is the largest diamond crystal discovered at that mine in the last five years. The rough is said to be of "excellent" clarity with a "light yellowish color." The final disposition of the crystal has not yet been announced. It is unlikely, however, that a diamond cutter outside of China will be able to obtain it because at this time China does not export rough diamonds, only cut goods.

Mwadui Mine to get new source of power. The Mwadui mine in western Tanzania (formerly called the Williamson diamond mine) has had a steady decline in output since 1976 because the fuel supply for its diesel generators is very unreliable. Recently, however, the minister of energy and minerals for Tanzania promised that the mine would have a continuous source of electric power when it is connected to the Kidatu hydroelectric plant in late 1988. This could more than double the current output at the Mwadui pipe, which is the major source of diamonds in Tanzania.

New alluvial deposit in Namibia. An extremely rich alluvial diamond deposit has been discovered near Luderitz, Namibia, by diver Dirk Lutz, of the Namibian West Coast Diamond Company. Mr. Lutz found the deposit 120 m off the coast in water 5–6 m deep. Within seven hours of his discovery, Lutz and two other divers had recovered 931 diamond crystals weighing a total of 1,550 ct. A spokesman for Namibian West Coast Diamond Company said that if this new area proves to be as productive as it now seems, they would apply to the government to open a diamond-cutting plant in Luderitz.

News from Murfreesboro. On the basis of preliminary investigations, geologists report that the deposit at Murfreesboro, Arkansas, may yield as much as $900 million worth of diamonds. To confirm this potential, however, more detailed, and much more costly, exploration will be required.

To this end, in 1987, the Arkansas State Legislature passed a law allowing commercial mining at Murfreesboro, and a seven-member Diamond Mining Advisory Task Force was appointed by the governor. Their job is to examine the possible economic and environmental effects of the proposed commercial mining, to determine how to take bids from private mining companies, and to decide the extent to which diamond mining should be allowed.

Seven different mining companies, with home offices in Australia, Belgium, Canada, Great Britain, and the United States, have expressed interest in the deposit.

COLORED STONES

Change-of-color garnets. Over the past 18 months, the editors of Gem News have encountered four exceptional color-change garnets, all from East Africa and all of similar appearance. Although color-change garnets from East Africa have been known for many years, these four gems are exceptional in that they exhibit a change-of-color much like that of fine Russian alexandrites (green in fluorescent, or day, light and red in incandescent light. Most of the color-change garnets that we have observed are either quite dark or do not exhibit a dramatic change, especially when cut.

GIA's Research Department was able to borrow three of these stones, as shown in figure 1, for closer examination. Two of the stones had a refractive index of 1.770, while the third gave a reading of 1.763. Examination with a Beck prism spectroscope revealed the absorption spectrum shown in figure 2, which is typical of color-change pyrope-spessartine garnets, for all these stones. These absorption features were corroborated by a Pye Unicam UV-visible dual-beam spectrophotometer. Semiquantitative chemical analyses (Carol M. Stockton, analyst) by means of a Tracor Northern energy dispersive X-ray fluorescence (EDXRF) system confirmed the composition to be that of pyrope-spessartine garnets with a fairly high manganese content.

Of even greater interest, however, is the fact that very little chromium was found (0.1 wt.% Cr_2O_3). The distinct and unusual color change was induced almost

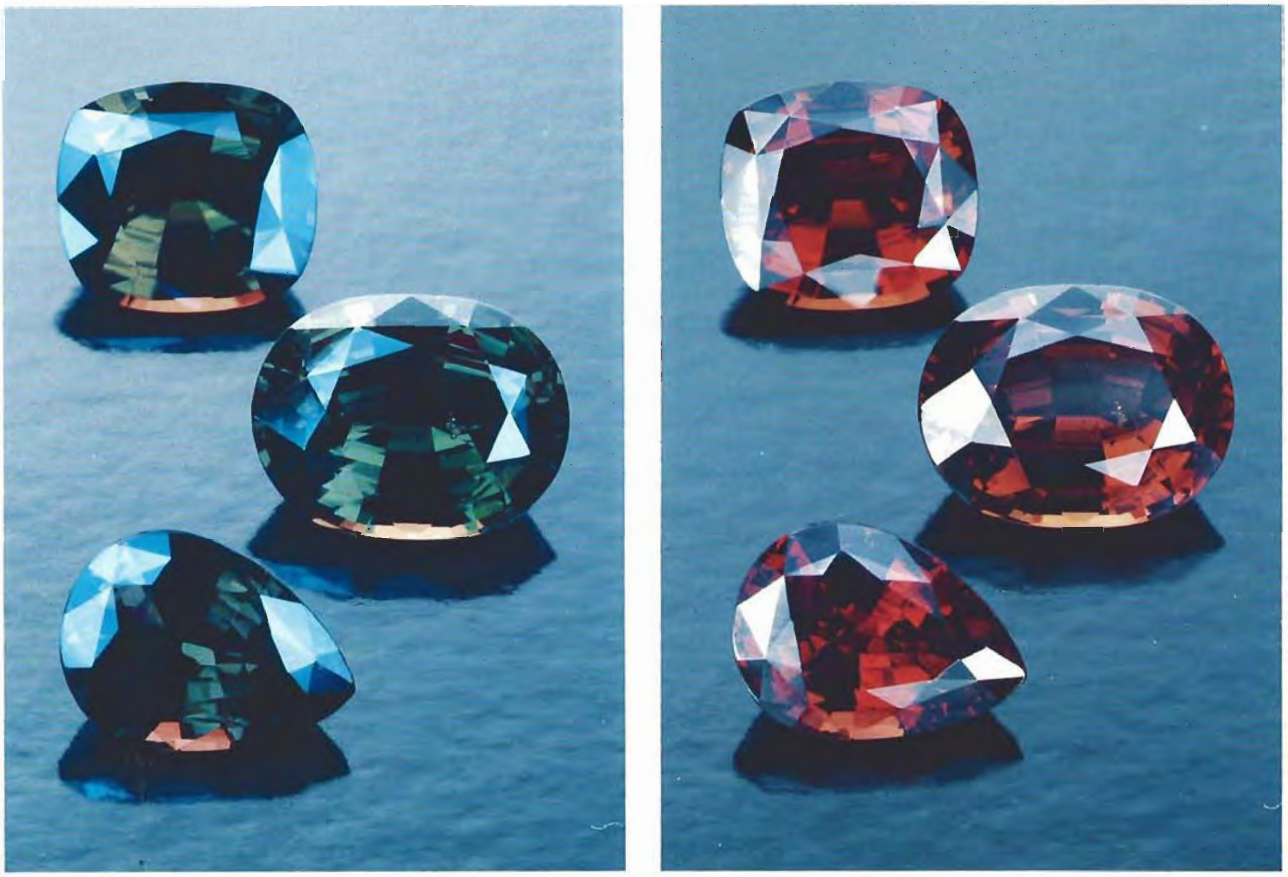


Figure 1. These three color-change pyrope-spessartine garnets from East Africa (1.65, 2.14 and 1.35 ct, from top to bottom) exhibit an exceptional change-of-color much like that of fine Russian alexandrites. The photo on the left was taken with fluorescent light; the photo on the right with incandescent light. Stones courtesy of Peter Flusser, Overland Gems, Los Angeles, and Horst Krupp, Heidelberg, West Germany. Photo © Tino Hammid.

Figure 2. The visible-light absorption spectrum shown by the three garnets illustrated in figure 1 is typical of color-change pyrope-spessartine garnets. Drawing by Carol M. Stockton.

entirely by the more than 1 wt.% V_2O_3 identified in each of these three stones.

Washington State garnets. Bright orange to dark yellowish brown grossular garnets and garnet clusters were mined in Washington State between 1975 and 1982 by Bart Cannon of Cannon Microprobe/S.E.M., Seattle, Washington. The garnet mine is a small open cut in an outcrop above a perpetual snowfield near the summit of Vesper Peak, in Snohomish County, Washington.

According to Mr. Cannon, the garnets from this area average about half an inch (a little more than 1 cm) in diameter. They occur as isolated crystals or as druses of crystals on a matrix of dark green diopside crystals. The specimens are popular with mineral collectors because of their pleasing color and the bright luster of the crystal faces; some of the crystal druses have been cleaned and set in jewelry in their natural form. The faceted garnets can have very nice color. Thus far, this is the only facetable garnet native to the Pacific Northwest.

New Mexico moonstone. Moonstone of very fine quality is currently being mined from the Black Range in New Mexico by David Menzie and Richard Boltz, of Black Range Gems and Stones, Faywood, New Mexico. Moonstones have been mined intermittently on a very small scale from this locality for over 50 years.

The mine owners report that the moonstones occur in small, high-temperature, shallow-seated pegmatites in a rhyolite porphyry plug that was injected into

Figure 3. Sanidine moonstone from New Mexico shows a pleasing blue adularescence and a high degree of transparency that lends itself to faceting, as shown by this 4.39-ct stone. Photo by Robert Weldon.

rhyolite tuffs of Tertiary age. The pegmatites are chiefly composed of quartz and sanidine: an undetermined percentage of the latter is of gem (moonstone) quality. Minor amounts of biotite, cleavelandite, ilmenite, magnetite, and titanite are also present as accessory minerals.

The rough moonstones have a high degree of transparency that lends itself to faceting. When the adularescence is properly oriented, the faceted material displays the phenomenon beautifully in colors that range from "cool" blue (figure 3) to silvery white (figure 4).

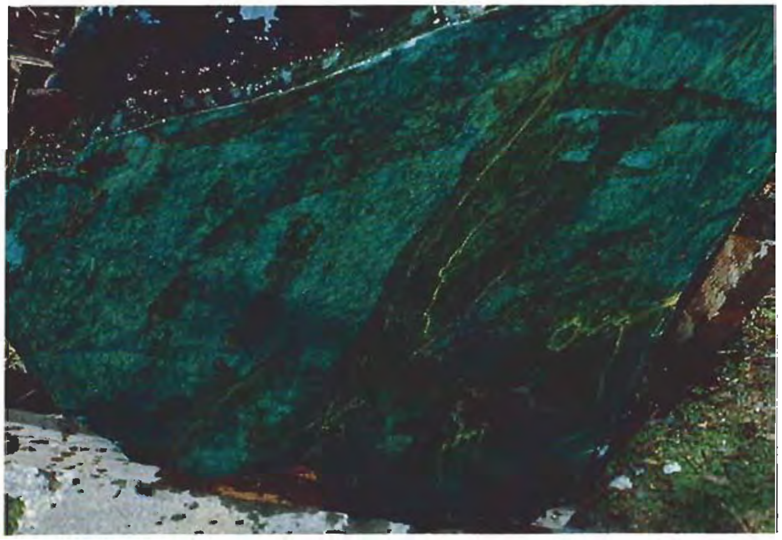


Figure 5. Nephrite from Dahl Creek, Alaska, often comes in a dark, rich green color, as illustrated by this "tabletop"-size boulder. Photo by Mrs. Ivan Stewart.

Figure 4. Moonstones with a bright silvery white adularescence, such as this 3.63-ct gem, are also found in the Black Range in New Mexico. Photo by Robert Weldon.

Alaskan nephrite jade. The main source in Alaska for its state gem, nephrite jade, is Dahl Creek. The Dahl Creek claims, owned by Mrs. Ivan Stewart of Stewart's Photo in Anchorage, are located above the Arctic Circle near the Eskimo villages of Shugnak (an Eskimo word meaning *jade*) and Kobuk.

At Dahl Creek, nephrite is found both as pebbles and as boulders, some weighing as much as 25 tons (22,600 kg). The color ranges from dark, rich green (figure 5) to lighter shades of green, sometimes mottled with "red or black moss." Gold, silver, and copper have also been observed imbedded in the jade. Other minerals found in association with the nephrite at Dahl Creek are coarse actinolite, serpentine (bowenite), rock crystal and rose quartz, and chrysoprase.

Diamond saws are used to slice the large boulders (figure 6) into various items such as table tops, bookends, and paperweights. Smaller pieces, and pieces of high gem quality, are cut into cabochons or are carved into decorative objects or jewelry. Leslie Williamson, a jade carver from England, works as foreman at the claims, overseeing the day-to-day mining operation. Weather permitting, the Dahl Creek claims are generally worked from May through August. Mrs. Stewart reports that in 1987 they recovered and shipped 8,000 lbs. (3,600 kg) of nephrite to their Anchorage facility. Although much of the lapidary work is done in Alaska, Mrs. Stewart also sends considerable quantities of the rough nephrite to Idar-Oberstein, West Germany.

Opal from Oregon. A significant discovery of gem-quality opal has been reported by Kevin Lane Smith, of Seattle, Washington. Mr. Smith is one of the individuals who is currently mining and marketing this new opal.

Some of this opal is transparent and of the "contra luz" type that shows its play-of-color in transmitted light (figure 7). Another type is hydrophane. Under normal conditions of humidity, this material appears almost opaque with a white body color. If viewed using surface-incident light, it shows a speckled play-of-color. When it is immersed in water for just a few hours, however, the hydrophane loses its white body color and becomes transparent; it then shows a weak play-of-color in transmitted light, but only a very slight play-of-color with surface-incident light. In the process, it gains a significant amount of weight. If it is removed from the water and left at room temperature to dry out, the hydrophane will once again become white and nearly opaque, regaining the original play-of-color but losing the extra water weight. The sample of Oregon opal that we tested went from 11.21 ct dry to 12.09 ct wet. Some jelly opal, with a strong orange-red body color, has also been found.

Mr. Smith is currently working on an article for *Gems & Gemology* that will provide a detailed description of this new deposit and the opals.

Sri Lanka. Our most recent communication from Gordon Bleck, a geologist who lives in Ratnapura, Sri Lanka, was full of interesting news concerning gem-mining activities in that island country.

In particular, Mr. Bleck reports that some unusual materials are being recovered. One of these is clinozoisite, a collector's gem material. It is being mined near Ratnapura, about 20 miles (32 km) from Badulla in the small village of Kandaketiya (town area of Migahakiula). The mining area, along a tributary of the Mahaweli River, is surrounded by very thick jungle and thus is very difficult to reach. Fine gem-quality pieces of any size are rare, but a large amount of specimen material has been recovered. The largest reported faceted clinozoisite from this area is said to weigh 10 ct, but the brownish stone is very flat, badly windowed, and not very attractive.

Small quantities of light purple anhydrite (rare in gem quality) are also being found in this same general area, even though this material is not generally known to occur in Sri Lanka. All of the gem-quality pieces examined by Mr. Bleck to date were less than 1 ct.

Limited amounts of sapphirine are being seen in the Sri Lankan gem market. Mr. Bleck has studied a total of 10 pieces so far this year, but no locality information has been made available to him.

Sapphirine from Greenland and Canada. Gem-quality sapphirine has also been found in Greenland and Can-

Figure 6. A circular diamond saw is used to cut sections from a nephrite boulder at the Dahl Creek mine. Photo by Mrs. Ivan Stewart.

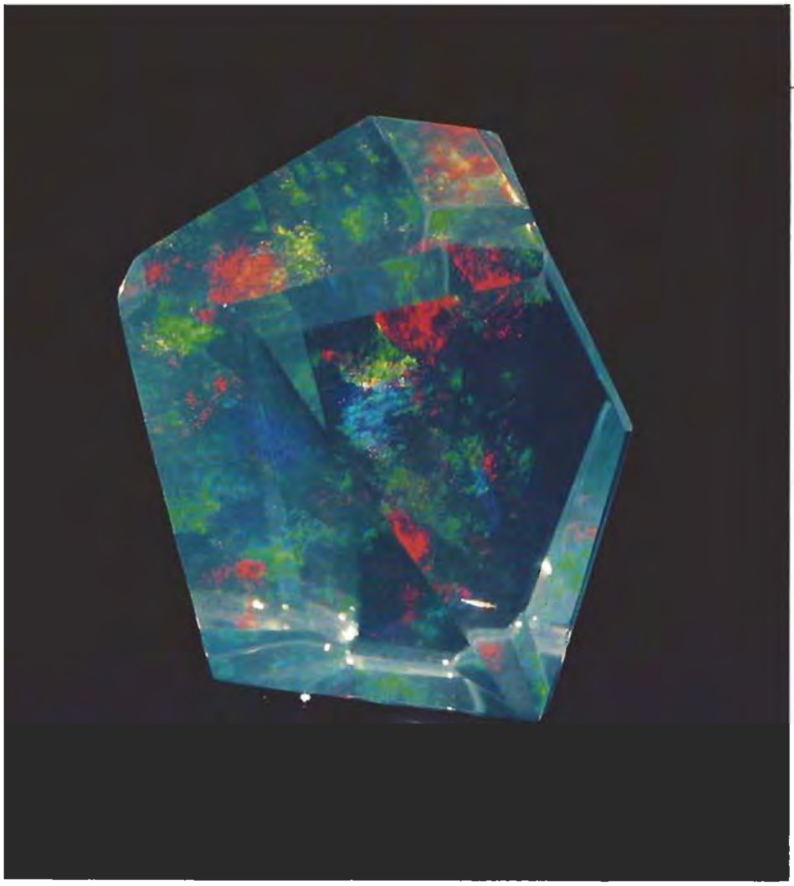


Figure 7. Much of the opal from the new locality in Oregon is transparent and shows considerable play-of-color. Specimen (approximately 5 cm in longest dimension) courtesy of Kevin Lane Smith; photo © Tino Hammid.

ada. Richard K. Herd, curator for the Geological Survey of Canada, recently reported to the Rochester Academy of Science on these two sapphirine deposits. Fiskenaesset, in western Greenland, is the type locality for sapphirine. According to Dr. Herd, over 80 highly metamorphosed, stratigraphically controlled rock layers and lenses in the region are known to contain sapphirine. A number of associated minerals, including cordierite, corundum, garnet, chatoyant gedrite, kornerupine, and spinel – some of which are gem quality – have also been identified.

Geologic conditions similar to those encountered in Greenland also exist in the Canadian Arctic, where sapphirine-bearing metamorphic rocks have been known since the 1950s. This area is currently being investigated for sapphirine and any potentially gem-quality associated minerals. Dr. Herd collected some very fine blue-gray sapphirine crystals on Somerset Island, south of Resolute. These crystals, which show a tabular, pseudohexagonal habit and are up to several centimeters across, are thought to be the best Canadian sapphirines ever found.

New find of zircons. At the Northwest Faceters' Convention held this last May in Vancouver, British Columbia, Australian master cutter Max Faulkner reported that a new deposit of zircons had been discovered in Australia's Northern Territory. Individual crystals have been found in large sizes; most of these are suitable primarily for use as mineral specimens, but some are of faceting quality.

Mr. Faulkner subsequently provided the editors of Gem News with a great deal of information concerning these new zircons, as well as an excellent representative sample of the rough for the GIA research collection. These gem zircons are found in a wide range of colors, from pink through purple and also from yellow through brown (figure 8); even colorless crystals have been reported. Apparently no one has yet tested these new Australian zircons to determine if they can be heat treated to turn them blue, as is possible with some of the zircons from Kampuchea. Because of the lack of internal

Figure 8. These gem zircons (ranging from approximately 3 to 7 ct) are from the new Harts Range locality near the town of Alice Springs in Australia's Northern Territory. Photo by Robert Weldon.

radioactivity, these zircons do not show the metamict structural breakdown that is so common to gem zircons from Sri Lanka.

These Australian zircons are found in a carbonatite host rock in the Harts Range, near the town of Alice Springs, close to the same area where ruby was found several years ago (see *Gems & Gemology*, Fall 1979). Commercial mining is not allowed in this "reserved area," which is known as Zircon Hill, and the crystals are presently being recovered only by collectors and hobbyists using picks and shovels. In view of this, it is not likely that significant quantities of these gem zircons will be available for faceting.

Erratum. In the Spring 1988 Gem News report on some of the gemstone carvings encountered at the most recent Tucson Gem and Mineral Show, we misspelled the name of one of the award-winning artisans, Michael M. Dyber. An example of Mr. Dyber's talent as a gem carver is the magnificent smoky rutilated quartz sculpture shown in figure 9.

PEARLS

New form of cultured pearl. In a recent ICA alert, Nobuo Horiuchi, of the Central Gem Laboratory in Tokyo, advised the gemological community that a new type of cultured pearl is being grown and marketed. Of particular interest is the nucleus that is used in the culturing process.

The pearl farmers prepare the nuclei for these cultured pearls by first finely powdering the shells of edible oysters and then mixing an inorganic blue (cobalt) or green (cobalt and copper) pigment into the shell powder. Next, the powder is baked and sintered into spheres that, with continued heating, become colored ceramic nuclei. These nuclei are then placed into the pearl oyster and a thin layer of nacre is allowed to form. The thin nacre layer provides orient and also allows the color from the nucleus to reflect through, giving the cultured pearl a pleasing body color.

Microscopic examination provides useful clues in the identification of this type of cultured pearl. In addition, the nucleus is opaque and will not transmit light in any direction, so a negative result from candling may also serve as an indicator. In some samples, however, the nacre layer may be so thin that the underlying colored nucleus can actually be resolved with a high-intensity fiber-optic light source.

These cultured pearls are being produced by Catalysts & Chemicals Industries Co., Ltd. in Japan, and are being marketed under the trade name "Maricen Pearl."

SYNTHETICS

A new hard material. David McKenzie, a physicist at Sydney University, in Sydney, Australia, has manufactured a material that can readily scratch diamond. Like diamond, this new material is a form of carbon; unlike diamond, it is amorphous with a glassy structure. According to Mr. McKenzie, the overall structure of this substance "is not regular like a diamond. Instead, it is a tangled network [of carbon atoms] which makes the glassy diamond film harder than the crystalline diamond because it is more resistant to distortion." This new hard material is largely transparent and, like diamond, is resistant to chemical attack. It could have important commercial applications.

Figure 9. Michael M. Dyber carved this 491-ct rutilated smoky quartz sculpture. Courtesy of Ledge Studio; photo by Larry Croes.

New use for synthetic quartz. With the widespread interest in the so-called healing and metaphysical properties of quartz, it was bound to happen eventually: Si and Ann Frazier, gem, mineral, and rare book dealers from El Cerrito, California, have reported seeing an obviously synthetic rock crystal quartz pyramid that was cut in Korea. The pyramid, which belonged to one of their customers, had a portion of the seed plate clearly visible as an inclusion. This same customer also reported to the Fraziers that quartz spheres have been cut from synthetic rock crystal, too.

ANNOUNCEMENTS

The United States Nuclear Regulatory Commission (NRC) has announced that it plans to license domestic firms and individuals that reactor-irradiate gem materials, as well as importers who distribute irradiated gems within the United States. Retail jewelers and jewelry manufacturers will not be required to obtain a license if they purchase their irradiated gems from a licensed firm or distributor.

The NRC's new regulations will require that those involved in domestic irradiation and importers of irradiated gems use detection devices capable of reading very low radiation levels. Under these new regulations, it will be illegal to release gem materials that emit more than 0.4 nanocuries of radioactivity per gram of gem weight. At present, the safety standard in Europe is equivalent to 2.0 nanocuries per gram. The NRC is also exploring options for disclosing these new requirements to the buying public.

Gemological Digest, a professional journal geared to gemologists, is now available from the gem-rich country of Thailand. Published by the Asian Institute of Gemological Sciences in Bangkok, under the guidance of editor-in-chief Richard W. Hughes, it has been completely restructured from its original "bulletin" format (first published in 1987) into a magazine that will be of interest to all practicing gemologists.

The first copy of this newly revitalized publication, designated volume 2, numbers 1 and 2, 1988, contains four articles, an editor's note, and a "Bangkok Gem Market Review." Considering the importance of Bangkok as a gem center, this last column alone will probably draw quite a readership.

New subscriptions and back issues are available free of charge, both in Thailand and abroad, and can be obtained by writing to: *Gemological Digest,* Asian Institute of Gemological Sciences, 987 Silom Rd., Rama Jewelry Building, Fourth Floor, Bangkok 10500, Thailand.

The Tucson Gem and Mineral Show will be held February 9–12, 1989, at the Tucson Community Center. The featured mineral for the show is galena. For more information, contact the Tucson Gem and Mineral Society, P.O. Box 42543, Tucson, AZ 85733.

The Gemological Institute of America will present various lectures and seminars in Tucson February 4–11. For information, call (800) 421-7250, ext. 227, or write GIA, 1660 Stewart St., Santa Monica, CA 90404. The American Gem Society will have seminars and other activities on Friday, February 3, at the Viscount Suite Hotel. Contact Marjery Lemlech of AGS at 5901 West Third St., Los Angeles, CA 90036, (213) 936-4367.

The American Gem Trade Association will be in Tucson February 4–9, at the Doubletree Hotel. They will announce the winners of the Spectrum Awards (a jewelry contest aimed at the effective use of colored stones) at that time. For information, contact the AGTA headquarters at the World Trade Center #181, P.O. Box 581043, Dallas, TX 75258, (214) 742-4367; for reservations call (800) 972-1162.

GEMOLOGICAL ABSTRACTS

Dona M. Dirlam, Editor

COLORED STONES AND ORGANIC MATERIALS

Corundum 'type' categories. W. J. Sersen, *Gemological Digest,* Vol. 2, No. 1 and 2, 1988, pp. 3–9.

The concept of corundum "type categories" was first described in 1981 by Henry Ho. The system is designed to describe the overall color appearance of individual rubies and sapphires. The various components that contribute to the stone's color appearance—such as hue, tone, and intensity, as well as pleochroism, extinction, windowing, brilliance, fluorescence, color zoning, and inclusions—are all considered. This article provides a detailed description of the corundum type categories: "A" through "E" for ruby, and "A" through "D" for blue sapphire.

The author states that type categories are a useful aid for teaching colored stone grading. Also, they are a practical means of describing corundum preferences from one country to another. Sersen lists the "type" preferences for nine different countries, which should be of interest to those who buy rubies and sapphires for resale. *Ron Conde*

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

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. Opinions expressed in an abstract belong to the abstracter and in no way reflect the position of Gems & Gemology *or GIA.*

Crystal chemistry of double-ring silicates: Structures of sugilite and brannockite. T. Armbruster and R. Oberhänsli, *American Mineralogist,* Vol. 73, No. 5/6, 1988, pp. 595–600.

The crystal structure of purple sugilite from the Wessels Mine, South Africa, was investigated to understand better the chemistry and crystallography of silicate minerals of this kind. The structure consists of rings of silicate tetrahedra which are interlinked by tetrahedra that contain lithium ions and larger octahedra that contain iron, manganese, or aluminium ions. Refinement of this crystal structure provided a clearer understanding of the structural and chemical variations possible within double-ring silicate minerals of this structure type. *JES*

The Empress of Lemuria. D. Webb, *Lapidary Journal,* Vol. 42, No. 3, June 1988, pp. 38–40.

Mr. Webb reports on the fashioning of a single crystal of Brazilian quartz to a finished weight of 42.5 lbs. (96,260 ct). This crystal, which is scheduled to be listed in the 1989 edition of the *Guinness Book of Records* as "the largest cut and polished quartz generator in the world," was worked by Glenn Lehrer and Lawrence Stoller of San Rafael, California. The original weight before fashioning was approximately 68 lbs. The fashioning took approximately 18 months to complete, and required a block-and-tackle pulley set-up to hold the stone during part of the process. The "Empress," unveiled at the 1987 Tucson Gem and Mineral Show, basically conforms to the original shape of the natural crystal, with the prism faces, termination, and base surfaces polished.

Bill Videto

Eye of a dragon. S. E. Thompson, *Lapidary Journal,* Vol. 42, No. 3, June 1988, pp. 21–27.

Ms. Thompson explores the ancient mythology regarding the association of animals with many colored stones. Drawing heavily on classic references, she provides an engaging, informative overview of this unusual topic. This abstracter would have liked to have stones called by such names as "corvia," "liparia," or "bezoar stone" in the myths and fables correlated with what they may have actually been, but appreciates the fact that turquoise, amber, and emerald are examined in considerable depth. *Bill Videto*

Gas bubbles in fossil amber as possible indicators of the major gas composition of ancient air. R. A. Berner and G. P. Landis, *Science,* Vol. 239, No. 4846, 1988, pp. 1406–1409.

These two researchers studied the gaseous contents of the air-bubble inclusions found in a number of samples of amber from various localities such as the Dominican Republic, the Baltic area, and Manitoba, Canada. The authors focused their efforts on studying the specific mix of gases trapped in the bubbles in order to determine the composition of the "ancient air" that existed when the bubbles were sealed (as long ago as 95 million years).

The authors first crushed the samples in a vacuum, and then analyzed the released gases by time-resolved quadrupole mass spectrometry. The detection limit of the authors' instrument was 10 parts per million, with an accuracy of about 3–5% of the amount of each gas detected.

The authors theorize that these gases (mostly O_2, N_2, and CO_2) represent original "ancient air" modified only by the aerobic activity of microorganisms. They discount the possibility that the major gases may have reacted with their surroundings, thus affecting their present percentages.

The results of these "ancient air" analyses, when compared with the gaseous makeup of our modern atmosphere, show that the atmosphere has evolved over time. The amount of oxygen present has decreased significantly from approximately 30% during the Late Cretaceous era (75–95 million years ago) to 21% today.

John I. Koivula

Gemmological investigation of a large faceted East African enstatite. J. I. Koivula, C. W. Fryer, and J. E. Shigley, *Journal of Gemmology,* Vol. 21, No. 2, 1988, pp. 92–94.

The properties of a 46.56-ct transparent brown enstatite, possibly the largest known, are described in this article. The stone was faceted from an approximately 75-ct rough crystalline mass from Tanzania. The R.I., S.G., spectrum, and X-ray diffraction pattern are typical of enstatite; microprobe analysis confirmed the identity. Examination with a microscope revealed numerous parallel acicular inclusions (some eye-visible) and, perpendicular to them, distinct color and growth zones. Five color illustrations accompany the article. *CMS*

Observations on turquoise, lapis-lazuli and coral, and some of their simulants. S. Taki and M. Hosaka, *Journal of Gemmology,* Vol. 21, No. 2, 1988, pp. 74–80.

This brief article (one-half page of text and five and one-half pages of photos) mentions a few helpful distinctive characteristics of turquoise, lapis lazuli, and coral – and their simulants and synthetics – as determined by X-ray diffraction and X-ray fluorescence. The photos illustrate structural differences that can be observed with a scanning electron microscope. While these criteria are potentially useful, there is no indication provided as to how all-inclusive they are for these three gem materials.

CMS

Orientated lath-like inclusions of a new type in spinel. K. Schmetzer, *Journal of Gemmology,* Vol. 21, No. 2, 1988, pp. 69–72.

On the basis of chemical and morphologic data, lath-like inclusions in a bluish violet spinel from Sri Lanka are identified as sillimanite. These constitute a new type of needle-like inclusion for spinel; previously only rutile and sphene needles have been identified. A discussion of the orientations of all three types of needle-like inclusions in spinel clarifies some potential confusion. Six black-and-white photomicrographs accompany the article. *CMS*

Origin and significance of blue coloration in quartz from Llano rhyolite (llanite), north-central Llano County, Texas. M. E. Zolensky, P. J. Sylvester, and J. B. Paces, *American Mineralogist,* Vol. 73, No. 3/4, 1988, pp. 313–323.

Blue quartz crystals found as small grains in a rock from

Llano County, Texas, derive their color from Rayleigh scattering of light by submicrometer-sized ilmenite inclusions, which were detected and identified by means of transmission electron microscopy. In some cases, larger, ribbon-shaped ilmenite inclusions (0.1 × 1 × 20 μm) produce some chatoyancy.

Further geochemical investigations revealed that the smaller ilmenite inclusions originated during magma crystallization. As blue quartz is usually found in rock of middle to late Proterozoic age (part of the Precambrian), this may reflect that conditions favorable to early ilmenite saturation prevailed at that time. The exact nature of these conditions is, however, still unclear.

A particularly useful feature of this article is that it contains an impressive review of the literature on blue quartz. *EF*

DIAMOND

Bourses more than a place to sell. V. Berquem, *Jewellery News Asia*, No. 48, August 1988, pp. 63, 64, and 66.

This article provides a brief history of the evolution of bourses from simple gatherings of diamond traders at local cafes, to a sophisticated network of diamond-trading centers around the world.

The first bourses began in Amsterdam and Antwerp in the late 1800s, after the South African diamond boom created a need for organization in the diamond trade. Today, bourses are found throughout the world, including London, Tel Aviv, Hong Kong, and New York, as well as Idar-Oberstein, Johannesburg, and Los Angeles. In addition to their role as centers for the sale and purchase of diamonds, bourses serve as sources of market information, arbitrators of disputes among traders, and a network for communicating with other diamond traders locally or worldwide.

This issue of *Jewellery News Asia* features the 24th World Diamond Congress of the World Federation of Diamond Bourses, which was held in Singapore from July 31 to August 3, 1988. *Becky Booker*

Famous diamonds of the world XXVIII: Matan. I. Balfour, *Indiaqua*, Vol. 45, No. 3, 1986, pp. 123–125.

In this article in his series on famous diamonds, Ian Balfour offers an account of the mysterious 367-ct Matan diamond.

Balfour draws on the historical accounts of Sir Thomas-Stamford Raffles, British appointed lieutenant-governor of Java to support the notion that this diamond was originally found on the island of Borneo in the mid-1700s. In his 1817 *History of Java*, Raffles writes about the workings of the Borneo diamond mines and, in particular, about the Matan diamond.

Balfour admits that the truth surrounding the existence of this diamond remains unclear, since it changed hands during political disputes for much of its history. It is rumored that the diamond may ultimately have been lost at sea during World War II, as Japanese ships transported cargoes of gems they seized during the occupation of Borneo. One of these ships, purported to have five boxes of diamonds (including the Matan) on board, sank off the coast of eastern Sumatra. *JLC*

Famous diamonds of the world XXIX: Emperor Maximilian. I. Balfour, *Indiaqua*, Vol. 45, No. 3, 1986, pp. 126–128.

With his keen attention to detail, Ian Balfour describes the history of the Emperor Maximilian diamond. This 41.93-ct cushion shape was named after the Archduke Maximilian of Hapsburg, who in 1864 became emperor of Mexico.

Balfour relates that the diamond was one of two acquired by Maximilian during a botanical expedition to Brazil in 1860. The second diamond, a 33-ct cushion shape known as the Maximilian, was lost by one of its 20th century owners.

In his articulate manner, Ian Balfour outlines the tragic circumstances that surrounded Emperor Maximilian and the manner in which the 41.93-ct diamond eventually surfaced into the modern-day diamond market. Chicago jeweler Ferdinand Hotz acquired the diamond in 1919 and later displayed it at the Century of Progress exhibition held in Chicago in 1934. On Mr. Hotz's death in 1946, the Emperor Maximilian was sold to a private collector in New York. Subsequently, in 1982, the diamond was acquired at auction by Laurence Graff; in January 1983, Graff sold it with two other famous diamonds, the Idol's Eye and the Sultan Abdul Hamid II, to a private individual. *JLC*

Will India be a force as a high-end diamond supplier? R. Shor, *Jewelers' Circular-Keystone*, Vol. 159, No. 7, July 1988, pp. 308–314.

Russ Shor is well known for his up-to-date, accurate reporting on diamonds, and this article is no exception. India has blossomed as a diamond-cutting center in the 1980s. The last three years in particular have seen India's leading diamond houses move into the quality diamond market. This is a natural by-product of the strong competition that Bombay manufacturers are now feeling from the even lower-cost cutting centers developing in the Far East. In effect, leaders of India's diamond-cutting trade have seen a need, and the opportunity, to adopt the high-tech methods used to cut larger, better-quality rough.

This article also discusses the deepening relationship between Argyle and India. Interwoven throughout are the complex and often friction-filled relationships of the world's traditional and emerging diamond-cutting centers. Credit India's youthful and energetic executives, determined to adapt to a changing diamond-cutting environment, with the present innovation and success.

In addition to the powerful role that it plays as a major cutter of Australian rough, India is striving to become a jewelry manufacturing center. Indeed, labor-intensive India may well become a source for finished diamond jewelry, as other Asian centers have done over the past decade. Relaxed government restrictions for both diamond and gold imports further enhance India's future potential in this area. *William E. Boyajian*

X-ray studies of the growth of natural diamond. M. Moore, *Industrial Diamond Review,* Vol. 48, No. 525, 1988, pp. 59–64.

After describing how the crystal structure of diamond diffracts X-rays, Dr. Moore explains the basics of X-ray topography and how it provides an image of extended defects present in a crystal. The use of synchroton radiation is also described, because it allows for shorter exposures and a wavelength of 1 Å, which is the best condition to reveal crystal imperfections in diamond. The study of extended defects provides information about the growth history of any given diamond crystal. The author's observations are summarized below.

With relatively undisturbed growth conditions, diamonds grow slowly along their most stable (octahedral) faces; this is called faceted growth. Dissolution and regrowth can create notched octahedra. Diamond may also grow as fibers along octahedral directions, resulting in a rough cubic morphology. If faceted octahedral growth is followed by fibrous growth, the result is a coated stone.

Sometimes growth occurs on curved surfaces where the average orientation is cubic. This is called cuboid growth.

X-ray topographs have proved that dissolution starting at the corners of an octahedron and propagating down the edges can transform the original crystal shape into a rounded rhombic dodecahedron. Twins form early on during growth, and depending on whether faceted or fibrous growth occurs, they lead to a macle or to interpenetrating cubes. Tetrahedral diamonds are actually cleavages of larger octahedra.

In conclusion, X-ray topography of various shapes of natural diamond crystals demonstrates that growth usually occurs on octahedral faces or in octahedral directions, with the exception of cuboid growth. *EF*

GEM LOCALITIES

L'amethyste au Brésil. Classification et localisation des gites – inclusions (Amethyst in Brazil. Classification and localization of the deposits – inclusions). J. Cassedanne, *Revue de Gemmologie a.f.g.,* No. 94, 1988, pp. 15–18.

Professor Cassedanne delivers the first in a two-part article dedicated to proposing and illustrating a classification for amethyst deposits in Brazil. Five main categories will be described: geodes in trapps (basaltic formations covering extended areas), deposits in fractures, granitic pegmatites, deposits in granitoids, and detrital deposits. This first installment describes trapps and one type of deposit in fractures, hydrothermal veins.

Amethyst-bearing geodes in Mesozoic trapps are all located in the Parana basin in southern Brazil. Most of the production today is in the Iraí area, in northwestern Rio Grande do Sul. How the geodes form is not yet understood, although we do know that they usually occur in stringers, with a green cortex of celadonite. The amethyst crystals found in these geodes rarely are longer than 10 cm, and only a very small portion of the production is gem quality. Most of the crystals are sold as mineral specimens. The various inclusions observed in this amethyst are listed. It is also noted that amethyst found in such geodes often fades on prolonged exposure to sunlight.

The hydrothermal deposition of amethyst in fractures almost always occurs in Precambrian rocks. Crystals, usually pyramidal, can reach 25 cm. The filling material may be clay, chalcedony, or milky quartz. Amethyst from this type of deposit may turn golden yellow, brownish orange, or green when heat treated. Crystals from the veins at Coruja and Montezuma turn yellow or green with heat treatment. These amethysts are described in some detail and possible inclusions are listed. A map and several illustrations of the deposits are provided. *EF*

Emeralds from Somondoco, Colombia: Chemical composition, fluid inclusions and origin. A. Kozlowski, P. Metz, and H. A. Estrada Jaramillo, *Neues Jahrbuch für Mineralogie Abhandlungen,* Vol. 159, No. 1, 1988, pp. 23–49.

The authors studied beryl samples from the Achiote emerald deposit, which is located in the Chivor region of Colombia, near the town of Somondoco, about 80 km east of Bogotá. The Cáqueza group, composed of limestones, black shales, and arenites, hosts the emerald-bearing veins, which probably resulted from fracturing associated with the San Fernando fault. The beryl samples studied were found at the Juntas No. 1 mine, in a quartz vein with calcite, pyrite, and albite/oligoclase. The samples range from almost colorless to dark green, and from 1 to 10 mm long. The techniques used for this careful study include the electron microprobe, chemical colorimetry, emission spectrography, thermogravimetry, and infrared absorption, as well as a heating and cooling stage light microscopy.

Fluid inclusions typically show about 75% water solution, 10% gas, up to 3% liquid CO_2, and 12% to 15% NaCl crystals. Frequently, carbonate daughter crystals are also found, and liquid hydrocarbon was detected in some inclusions. The total concentration of salts in the water solution is close to 40 wt.%; in addition to Na and

Cl, the solution contains Ca in significant amounts. Other elements present are Si, Al, Fe, K, Mg, Mn, Ti, and Cr. The deficient stoichiometry of the beryl is discussed in great detail.

The authors estimate that the emeralds formed under a pressure of approximately 1 kbar, in the water solution described above, at temperatures around 470°C (derived from the temperature of homogenization of the fluid inclusions). Several indications are given that the source of beryllium and NaCl might be the surrounding rocks. If this is the case, calculations show that the emerald deposits of this region should actually be richer in gems than they are, and the authors propose a few possible explanations for why they are not. *EF*

The emeralds of Fazenda Boa Esperança, Tauá, Ceará, Brazil: Occurrence and properties. D. Schwarz, H. A. Hänni, F. L. Martin, Jr., and M. Fischer, *Journal of Gemmology*, Vol. 21, No. 3, 1988, pp. 168–178.

This thorough and concise article describes the occurrence and properties of the emeralds from the title locality in Tauá, Brazil. Maps of the geography, regional geology, and local geology accompany a detailed description of the occurrence, which is essentially pegmatitic. Associated minerals include quartz, albite, garnet, muscovite, biotite, beryl, columbite-tantalite, tourmaline, apatite, molybdenite, and bismuth or bismutite.

Microprobe analyses of six specimens reveal typical compositions for natural emeralds, with low Cr, little or no V, but relatively high Fe. The Tauá emeralds contain numerous mineral inclusions: Biotite/phlogopite, tremolite, allanite, molybdenite, and apatite have been identified (microprobe analyses of the first three are provided). Also observed were orangy-red irregular crystals that could not be identified. Eleven excellent photomicrographs illustrate the inclusions.

In general, the quality of the Tauá emeralds is poor by gemological standards. Large-scale mining operations were halted after it was determined that they were not economically feasible. *CMS*

Mineraliensuche in Nevada und Utah (Mineral prospecting in Nevada and Utah). E. Schuhbauer, *Lapis*, Vol. 13, No. 5, May 1988, pp. 11–27.

For the mineral collector seeking unusual specimens of great beauty, Nevada and Utah hold singular promise. Areas covered in this article include the White Caps mine in Nevada, the Steamboat Hot Springs, the Copper Basin in Battle Mountain, Nevada, the Thomas Range and, of course, the Violet claims in the Wah Wah Mountains of Utah. Also provided is a list of 17 important mineral sites throughout the area and a map that identifies the location of each. A collection of exquisite mineral photographs, as well as several locality shots, illustrates the article. Some of the beautiful minerals depicted are red beryl, green beryl, topaz, garnet, and zircon. *RW*

INSTRUMENTS AND TECHNIQUES

Etch figures on beryl. J. I. Koivula, *Journal of Gemmology*, Vol. 21, No. 3, 1988, pp. 142–143.

A brief text accompanies the four superb photomicrographs that are the main purpose of this note. Mr. Koivula's color photos illustrate the most common etch features encountered on natural beryl crystals. The author refers the reader to John Sinkankas's "excellent book" *Emerald and Other Beryls* for detailed drawings of numerous other etch figures. *CMS*

Notes on the inclusions in a greyish kyanite. A. Ghera, G. Graziani, and E. Gübelin, *Journal of Gemmology*, Vol. 21, No. 2, 1988, pp. 83–87.

This article presents a thorough chemical, optical, and physical description of a grayish blue gem-quality kyanite crystal and its crystalline inclusions. Microprobe analyses are provided for the kyanite and four of its inclusions: andalusite, apatite, calcite, and zircon. Also described are needle-like euhedral channels filled with minute andalusite crystals, yellow slabs formed by thin lamellae (probably lepidocrocite) intergrown with brownish red iron oxide and hydroxide platelets, and colorless transparent crystals (apparently kyanite). Minute needles, possibly TiO_2, were also observed intergrown with apatite crystals. Conditions of formation for this kyanite sample are drawn from the properties and inclusions observed. Nine photomicrographs clearly illustrate this excellent descriptive study. *CMS*

JEWELRY ARTS

Gold chains and mesh–I. J. Wolters, *Aurum*, No. 31, 1987, pp. 46–57.

In this first of a two-part article, the author skillfully leads us through the history of chain making in a brief but concise manner. He describes the various types of chain and mesh devised, and outlines the development of machines for chain making in the 18th and 19th centuries. The earliest examples of gold chain were found in the tombs of Ur, dating from around 2400 B.C. Known as the foxtail or column chain, this style continued to dominate for the next 3,000 years. The various types that subsequently gained favor are also discussed in detail.

Although the article does not cover chains embellished with gems or enamel, since it is limited to "chains made of precious metal wire, tubing or sheet," it is nevertheless an important account of this aspect of the jewelry manufacturing arts. The article is peppered with references and is well illustrated with photos, engravings, and drawings of chains, meshes, and the machinery developed to make them. *EBM*

Precolumbian jewelry from Peru. T. Gessler, *Ornament*, Vol. 11, No. 3, 1988, pp. 50–55.

As Gessler, curator of the Queen Charlotte Island

Museum in British Columbia, Canada, states, this article provides a "rare glimpse at authentic South American precolumbian design in jewelry." The author points out how unusual it is to find intact bead jewelry from the Inca and pre-Inca periods, because most of the cords on which they were strung are perishable. It is much more common to find individual beads from dismantled necklaces or bracelets. Included in Gessler's 13 photographs, however, are necklaces of shell with some silver that are strung on their original cord. Not only does this intact jewelry give an accurate idea of the materials used, but it also provides examples of the designs employed. This well-researched article is a "must read" for anyone interested in pre-Columbian jewelry. *DMD*

The unconventional Elizabeth Gage. J. Fallon, *W*, May 2–9, 1988, p. 57.

Jewels by Elizabeth Gage exhibit a unique blend of styles derived from classical, baroque, and contemporary designs. Her motto for designing jewelry is "no rules."

Most of her creations are one-of-a-kind pieces fabricated in gold with an unusual mix of gems accented by enameling and granulation. In fact, about 40% of her business is in special commissions. Only her enameled-gold Zodiac Ring Series is produced in quantity.

Gage's creations are sold exclusively at her shop in London, with the exception of the few days each year that she exhibits in New York and occasional special showings. Perhaps the secret to her success is her exclusivity: Owners of her pieces feel that they are members of a special elite. By not allowing commercialism to consume her, she has been able to maintain control over her business; thus, there is little likelihood of her creations ever becoming overdone or trite. *EBM*

SYNTHETICS AND SIMULANTS

Characterization of Russian hydrothermally-grown synthetic emeralds. K. Schmetzer, *Journal of Gemmology*, Vol. 21, No. 3, 1988, pp. 145–164.

Dr. Schmetzer's meticulous attention to detail is evident in this thorough study of 13 faceted Russian synthetic emeralds. Following a review of previous work reported on similar material, he cites the observation of anomalous absorption features, as well as traces of nickel and copper, as the stimulus for his current work.

Chemical, optical, and physical data for one representative sample are provided in their entirety. In general, although the standard gemological properties of the synthetic overlap with those of natural emeralds, chemical analysis and microscopy provide means of separation.

An extensive discussion of optical and infrared absorption features and how they relate to color and chemistry is included. Descriptions of inclusions and growth features essentially confirm previous reports; 18 photomicrographs will aid the gemologist in identifications.

Of special value in this article is Dr. Schmetzer's review of the Russian literature on synthetic beryl, most of which is published only in Russian. In fact, the bibliography as a whole is a useful resource. *CMS*

L'Emeraldolite, une nouvelle matière (Emeraldolite, a new material). D. Robert, *Revue de Gemmologie a.f.g.*, No. 94, 1988, pp. 9–10.

"Emeraldolite" is a several-millimeters-thick epitaxial overgrowth of synthetic emerald on natural "ivory-white" beryl. Because it is not similar to anything found in nature, it should not be an identification problem for gemologists. "Emeraldolite" can be used for jewelry purposes in the rough, taking advantage of the multitude of small sparkling crystals; it is particularly suited to cameos and other types of carving, as one can play on the contrast of the green overgrowth with the "ivory-white" seed. Two color and six black-and-white photographs accompany the short description of this new synthetic gem material. *EF*

Hallmarked synthetic emerald. A. Hodgkinson, *Journal of Gemmology*, Vol. 21, No. 3, 1988, pp. 179–181.

Nine photomicrographs illustrate features recently observed by Mr. Hodgkinson in two specimens of Lennix synthetic emerald. These include growth lines; multiphase inclusions of gas, flux, and phenakite; ball-like aggregates of phenakite crystals; and features that mimic the negative-prism cavities that are characteristic of emeralds from India. This note serves to remind gemologists that the Lennix synthetic emeralds require special attention, since their inclusions are numerous and frequently look natural. *CMS*

Lechleitner synthetic rubies with natural seed and synthetic overgrowth. K. Schmetzer and H. Bank, *Journal of Gemmology*, Vol. 21, No. 2, 1988, pp. 95–101.

This very thorough article describes new material produced by Lechleitner that consists of natural corundum overgrown with a layer of Verneuil synthetic ruby. While more difficult to identify than the earlier synthetic ruby overgrown on synthetic corundum, this new Lechleitner product does have a variety of distinctive characteristics. The optical absorption spectrum reveals features arising from a combination of Cr^{3+} in the overgrowth layer and Fe^{2+}/Ti^{4+} in the natural seed, although it is not stated whether these features can be seen with a hand spectroscope. Also useful is the presence of molybdenum as detected by X-ray fluorescence. Of more use to the trade gemologist, however, are microscopic features such as angular growth planes, negative crystals, and rutile needles characteristic of Sri

Lankan corundum, in conjunction with flux residues, needle-like inclusions (not previously described), and growth boundary features. These are well illustrated in 18 black-and-white photomicrographs. Two color photographs of the material also accompany the article.
CMS

Low-pressure, metastable growth of diamond and "diamondlike" phases. J. C. Angus and C. C. Hayman, *Science,* Vol. 241, No. 4868, August 19, 1988, pp. 913–921.

Because of diamond's remarkable properties as a crystalline solid, its synthesis has attracted much scientific attention. Following the successful development of a process to crystallize diamond in the mid-1950s, research on diamond synthesis has taken two different but parallel directions. The first is the high-pressure growth of diamond from a molten metal solvent-catalyst at pressures where diamond is the thermodynamically stable phase of carbon. This process has been used to produce small synthetic diamonds for industrial use and, more recently, single crystals up to several carats in size. The second area of research is the growth of diamond at low pressures, where it is a metastable phase. This article provides an excellent summary of the historical development of the latter research area and the current understanding of the processes involved.

Synthetic diamond grown at low pressures is produced as a thin film on a substrate material. Initial efforts succeeded in forming diamond thin films only at extremely slow growth rates. Recent developments, however, have led to a number of processes that can grow diamond thin films at much faster growth rates. The thin films produced thus far consist of a polycrystalline aggregate of diamond. Because hydrogen plays an important role in the crystallization of carbon at low pressures, some of these films are not identical to diamond; rather, they are called "diamondlike" carbons and hydrocarbons, with physical properties that are slightly different from those of thin-film polycrystalline diamond. Nevertheless, these thin films also have a number of potential technological applications. This article compares the properties of all three classes of materials and concludes with some observations of likely future developments in this area. In addition, it provides an extensive 107-item bibliography. For those interested in a review of diamond thin films, the article presents current information in a journal that is readily available.
JES

Synthetic opal. A. Hodgkinson, *Journal of Gemmology,* Vol. 21, No. 2, 1988, p. 73.

The author notes two characteristics that may help identify some synthetic opals manufactured in Japan in the early 1980s: a "venetian blind" effect visible with immersion and polarization under magnification, and lack of fluorescence and phosphorescence to long-wave ultraviolet radiation. The venetian-blind effect is illustrated.
CMS

TREATMENTS

Die Abkühlungsgeschwindigkeit als Ursache für die Bildung entweder von Sternkorunden oder von kornblumenblauen Saphiren (The influence of cooling history to produce either star corundum or cornflower blue sapphire). H. Harder and A. Schneider, *Neues Jahrbuch für Mineralogie Monatshefte,* No. 8, August 1987, pp. 344–346.

The authors discuss the role of iron and titanium in the coloration of blue sapphires. They believe that Fe^{2+}-Fe^{3+} charge-transfer alone, without the participation of Ti, could give a blue coloration.

Corundum containing Ti can follow two types of cooling behavior during its geologic history. If it cools slowly, as is typical of regional metamorphism, titanium oxide exsolution creates rutile inclusions, resulting in a star sapphire. If the corundum cools very fast, as in a volcanic environment, no exsolution occurs and cornflower blue sapphires are created.
EF

Investigation of cat's-eye zircons from Sri Lanka. M. Gunawardene and M. Gunawardene, *Journal of Gemmology,* Vol. 21, No. 2, 1988, pp. 88–91.

The recent abundance of cat's-eye zircons from Sri Lanka prompted this study, which revealed that most were being produced by heat treatment. Comparison of samples (the exact numbers are not given) of natural and heat-treated material disclosed a number of distinguishing characteristics: R.I., S.G., absorption features visible with a hand spectroscope, and microscopic features. Differences in the spectra suggest that the heat-treated material is high-type zircon, whereas the natural cat's-eyes are of the intermediate type. The most notable difference, however, is that the chatoyancy in natural cat's-eye zircons is due to parallel hollow or growth tubes, whereas the heat-generated phenomenon is caused by minute oriented disc-shaped fissures; both types of features can be observed with a gemological microscope. Photomicrographs illustrate these characteristic features.
CMS

NRC encore: More topaz blues. S. Mitchell, *American Jewelry Manufacturer,* Vol. 36, No. 5, May 1988, pp. 32–42.

After prolonged negotiations with the AGTA, the Nuclear Regulatory Commission (NRC) announced in January of this year that, due to the importance of blue topaz to the jewelry industry, they would "act expeditiously on the licensing of domestic reactors and importers." Added to this was the warning that "failure to obtain a proper license could result in enforcement action." As of the date this article was published, no licenses had been forthcoming, despite the good intentions of many laboratories and importers who have applied. In this overview, the author leads us through the governmental labyrinth, pointing out the pitfalls and dead ends that exist. Even though the article cannot answer all the questions that have been raised, it does bring many of them into sharp focus: Are the regulations fair? When will they be put into effect? Will they be enforceable? What will be the costs? Everyone is wondering what will happen next. *EBM*

Role of natural radiation in tourmaline coloration. I. M. Reinitz and G. R. Rossman, *American Mineralogist,* Vol. 73, No. 7/8, 1988, pp. 822–825.

Previous studies have shown that both gamma and X-radiation develop and intensify the pink color in elbaite tourmaline. In addition, heat treatment at 600°C removes the pink coloration from both natural and laboratory-irradiated elbaites. Comparison of the optical absorption spectra of colorless and pink elbaites indicates that the oxidation state of the manganese changes from 2+ to 3+ during radiation exposure. The Mn^{3+} produces the pink color. Both naturally pink and laboratory-irradiated elbaites show the same spectroscopic features. In experiments using different amounts of radiation exposure, the authors found that the concentration of Mn^{3+} in a pink elbaite correlated with the dose of radiation received by the sample.

From these observations, the authors conclude that the color in naturally pink elbaite is due to natural radiation exposure. This conclusion is supported by measurements of radiation levels in tourmaline pockets in Southern California pegmatites. The radiation dose computed from these measurements generally corresponds to the dose that will induce pink color in elbaite by laboratory irradiation.

The authors also conclude that natural pink color develops in elbaite only if irradiation occurs after the pegmatite has cooled below the temperatures known to bleach such color. Thus, most pink elbaite initially formed in a colorless state and only later attained a pink color through the oxidation of manganese via ionizing radiation.

The results of this study suggest that the gemological separation of naturally colored from laboratory-irradiated deep pink elbaites may be impossible because, in both instances, the cause of color is radiation exposure. *JES*

Thermal stability of yellow colour and colour centres in natural citrine. K. Schmetzer, *Neues Jahrbuch für Mineralogie Monatshefte,* No. 2, February 1988, pp. 71–80.

Several bleaching and irradiation experiments were performed on natural citrines to better understand the thermal stability of the various color centers. The author deduced from these experiments the presence of five different color centers, which are defined by either their optical absorption or their thermal behavior. Two electron energy band models are proposed for the bleaching of these centers, but no comment is made as to the physical description of the color centers themselves. *EF*

MISCELLANEOUS

Contemporary jewelry. J. Tenhagen, *Lapidary Journal,* Vol. 42, No. 5, 1988, pp. 49–52.

Written as a broad overview, this article describes Tenhagen's approach to evaluating a modern jewelry item. Focusing on a woman's cluster ring that contains colored and white stones, the author outlines the steps he would take in the appraisal process. The article includes brief discussions of proper gemstone identification, quality estimations, measuring, manufacturing considerations, and price estimates.

This article is not intended to address the complete appraisal format, for which proper training is recommended. However, it does present one person's approach to the appraisal procedure. *JLC*

An introduction to mineralogy. F. H. Pough, *Lapidary Journal,* Vol. 42, No. 4, July 1988, pp. 21–34.

Dr. Pough discusses the major categories and divisions that comprise the subject of mineralogy. The subcategories of composition, physical properties, crystallography, and modes of formation are covered briefly in lay terms. Dr. Pough's illustrative writing style is easy to follow and understand. *Bill Videto*

Notes from the laboratory—12. K. Scarratt, *Journal of Gemmology,* Vol. 21, No. 3, 1988, pp. 131–139.

Mr. Scarratt's latest report includes a thorough description of recently encountered specimens of Lennix synthetic emerald, Adachi synthetic beryl (red, purple, blue, and watermelon), and Kyocera synthetic emerald, star ruby, alexandrite (including cat's-eye), blue sapphire, and opal. Also briefly described are the continued encountering of glass- and plastic-filled cavities in rubies, a compact disk–like tension halo in a heat-treated sapphire, and a "fashion stone" of unknown nature that is being marketed as "fluorolith" and exhibits pronounced green phosphorescence when it is exposed to visible light. For archeo-gemology buffs, Mr. Scarratt cites an 1830 edition of R. J. Bridges' *Familiar Lessons on Mineralogy and Geology,* in which an unusual test for diamond is described that involves two pennies. Twenty-nine informative color and black-and-white photographs accompany the text, although the reader may encounter some brief confusion from the irregular order of figures 18–26. *CMS*

BOOK REVIEWS

Elise B. Misiorowski, Editor

GEMS AND JEWELRY APPRAISING

*By Anna M. Miller, 198 pp., illus., publ. by Van Nostrand Reinhold, New York, 1988. US$29.95**

With the emerging acknowledgment of appraising as a field of professional endeavor, *Gems and Jewelry Appraising* is a welcome addition to the "how to be an appraiser" genre.

This well-organized and remarkably complete reference guide differs from its predecessors in that it is written by a professional appraiser for the professional appraiser. The author, working from years of personal experience and with an extensive bibliography, has assembled a useful tool for anyone who may do appraisals, from the retail jeweler who does them only occasionally to the full-time independent appraiser. Tables and charts, historical data, and helpful caveats make this book an important part of every gemological library.

Basics such as appraisal concepts and opening or adding an appraisal service lead to discussions of the different purposes and functions of appraisals. Valuable suggestions on take-in, preparation, and actual appraisal procedures are given. Unfortunately, an overdone discussion of telecommunications is followed by a section on regional pricing that doesn't seem to make its point. A full chapter is devoted solely to the pricing of less common items, but there is no mention elsewhere of modern cut diamonds or commonly used colored gemstones, a sign that this book is not intended for the novice. A chronological history of jewelry from antiquities to "new-wave," touching on many different types of jewels, adds a unique dimension. Also covered are watches, carvings, and silverware. The book concludes with chapters on the legal and ethical aspects of appraising, techniques for expert witnesses, sample report formats, and additional sources of information.

The subject matter is presented in a concise manner, and the text is quite readable. The lack of color photography is disappointing, but this was never meant to be a coffee table book. The trade-off is reasonable considering the relatively low price.

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DICTIONARY OF GEMMOLOGY, 2nd edition

*By Peter G. Read, 266 pp., illus., publ. by Butterworths, London, 1988. US$49.95**

There is no question that Mr. Read's book makes a valuable addition to the gemological literature. It has been many years since a new edition of the Shipley *Dictionary of Gems and Gemology* last appeared, and a good up-to-date gemological dictionary is certainly needed.

Twenty-two pages have been added since the first edition (which was published in 1982). On the whole, the vast majority of essential entries are included, and generally the definitions are clearly worded and understandable. There are, however, weaknesses in some specific areas.

One category that leaves something to be desired is that of pearls and cultured pearls. There seems to be no reference to tissue nucleation (or mantle tissue nucleation) of cultured pearls, or to the existence of freshwater cultured pearls. Black pearls are mentioned as coming only from the Gulf of Mexico, with the waters of the South Seas conspicuously absent. Freshwater pearls are to be found in "Scandinavia, Canada, and the U.K.," but there is no mention of the rest of Europe or of the U.S., let alone Japan or China.

Often, after an entry, a "see" another entry will follow. The relationship is frequently left to the reader's imagination. For example, after the entry *fowlerite* comes "see rhodonite." Under rhodonite, there is no mention of the fowlerite variety.

The Hoge Raad people will be startled by the omission of the International Diamond Commission Grading Standards for Diamonds in Read's table comparing the different standards used in various parts of the world, or worldwide. In addition, Burma sapphire is described as a synthetic. Also, there is an entry for "shatter marks," followed by "see fire marks." Does he mean "chatter marks," or is this another difference between U.K. English and the version used in the "colonies"?

However, these are minor cavils about individual items in what is a very useful publication overall. Anyone can gain a wealth of information from this dictionary. Even though the tag seems a bit pricey for a volume of less than 300 pages without color, the book is a worthwhile addition to any gemological library.

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MODERN JEWELER'S GEM PROFILE, THE FIRST 60

*By David Federman and Tino Hammid, 129 pp., illus., publ. by Vance Publishing Corp., Lincolnshire, Illinois, 1988. US$39.95**

Subscribers to *Modern Jeweler* who enjoy the "Gem Profile" section that appears in each issue will savor this collection of award-winning pieces and superb photos (a total of 60) from the past five years.

As Richard T. Liddicoat says in the foreword, "No one investigates a subject in more depth than Mr. Federman and no one writes with greater clarity on the matters that he

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**This book is available for purchase at the GIA Bookstore, 1660 Stewart Street, Santa Monica, CA 90404. Telephone: (800) 421-7250, ext. 282.*

studies so assiduously." Further, his turn of phrase is frequently amusing as well as illuminating. For instance, rough sapphires that refuse to change color with heat treatment become "incorrigible corundums" as opposed to "redeemable roughs." Frequently his color descriptions, while spectrally unacceptable, lend sense and humor. For instance, who can fail to visualize "bubble gum pink"? (Less identifiable to this reviewer is "eye-shadow blue.")

When the author uses spectral colors in his description, however, a few less than satisfactory terms result. For instance, basically red gemstones such as ruby are referred to as "violet or violetish red," but should be termed purplish red. More unjustified is the description of rhodolite garnet as an "intense-violet." Perhaps all who are concerned with color nomenclature would do well to review that old nursery rhyme, "Roses are red, violets are blue . . .," because violet is right next door to blue. Between violet and red comes purple (actually a nonspectral but necessary term).

Tino Hammid's gem portraits have been acknowledged as among the best currently being taken. In fact, some may be too good! This reviewer has rarely if ever seen color changes as complete as the photographs of both Brazilian and Russian alexandrites shown here. These idealistic photos could come to haunt an inexperienced jeweler looking to satisfy a customer who expects that result. As textbook illustrations, of course, they are excellent.

Admirably, the authors make no pretense at completeness since these are profiles. To some purists, however, several of the titles belie the fact that they were written by the doyen of disclosure. For example, by "Chinese Fresh Water Pearl," he means cultured pearl, just as he does in "Japanese Akoya Pearl" (few readers know what Akoya means) and "Tahiti Black Pearl." It would also seem to be in line with the instructional goal of these profiles to indicate in the title that indicolite and rubellite are tourmaline.

One especially well-rounded profile, though, is that for peridot. Entitled "Burma Peridot," it is actually a good discussion of all current commercial peridot sources.

In the nit-picker's corner would have to be placed certain errors of fact or observation or spelling. For instance, "synthesized plastic imitation" under amber is a singular usage; the effect seen in cat's-eye is reversed; the shape of the Hope diamond is cushion antique, while the Tiffany is square antique; Malaya garnet is not a species, but a group mixture or variety. In the excellent profile of lapis lazuli and sodalite, the latter is misspelled four times as "sodolite." Finally, it is difficult to picture "colorlessness" in coral.

All in all, *Modern Jeweler's Gem Profile, The First 60* accomplishes the author's goal "to teach, to inform and delight." The quality of the color reproductions, the format, and the innovative text make this book a must for all who love gemstones—particularly readers of *Gems & Gemology.*

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THE HISTORY OF BEADS

*By Lois Sherr Dubin, 364 pp., illus., publ. by Harry N. Abrams, New York, 1987. US$60.00**

Brilliantly organized and genuinely readable, this long-awaited book is the first comprehensive history of beads and the role they have played in society since the advent of modern man. Author Dubin focuses on 12 geographic areas where beads are known to have been important. The social, political, spiritual, psychological, and aesthetic significance of beads within the various cultures is examined, as is the archaeological and technological information that beads carry. The international trade patterns of beads are not only explained but are also charted in 15 maps of bead sources and distribution patterns worldwide.

Dubin took a scholarly approach to this project, which required five years to complete. In her research, she enlisted the help of many respected bead scholars and gained access to the finest private and museum bead collections. All the contributors, from Dr. Robert K. Liu of *Ornament* magazine to the researchers at the British Museum, shared their best.

The result of this major collaborative effort is immensely informative and absolutely gorgeous. The 364-page book features 356 illustrations, 254 of them in color. The eight-page, full-color foldout bead/time chart is inspired. By showing 2,000 beads assembled in time lines, it visually places every important bead type in its cultural and historic context. The sensitivity of the photography does justice to the magnificent artifacts it records, and qualifies *The History of Beads* as an art book filled with powerful visual imagery as well as a landmark text.

In Harry N. Abrams, Dubin found the perfect publisher. Using first-class talent and materials, Abrams has given the charts, illustrations, and photographs the elegant presentation they merit. Excellent editing keeps the text clear and concise down to the last meticulously prepared annotation, although careful reading reveals occasional contradictions, a reminder that bead research is an evolving area of study, with new facts constantly being discovered and new interpretations being set forth.

The History of Beads is a recommended investment. Not only is it an exciting and essential reference for knowledgeable bead enthusiasts, but it is also the perfect vehicle to introduce the general public to the true significance of beads.

LOIS ROSE ROSE
Past President, The Bead Society
Los Angeles

Suggestions for Authors

The following guidelines were prepared both to introduce you to *Gems & Gemology* and to let you know how we would like a manuscript prepared for publication. No manuscript will be rejected because it does not follow these guidelines precisely, but a well-prepared manuscript helps reviewer, editor, and reader appreciate the article that much more. Please feel free to contact the Editorial Office for assistance at any stage in the development of your paper, whether to confirm the appropriateness of a topic, to help organize the presentation, or to augment the text with photographs from the extensive files at GIA. We look forward to hearing from you.

INTRODUCTION

Gems & Gemology is an international publication of original contributions concerning the study of gemstones and research in gemology and related fields. Topics covered include (but are not limited to) colored stones, diamonds, gem instruments, gem localities, gem substitutes (synthetics), gemstones for the collector, jewelry arts, and retail management. Manuscripts may be submitted as:

Original Contributions—full-length articles describing previously unpublished studies and laboratory or field research. Such articles should be no longer than 6,000 words (24 double-spaced, typewritten pages) plus tables and illustrations.

Gemology in Review—comprehensive reviews of topics in the field. A maximum of 8,000 words (32 double-spaced, typewritten pages) is recommended.

Notes & New Techniques—brief preliminary communications of recent discoveries or developments in gemology and related fields (e.g., new instruments and instrumentation techniques, gem minerals for the collector, and lapidary techniques or new uses for old techniques). Articles for this section should be approximately 1,000–3,000 words (4–12 double-spaced pages).

Gems & Gemology also includes the following regular sections: *Lab Notes* (reports of interesting or unusual gemstones, inclusions, or jewelry encountered in the Gem Trade Laboratories), *Book Reviews* (as solicited by the Book Review Editor; publishers should send one copy of each book they wish to have reviewed to the Editorial Office), *Gemological Abstracts* (summaries of important articles published recently in the gemology literature), and *Gem News* (current events in the field).

MANUSCRIPT PREPARATION

All material, including tables, legends, and references, should be typed double spaced on 8½ × 11" (21 × 28 cm) sheets with 1½" (3.8 cm) margins. Please identify the authors on the title page only, not in the body of the manuscript or the figures, so that author anonymity may be maintained with reviewers (the title page is removed before the manuscript is sent out for review). The various components of the manuscript should be prepared and arranged as follows:

Title page. Page 1 should provide: (a) the article title; (b) the full name of each author (first name, middle initial, surname), with his or her affiliation (the institution, city, and state or country where he/she was working when the article was prepared); (c) acknowledgments of persons who helped prepare the report or did the photography, where appropriate; and (d) five key words that we can use to index the article at the end of the year.

Abstract. Page 2 should repeat the title of the article followed by an abstract. The abstract (approximately 150 words for a feature article, 75 words for a note) should state the purpose of the article, what was done, and the main conclusions.

Text. Papers should follow a clear outline with appropriate heads. For example, for a research paper, the headings might be: Introduction, Previous Studies, Methods, Results, Discussion, Conclusion, and Implications. Other heads and subheads should be used as the subject matter warrants. Also, when writing your article, please try to avoid jargon, to spell out all nonstandard abbreviations the first time they are mentioned, and to present your material as clearly and concisely as possible.

For general style (grammar, etc.) and additional information on preparing a manuscript for publication, *A Manual of Style* (The University of Chicago Press, Chicago) is recommended.

References. References should be used for any information that is taken directly from another publication, to document ideas and facts attributed to—or facts discovered by—another writer, and to refer the reader to other sources for additional information on a particular subject. Please cite references in the text by the last name of the author(s) and the year of publication—plus the specific page referred to, if appropriate—in parentheses (e.g., Liddicoat and Copeland, 1967, p. 10). The references listed at the end of the paper should be typed double spaced in alphabetical order by the last name of the senior author. Please list only those references actually cited in the text (or in the tables or figures).

Include the following information, in the order given here, for each reference: (a) all author names (surnames followed by initials); (b) the year of publication, in parentheses; (c) for a *journal,* the full title of the article or, for a *book,* the full title of the book cited; and (d) for a *journal,* the full title of the journal plus volume number and inclusive page numbers of the article cited or, for a *book,* the publisher of the book and the city of publication. Sample references are as follows:

Daragh P.J., Sanders J.V. (1976) Opals. *Scientific American,* Vol. 234, pp. 84–95.

Heinrich K.F.J. (1968) Common sources of error in electron probe microanalysis. In J. Newkirk et al., Eds., *Advances in X-ray Analysis,* Plenum Press, New York, pp. 40–45.

Liddicoat R.T. Jr., Copeland L.L. (1967) *The Jewelers' Manual,* 2nd ed. Gemological Institute of America, Santa Monica, CA.

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Type each table double spaced on a separate sheet. If the table must exceed one typewritten page, please duplicate all headings on the second sheet. Number tables in the order in which they are cited in the text. Every table should have a title; every column (including the left-hand column) should have a heading. Please make sure terms and figures used in the table are consistent with those used in the body of the text.

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Submit black-and-white photographs and photomicrographs in the final desired size if possible. Where appropriate, please use a bar or other scale marker on the photo, not outside it.

Use a label on the back of each figure to indicate the article's title (or a shortened version thereof) and the top of the figure. Do not trim, mount (unless one figure is composed of two or more separate photos), clip, or staple illustrations.

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MANUSCRIPT SUBMISSION

Please send three copies of each manuscript (and three sets of figures and labels) as well as material for all sections to the Editorial Office, in care of:

Alice S. Keller, Editor
Gems & Gemology
1660 Stewart Street
Santa Monica, CA 90404

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