GEM LOCALITIES OF THE 1980s

By James E. Shigley, Dona Mary Dirlam, Karl Schmetzer, and E. Alan Jobbins

The 1980s saw major developments in new sources for diamonds and colored stones, as well as expanded production at many existing mines. This article identifies important new discoveries, as well as localities that were major gem producers, during the decade. Brief descriptions are provided for many of these, and their impact on the jewelry industry is reviewed. The article also provides an index to key recent publications on these occurrences.

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The past decade has witnessed an unprecedented increase in the availability and popularity of many varieties of gemstones. The greater appreciation of all aspects of color in today's society has been reflected in the gem market by both new enhancement techniques and new synthetics, as discussed elsewhere in this issue, and has been supported by important discoveries in a number of new localities. Fine alexandrites from Brazil, sapphires from Southeast Asia and Australia, emeralds from Colombia and Zambia, and pegmatite gemstones (tourmaline, aquamarine, etc.) from Brazil, Pakistan, Afghanistan, and several countries in Africa were key components of the gem market during the last 10 years. At the same time, major quantities of colorless diamonds emerged from new mines in Australia and Africa, joining traditional suppliers to more than double the production of rough over the course of the decade.

This article highlights a number of these major gem deposits. It identifies important gem localities that were found during the last decade, and also those that were known before but either reached or continued at a major level of production during the 1980s (figure 1). In general, the discussion is restricted to the more commercially important inorganic gem materials, with the text organized alphabetically by gemstone. Of necessity in some instances, the decision as to which localities to include has been somewhat subjective. To minimize redundancy, most references to specific localities and gem materials are not included in the text, but rather are provided in table 1, which follows the text portion of this article.

A number of excellent books published in recent years include information on gem localities (as indicated at the end of the reference list). A comprehensive world map of gem localities, showing the types of gem materials produced and an indication of their geological settings, was created by Dr. E. Gübelin and published in 1988 by the

Figure 1. The excitement colored stones produced in the 1980s in large part grew out of the greater availability of gemstones from both traditional and new gem localities. East Africa emerged as one of the most important gem-producing regions. These six stones represent the remarkable variety of gems found there. From top to bottom, left to right, are a 42.33-ct pyrope-spessartine garnet, a 28.41-ct tanzanite, a 22.69-ct tourmaline, a 27.03-ct yellow scapolite, a 9.73-ct tsavorite garnet, and a 7.02-ct purple scapolite. From the John Jago Trelawney Gem Collection at the Los Angeles County Museum of Natural History; photo © Harold & Erica Van Pelt.

Swiss Gemmological Society. A simplified map of the major sources for important gem materials is provided in figure 2.

BERYL

Emerald. Major expansion has occurred in the sources of this very important gemstone. Colombia, long recognized as the principal supplier of high-quality material, must now compete with new localities in Brazil, Zambia, Zimbabwe, Madagascar (Malagasy Republic), Pakistan, and Afghanistan. However, important new mining developments helped Colombia retain a 30% share of the world output in the late 1980s (Barot, 1987). For example, under the direction of lessee companies Tecminas and Coesminas, the Muzo mine is now fully mechanized and has introduced a sophisticated tunneling operation. Prospecting in the region continues to provide new data on the geology and origin of these Colombian deposits, and there is every indication that they will remain an important source of high-quality emerald (figure 3).

Even so, newer sources now account for most of the emeralds on the world market. In the 1980s, deposits of major significance came into full operation in Brazil. The Carnaíba mine, first found in the 1960s, continued to be active during the 1980s. A major deposit found in 1981 at Santa Terezinha, in the state of Goiás, was highly productive throughout the decade. The Santa Terezinha crystals are generally small (less than 1 cm) and range from pale to very dark green, with a distinct bluish green tone (Cassedanne and Sauer, 1984). In 1988, new emerald discoveries were made in Bahia at Socotó, in Ceará at Tauá, and in Minas Gerais at Nova Era. The Nova Era deposit, which may be an

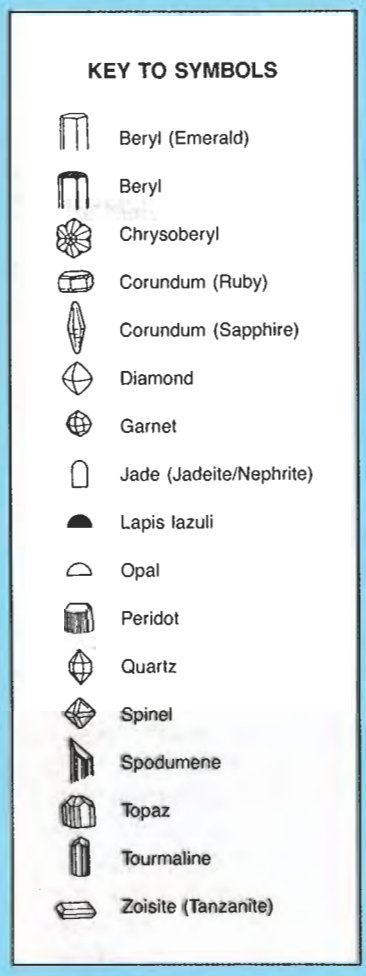


Figure 2. The symbols on this simplified world map indicate the important gem materials produced during the 1980s in the countries designated. For details on the specific locations within a country, please refer to the references listed in table 1. For a comprehensive map of historic and contemporary gem materials and their formation environments, see Gübelin (1988). Art by Carol Winkler.

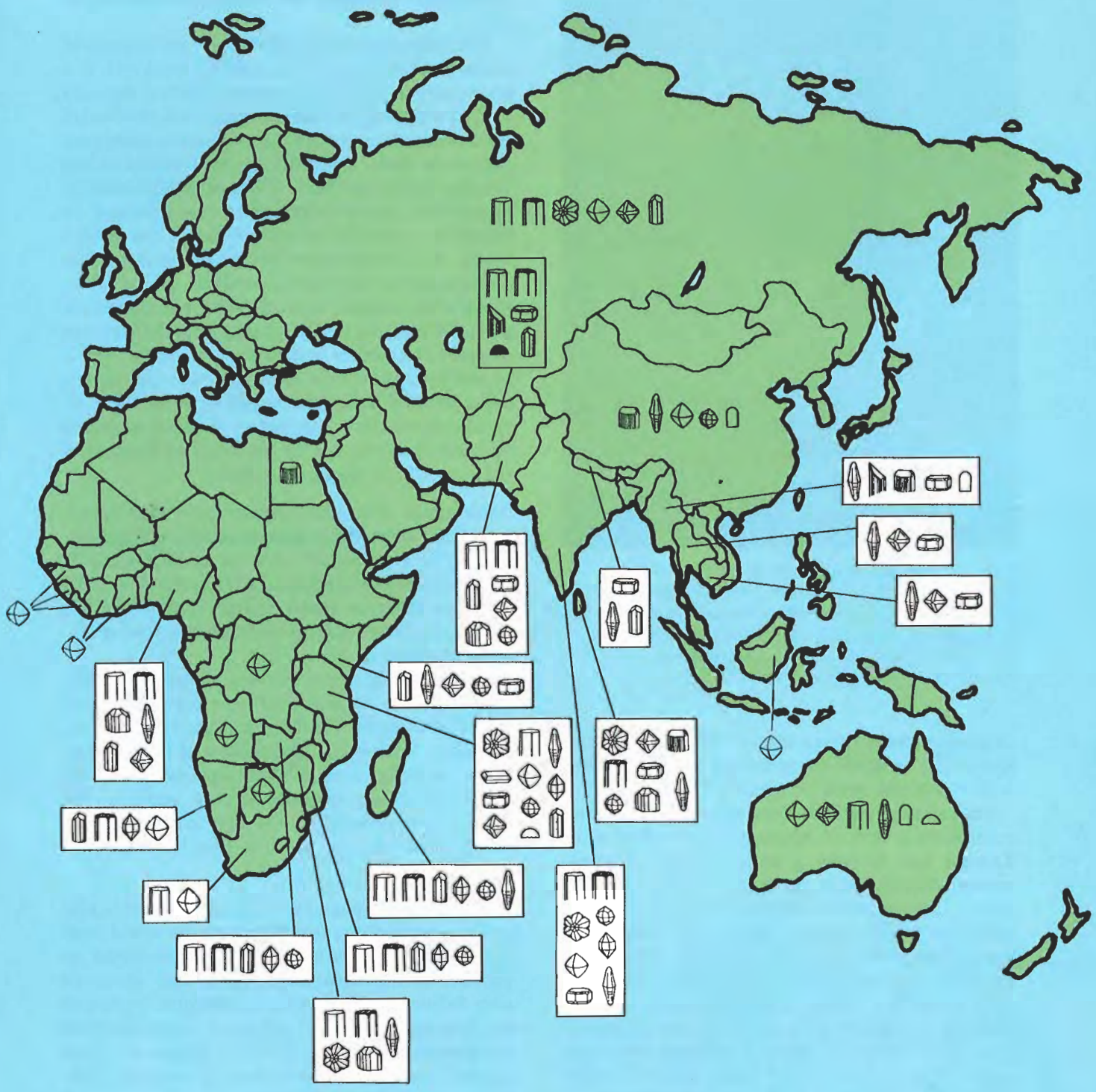


Figure 3. Colombia continues to produce some of the world's finest emeralds. One example of the spectacular specimens recovered in the latter part of the decade is this 6.03-cm emerald crystal. Courtesy of Tecminas; photo © Harold & Erica Van Pelt.

extension of the Itabira deposit discovered in the late 1970s, is noted for relatively large emeralds, with many cut stones exceeding 5 ct.

Important emerald deposits were found on other continents as well. In Africa, the Kitwe district in Zambia has become a major source of good, strongly bluish green, material. At Kafubu, crystals as large as 130 ct have been found; they are noted for being very dark green, with high R.I.'s (Sinkankas, 1981, p. 603). By 1989, 40% of all emeralds imported into the U.S. came from Zambia (Berenblatt, 1989). The Mberengwa area of Zimbabwe continues to produce fine material, particularly from the older Sandawana and more recently discovered Machingwe and Adriadne mines (Kanis, 1986). The emerald deposits of Madagascar occur in the southeast part of the island, at Ankadilalana, in a biotite schist. Hänni and Klein (1982a,b) described them as blue-green in color, similar to Zambian emeralds. Cavey reported in the 1989 *Mining Annual Review* that Madagascar produced the largest emeralds in Africa.

The 1980s also saw the first major influx into the world market of emeralds from Pakistan and, to a lesser extent, from Afghanistan. Several deposits in the Swat Valley of Pakistan produced material of good to excellent quality, although some stones are extremely dark. Emeralds are also mined in the Panjshir Valley northeast of Kabul in Afghanistan. Meanwhile, sparse information has appeared on emeralds recently recovered from the Soviet Union. All of these deposits produce material that rivals some of the best Colombian emeralds, although not, perhaps, with the same consistency. It is also interesting to note that most of these recent emerald discoveries occur in metamorphic rocks, in environments very different from the classic hydrothermal vein-type deposits found in Colombia; an excellent discussion of the occurrences of emerald worldwide can be found in Kazmi and Snee (1990) and Sinkankas (1981).

Aquamarine. The major source of gem aquamarine continued to be Minas Gerais, Brazil, where aquamarine is a principal constituent of numerous weathered pegmatite deposits (Proctor, 1984). The states of Espírito Santo, Bahia, Ceará, and Rio Grande do Norte also produce commercial quantities of aquamarine.

During the decade of the '80s, additional significant amounts of gem-quality aquamarine were found in Nigeria, Zimbabwe, Zambia (figure 4), Namibia, Madagascar, Pakistan, and India. Much of the material from Nigeria emerges from the ground in classic aquamarine blue, and does not require (nor respond to) the heat treatment routinely used on the greener Brazilian material (Barot, 1987).

Morganite. The pegmatites of Minas Gerais also provide most of the morganite on the world market. While the Urucum deposit continued to produce during the decade, a major find was made near Salinas in 1986. This occurrence, known as the Bananal mine, produced many large, bicolored morganite-aquamarine crystals. Many of these crystals contained large nodules of virtually flawless morganite at their centers—the first reported occurrence of gem nodules in a material other than tourmaline (Kampf and Francis, 1989). Early in the decade, significant amounts of light orange mor-

ganite were also mined in Mozambique, but supplies have been erratic in recent years because of the political turmoil in that country (Barot, 1989).

Other Beryls. The yellow variety, known as heliodor, also occurs in the pegmatites of Minas Gerais. Although much rarer than aquamarine, some attractive crystals were recovered in the 1980s. While pale stones were heat treated, those with good color survived as specimens or were cut into faceted stones (Proctor, 1984). Red beryl is the rarest of all the gem beryls. Commercial mining in the Wah Wah Mountains of Utah, begun in the late 1970s, continued sporadically during the 1980s. By the end of the decade, annual production averaged more than 200 stones greater than 0.25 ct and about 2,000 smaller stones (R. Harris, pers. comm., 1990).

CHRYSOBERYL

The gem fields of Sri Lanka continued to be the major source of fine chrysoberyl, particularly cat's-eye material. Alexandrites were occasionally found as well.

However, the 1980s saw several major new finds of chrysoberyl, cat's-eye chrysoberyl, and alexandrite in Brazil. Cassedanne (1984a,b) discusses the main localities and their geologic settings. Proctor (1988) describes the exciting discoveries of alexandrite in Minas Gerais, first in the Malacacheta region (1975) and then at the deposit near Lavra de Hematita (1986). The latter occurrence has furnished some of the finest alexandrite ever found (figure 5).

Although Russia has historically produced fine chrysoberyl and alexandrite, no reliable production information for this decade is available.

CORUNDUM

Ruby. The classic ruby occurrences of Southeast Asia (i.e., Mogok, Burma [Myanmar]; Chanthaburi, Thailand; and Pailin, Cambodia) continue to be major producers of ruby, but the 1980s also saw the exploitation of new occurrences in East Africa, specifically Kenya, Tanzania, and, more recently, Malawi (figure 6). Although the quality of material from these African localities may not always equal that of stones from Southeast Asia, it is regularly encountered in the trade. Cavey reports in the 1988 *Mining Annual Review* that heat treatment has been used extensively on stones from Thailand and Africa to improve color and clarity. Small amounts of ruby have also come from Pakistan, Afghanistan, India, and Nepal.

Figure 4. Aquamarine was one of the gems that benefited from increased mining throughout Africa. These two fine aquamarines are from Zambia: The pendant contains a 10.12-ct pear shape, while the ring is set with a 6.91-ct emerald cut. Jewelry courtesy of Andrew Sarosi; photo © Harold & Erica Van Pelt.

Sapphire. As with ruby, much of the sapphire in the jewelry trade today comes from Southeast Asia. During the 1980s, significant amounts continued to be found in Sri Lanka and Burma, with the Cambodian deposits largely remaining dormant until the end of the decade. The sophisticated operation at Kanchanaburi, in southwest Thailand, is a major new producer of natural-color blue sapphire (figure 7).

Two localities played a major role in the greater availability of sapphires during the 1980s: Australia and East Africa. Although both Queensland and New South Wales have long been known as sources of gem sapphire in a wide range of colors, only within the last 10 years did they reach a significant level of commercial production.

In East Africa, expanded production was seen from Kenya, Tanzania, Malawi, Burundi, and Rwanda. Particularly noteworthy are the sap-

Figure 5. In late 1986, gemologists enthusiastically welcomed the discovery of alexandrite at Lavra de Hematita, in Minas Gerais, Brazil. The attractive color change of two Brazilian stones (1.06 ct, center; 1.32 ct, right) is shown compared to a Russian alexandrite (1.29 ct, left). The two Hematita alexandrites are courtesy of Mayer & Watt, while the Russian stone is courtesy of Mary Murphy Hammid. Photo © Tino Hammid.

phires found along the Umba River in Tanzania, which occur in a wide range of colors (figure 8), with the orange and color-change varieties being especially interesting. These relatively new sources of corundum have contributed greatly to our understanding of the relationship between color, absorption spectra, and trace-element chemistry in this important gem material (see Schmetzer and Bank, 1981a). More recently, fine-quality material began to come out of the Kaduna area of Nigeria (Kiefert and Schmetzer, 1987b). In 1989, sapphires and star sapphires from new deposits in northern Kenya, close to the Ethiopian border, began to appear (N. Barot, pers. comm., 1989).

During the 1980s, more than ever before, heat treatment was used to alter the appearance or improve the color of sapphires of virtually every hue. While some of the blue material from Australia is of good color and clarity, much of the remainder—which is often affected by heavy silk—can be improved by heat treatment (Coldham, 1985). Large quantities of low-quality starting material, such as the pale white "geuda" that can be transformed into deep blue stones, originate in Sri Lanka (Gunaratne, 1981), as do considerable amounts of fine-quality untreated yellow sapphire, "padparadscha" sapphire, and asteriated stones.

Heat treatment has also contributed to the availability of sapphire from Montana. The past few years have seen a major effort to exploit the sapphire occurrences at a number of deposits in the areas of Rock Creek and the Missouri River as well as Yogo Gulch. Although the stones found typ-

Figure 6. In the 1980s, rubies continued to be produced from classic occurrences such as Burma and Thailand, as well as from newer localities such as Kenya and Tanzania. Many of these were cut en cabochon *as depicted here in a stunning ruby and diamond necklace. The pendant stone is 47.69 ct. Courtesy of Color by Design, B. Laird and B. Forrest; photo © Harold & Erica Van Pelt.*

Figure 7. Kanchanaburi, in southwest Thailand, emerged as a major producer of natural-color blue sapphire in the 1980s. It is noteworthy for both the large-scale production and the sophisticated mining operation. Note the size of this one excavation by the S.A.P. Company at Bo Phloi. Photo by Robert C. Kammerling.

Figure 8. From the Umba River valley in northeast Tanzania, comes this array of ruby and fancy-color sapphires. These unusual colors were widely marketed in the 1980s. Courtesy of Tsavo Madini, Inc.; photo © Tino Hammid.

ically are very small, heat treatment produces a variety of interesting colors. Using sophisticated retrieval techniques, mining concerns in Montana increased gem production over the course of the decade 1200%, from $100,000 to $1.3 million, primarily due to sapphire production (Austin, 1990).

In 1981, for the first time in almost four decades, Westerners visited the historic Kashmir deposits (Atkinson and Kothavala, 1983). Although it appears that these famous deposits still have significant mining potential, there has been little recent production.

New deposits with considerable future potential have been found in Fujian and Hainan Island, China. The first detailed report on Colombian sapphires was published in 1985 (Keller et al., 1985). Small sapphires recovered during gold-dredging operations in Minas Gerais, Brazil, were encountered at the 1990 Tucson Gem and Mineral Show.

DIAMOND

Some of the most exciting discoveries in the 1980s involved diamonds. At the end of the preceding decade, the three top producers (in quantities of rough) were the Soviet Union, Zaire, and South Africa. During the 1980s, Russian production remained significant and production in Zaire more than doubled (but continued to be primarily industrial-quality stones). Production also continued steadily at most of the classic South African mines, although there was some increase later in the decade with the reopening of the Koffiefontein mine and the expansion of operations in Namaqualand. Also during the 1980s, however, several relatively new areas completely changed the production hierarchy. Within three years after it opened in 1982, the Jwaneng mine—in conjunction with the operating Orapa and Letlhakane mines—had propelled Botswana to third rank in total production and second in value (Boyajian, 1988). Among all diamond mines in this decade, the Jwaneng mine had the highest average mining grade (154 ct of diamonds per ton of kimberlite; "Diamonds," 1989). And Australia, which had no significant production at the beginning of the decade, by the end was the top producer.

Western Australia, in fact, is one of the most exciting areas developed in the 1980s. After extensive exploration, diamond-bearing volcanic "pipes" of lamproite composition and some accompanying alluvial deposits were discovered at several localities—including Ellendale and Argyle—in the late 1970s and early 1980s. Because of the occurrence of the diamonds in lamproite host rocks, these discoveries caused a major revision in the scientific understanding of the conditions of diamond formation. The quantities of diamonds that have been processed since Argyle's AK-1 pipe became fully operational in 1985 (figure 9) have had a dramatic impact on the world market. For 1986, Australia was the number one source, and by 1988 it was producing 35 million carats annually ("Diamonds," 1989). Even though most of this material is industrial quality, the large quantities of gem and near-gem stones that became available stimulated the development of a mammoth diamond-cutting industry in India to process them efficiently and inexpensively (Boyajian, 1988). Australia is also notable for a relative abundance of colored diamonds, in particular pinks (figure 10), but also brownish ("champagne"), blue, and violet stones.

Figure 11. This attractive brown 7.66-ct diamond from the Xiyu mine, in the Mengying Province of China, gives some idea of the diamond potential of this Asian nation. It is likely that China will emerge as a major gem force in future decades. Courtesy of Gary R. Hansen; photo by Robert Weldon.

Figure 12. As new localities such as those in East Africa produced unusual hues of garnet—as well as sapphire and tourmaline—jewelers created dramatic designs that incorporated these rainbow hues in calibrated stones. Jewelry courtesy of The Collector, Fallbrook and La Jolla; photo © Harold & Erica Van Pelt.

for diamonds (and colored stones) in response to easier exchanges of technology. Elsewhere, exploration is being conducted worldwide, throughout the United States and Canada as well as in traditional producing countries, to locate diamond-bearing kimberlite and lamproite pipes.

GARNET

Gem garnets continue to be produced from numerous major deposits in India, Sri Lanka, Mozambique, and Madagascar, but the most exciting development of the 1980s was the emergence of East Africa as a principal source and the discovery there of a number of "new" species and varieties of this complex gem group. Following the discovery of green grossular ("tsavorite" or "tsavolite") in both Kenya and Tanzania in the early 1970s, this region continued to produce gem garnets in a range of composition and color beyond that previously encountered. Among these remarkable new types are the reddish brown "umbalite" or "malaia" ("malaya") garnets, which have been shown to be members of a solid-solution series between pyrope and spessartine. Their discovery led to a re-evaluation of the chemistry of this gem material, and to a revised system of classifying gem garnets on the basis of their refractive index, specific gravity, color, and absorption spectra (Stockton and Manson, 1985; Hänni, 1987a, b).

East Africa also produced quantities of previously rare color-change garnets as well as unusual hues such as "raspberry" rhodolites. Multi-color suites of garnets are often transformed into dramatic pieces called "rainbow" jewelry (figure 12).

OPAL

During this decade, the major source of gem opal continued to be Australia (figure 13) and, specifically, the territories of New South Wales, South Australia, and Queensland. Mining activity at White Cliffs, New South Wales, famous for "crystal opal" (a transparent, colorless variety that displays intense play-of-color), was revitalized by the introduction of heavy equipment in the mid-1980s. Lightning Ridge, best known for black opal, showed a small increase in production in the late 1980s, also due to improvements in mining techniques.

The most important development in Australian production, however, has been the intense mining activity at Mintabie, South Australia, where a

Figure 9. The Argyle mine entered full production in December 1985, and within a year Australia was the number one source of rough diamonds worldwide. This occurrence of a diamond pipe in a lamproite has caused geologists to re-examine many of their theories about diamond formation. Photo by James Lucey.

Exploration in recent years suggests that there will be even greater production from alluvial deposits. For example, Consolidated Diamond Mines Proprietary Ltd. continues to expand mining of alluvial diamonds along the coast of Namibia between Swakopmund and the Orange River. For the first time in many years, an organized effort is being made to exploit the alluvial fields (as well as to determine the kimberlite source) in Kalimantan in southeast Borneo. Sophisticated alluvial mining has also been successful in parts of Brazil and Venezuela, as well as in Sierra Leone. In 1987, the first mining in Brazil of a diamond-bearing pipe began 20 km from Julina in the Alto Paraguai District of Mato Grosso (Austin, 1987).

While diamond mining in China is still in its infancy, preliminary reports indicate significant potential at a variety of locations throughout the country (figure 11). The changing political scene in the Soviet Union and Eastern Europe is likely to open these areas to more sophisticated exploration

Figure 10. The 1980s saw an increased awareness and appreciation of color in diamonds. This coincided with the greater availability of colored diamonds from Australia. Particularly notable is the relative abundance of pink and brownish pink stones, as well as the blues and greens. These diamonds range from 0.51 ct to 1.20 ct. Courtesy of Argyle Diamond Sales; photo © Harold & Erica Van Pelt.

Figure 13. New mining techniques, as well as new discoveries, have increased the availability of opals, especially black opals, in the 1980s. These opals from Australia and Mexico (the largest is 17.84 ct) are courtesy of the American Gem Trade Association; photo © Harold & Erica Van Pelt.

series of new deposits were found at the end of the 1970s (Keller, 1990). In addition to the fine white opal for which South Australia is known, Mintabie also produced black opal in qualities and colors similar to the Lightning Ridge material. Mintabie and the classic deposit at Coober Pedy are now the most important producers of opal in the world.

One of the more interesting developments of the past decade was the mining of commercial amounts of contra luz, hydrophane, and rainbow opal at Opal Butte, Oregon. During this period, some unusual colors of opal, including green and blue, came from Piauí, Brazil. Discovered in the 1960s, green opal from Tanzania first became available in commercial quantities during this last decade. Traditional deposits elsewhere in the U.S. and in Mexico continued to be active.

QUARTZ

Amethyst and Citrine. Brazil was the major producer of fine amethyst and citrine during the 1980s (figure 14). As summarized by Franco (1981) and Cassedanne (1988a), amethyst occurs in both igneous and sedimentary geologic environments, principally in the states of Pará, Goiás, Ceará, Bahia, Minas Gerais, and Rio Grande do Sul. Epstein (1988) described the occurrence of amethyst in fractures in quartzite in Marabá, the alluvial deposits at Pau d'Arco, and the mining of amethyst geodes from basalt near Santa Maria and at Iraí. Amethyst is also produced in Uruguay in colors comparable to fine "Siberian" grade.

Figure 14. The quartz family of gemstones experienced renewed appreciation in the 1980s, fueled by the popularity of purple and yellow in the fashion palette, as well as by the enthusiasm of New Age groups. Brazil exported millions of carats of amethyst and citrine over the course of the decade. Stones courtesy of Kalil Elawar; photo © Harold & Erica Van Pelt.

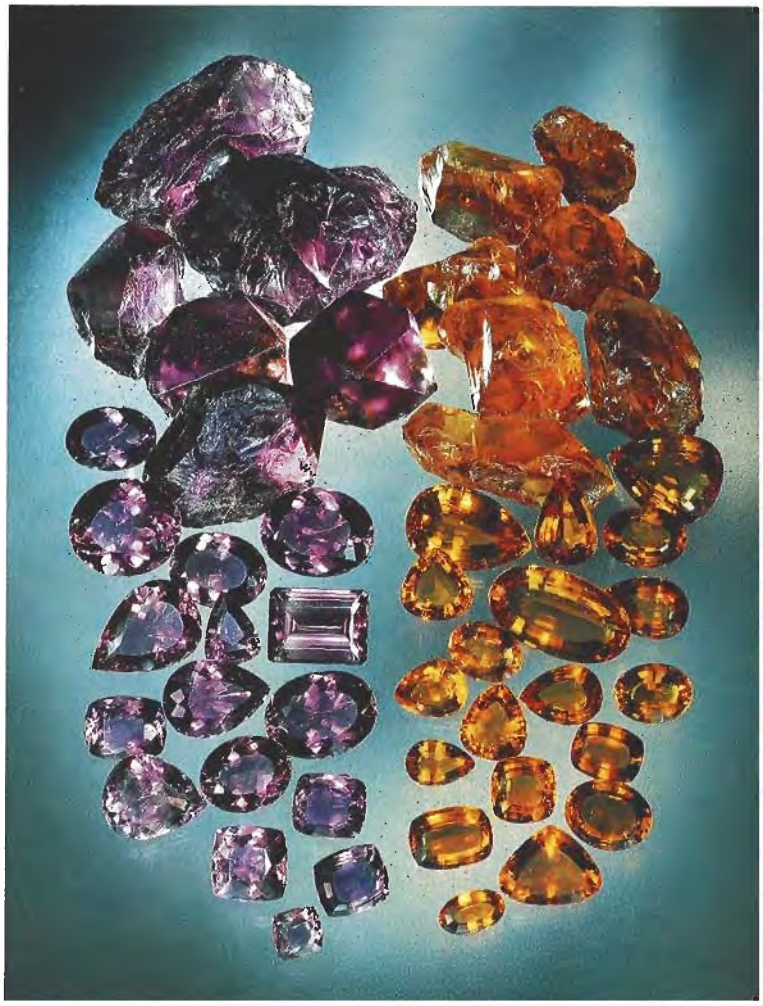


Figure 15. With the rapidly changing political situation in Eastern Europe, the USSR promises once again to be a major source of colored gems. Recently, a number of fine pink spinels emerged from the Pamir Mountains of the Soviet Union. The 27.80-ct cushion-shaped mixed cut in the pendant is shown here with a 146.43-ct cushion-shaped step cut from this locality. Stones courtesy of A.G.T. International; faceting by Justina. Photo © Harold & Erica Van Pelt.

New in the 1980s were major deposits of intensely colored, reddish purple amethyst in Zambia. As is the case in many Third World countries, the rough crystals must be purchased through a state agency, in this instance known as Mindico. A new locality near Port Hedland in Western Australia has also produced fine material (R. Kane and W. L. Cotton, pers. comm., 1990).

The great majority of citrine available during the past decade was actually heat-treated amethyst from Brazil. In 1986 alone, more than 15 tons of cobbed citrine was shipped from Rio Grande do Sul (Epstein, 1988).

One of the most interesting materials to emerge in the gem market of the '80s was bicolored amethyst-citrine ("ametrine"). Although reports early in the decade speculated that these stones were produced by treatment (Nassau, 1981), crystals displaying both colors have been confirmed from a deposit known as La Gaíba, in the Rincón del Tígre region of Bolivia, near the border with Brazil (R. Weldon, pers comm., 1989).

Rose Quartz. At the beginning of the decade, rose quartz was found in relatively small amounts of average quality, principally in Brazil. Toward the end of the decade, increased mining in Namibia, Mozambique, and Madagascar, as well as Brazil, made available fine gem-quality material and phenomenal varieties, both star and cat's-eye stones (G. Becker, pers. comm., 1990).

SPINEL

During the past decade, spinel came principally from traditional sources, including both primary and secondary deposits in Southeast Asia (Burma, Cambodia, Thailand) and secondary (alluvial) deposits in Sri Lanka. Some material also came from Tanzania and Brazil. Characterization of material from old and some new localities led to a better understanding of the causes of color and the range of properties among gem spinels. For example, 1980 saw the first description of color-change spinel (Schmetzer and Gübelin, 1980). Anderson (1972), Jackson (1982), and Schmetzer and Bank (1985) reported the properties of gem-quality, zinc-bearing gahnite and gahnospinel from Nigeria and Sri Lanka. The 1980s also saw the rediscovery of an intense blue spinel from Sri Lanka that contains the element cobalt as a coloring agent (Shigley and Stockton, 1984; Harder, 1986).

In the mid-1980s, demand for red spinel increased dramatically as it gained appreciation as a medium-priced red stone. One of the newest and most promising developments has been the discovery of exceptionally large, transparent pink spinels from the Pamir Mountains of the Soviet Union. At least one fine stone of 146 ct has been cut (figure 15).

SPODUMENE

Because gem spodumene occurs in granitic pegmatites, its distribution is similar to that of other pegmatite gems such as beryl and tourmaline. Major production of kunzite is centered in Brazil, with lesser amounts originating from Afghanistan and Madagascar. The principal Brazilian deposits are in Minas Gerais—Urucum, Kunzita, and

Urupuca. Although these localities were discovered prior to this decade, they have continued to be important producers. In 1989, kunzite was discovered at Resplendor near Governador Valadares in Minas Gerais. A 10.2-kg crystal was displayed at the 1990 Tucson Gem and Mineral Show.

Throughout the political turbulence of the 1980s, Afghanistan continued to supply superb crystals of kunzite (figure 16). With the changing political climate at the end of the decade, Westerners were again able to enter the pegmatite district (G. Bowersox, pers. comm., 1989), and it is anticipated that more material will emerge.

Figure 16. Afghanistan, which continued to produce during the decade, promises to be even more important now that Westerners have been allowed back into the country. This 31.12-cm-high kunzite crystal from Afghanistan is courtesy of Sam Goldowski and Osorio Neto. Photo © Harold & Erica Van Pelt.

TOPAZ

Topaz production in the 1980s involved three distinct color groups: colorless and light blue topaz used for treatment, golden yellow to "sherry" red Imperial topaz, and pink topaz. Brazil, Sri Lanka, and Nigeria produced millions of carats of colorless to light blue topaz for treatment by irradiation and annealing to create various intensities of blue. Not all topaz yields the desired result when treated, but exploration is constantly being undertaken worldwide to identify new sources of treatable material.

Brazil continues to be known for its famous Imperial topaz mines in the vicinity of Ouro Preto, in Minas Gerais. First documented in the 1700s, these mines are the only source of material in this attractive range of orange-to-red colors (figure 17). Of the eight or more mines active in this area, Capão do Lana is technologically the most advanced, and was characterized in the 1980s by sophisticated mining and processing techniques (Keller, 1983a).

Small quantities of fine pink topaz were mined from the Katlang district of Pakistan in a deposit that produces material ranging from colorless to light brown, and from pale pink to deep pink. Under the auspices of the Gemstone Corporation of Pakistan, which controls all gem mining in that country, tunneling began in the mid-1980s. By 1986, production of gem-quality material ranged from 20,000 to 30,000 ct, at least double what it was in 1980. The largest known pink topaz to be cut from Pakistan material in the 1980s is a 37.76-ct emerald cut stone (Spengler, 1985). Other topaz deposits were found about 20 km from Katlang, at Shakertangi. As more of the mountainous area of northern Pakistan is explored, it is likely that additional deposits will be found. The gem potential of this region seems high.

Even with the increased mining in Pakistan, most of the pink topaz on the market during the last decade was produced by heat treating yellow

Figure 17. While blue stones dominated the topaz market in terms of total production, fine yellow to "sherry" red Imperial topaz continued to emerge from the historic localities near Ouro Preto, Brazil. This Imperial topaz crystal is 4 cm high; the faceted stone is 32 ct. Courtesy of Kalil Elawar; photo © Harold & Erica Van Pelt.

topaz from Brazil (Nassau, 1985). Gübelin et al. (1986) stated that the pink stones from Pakistan could be distinguished from their heat-treated Brazilian counterparts by the presence of a violet component in the natural-color stones.

TOURMALINE

Brazil is by far the most important source of gem tourmaline, which occurs there in an astonishing range of colors. Proctor (1985a,b) described the major tourmaline-producing areas, principally in Minas Gerais. The most productive districts are Araçuaí-Itinga, Araçuaí-Salinas, and the region around Governador Valadares (including the famous Cruzeiro mine).

Perhaps the most exciting tourmaline discovery of the decade was made in the late 1980s in another area of Brazil, the state of Paraíba, where the São Jose da Batalha mine has produced significant amounts of tourmaline in a variety of unusual violet, blue, and green colors (figure 18). Research is now being conducted to determine the extent to which some of these colors are produced by heat treatment (see also Koivula and Kammerling, 1990).

Commercial amounts of tourmaline also continued to come from long-recognized sources such as Afghanistan, Namibia, Sri Lanka, and the United States. In the U.S., the 1980s witnessed the opening of exciting new gem "pockets" in the famous Himalaya mine of California, the most recent in spring 1989 (figure 19). Particularly important discoveries of tourmalines of unusual color and composition (some rich in chromium

and some in manganese) were made in East Africa, specifically in Kenya, Zambia, and Tanzania. Nigeria is now producing interesting bicolored tourmaline (figure 20), with commercial amounts of other colors also coming from Mozambique. Madagascar continued to produce a broad range of tourmaline species and varieties, and is experiencing an increase in exploration and mining activity (S. Salerno, pers. comm., 1989). In 1989 and 1990, excitement was generated at the Tucson Gem and Mineral Show by the appearance of pink, purple, "watermelon," and orange tourmalines from Namibia. The deposit, located 50 miles (80 km) from Windhoek, is described as the largest gem-bearing pegmatite ever found. Twelve-ton plates of quartz with tourmaline are being mined there (G. Austin, pers. comm., 1990).

Figure 18. No group of gem materials is more complex than tourmalines. Therefore, it was with great enthusiasm that the gem community worldwide embraced the dramatic new colors that emerged from Paraíba, Brazil, at the end of the 1980s. These stones, which range from 2.45 ct to 26.58 ct, are courtesy of Kalil Elawar. Photo © Harold & Erica Van Pelt.

ZOISITE

Tanzanite, the gem-quality blue variety of zoisite from East Africa (figure 21), is experiencing a resurgence of popularity. Discovered just over 20 years ago in Tanzania, tanzanite has been plagued by irregular production. Although this situation persisted throughout the 1980s, as the government periodically added and withdrew sanctions, the decade ended with fewer restrictions and a new find, a combination that has produced a significant increase in supply as well as in the availability of larger stones. This was especially noticeable at the 1990 Tucson shows.

OTHER NEW MATERIALS AND NEW LOCALITIES OF THE DECADE

It is impossible to review the key events in mining and production of the 1980s without mentioning some of the new materials that entered the marketplace during this decade. These include iridescent andradite from Mexico and New Mexico, rainbow moonstone from India, blue pectolite from the Dominican Republic, and sugilite from

Figure 19. Increased production from the Pala District has brought California tourmalines to markets around the world. A number of major pockets were found at the Himalaya mine in the course of the decade. This 10.8-cm-high crystal of tourmaline with microcline and cleavelandite was one of the fine specimens recovered in spring 1989. Courtesy of Pala International; photo © Harold & Erica Van Pelt.

Figure 20. Bicolor tourmalines were once destroyed to recover only the more salable of the two colors. Now, bicolored tourmalines are treasured for the unique combination of colors in each piece. Nigeria is a new source to emerge in the 1980s, represented here by this 11.43-cm-high crystal. Courtesy of Alex Blythe; photo © Harold & Erica Van Pelt.

South Africa. New localities were also reported for many gemstones. Some examples are peridot from China, cat's-eye scapolite from Sri Lanka, and zircon from Tanzania. Details can be found in the books, yearly reports, conference proceedings, and journals listed in the reference section.

CONCLUSION

The past decade was one of intense activity in gemstone mining and production. Expanded enhancement operations opened new markets for low-grade gem materials, such as colorless to pale-color sapphires and topaz. Advances in mining technology reopened previously dormant deposits, such as the diamond fields of Kalimantan, and led to increased production at many historic deposits, such as Muzo (for emeralds), Ṃontana (for sapphires), and Capão do Lana (for Imperial topaz). A growing awareness by developing countries of the important economic role gem resources can play led to major discoveries in various parts of Africa and Pakistan, both of which hold great promise for the future. Exploration in Australia revealed an abundance of gem riches.

The dynamic political developments of the last years of the decade may have the greatest impact on discoveries and production in the future. The "opening" of Afghanistan promises the increased availability of emeralds, tourmalines, and lapis lazuli from that country. During the 1980s, the more relaxed political climate in China revealed dozens of areas, such as the Shandong Province diamond deposits and the sapphire fields of Hainan Island, that have great potential for the future. Changing attitudes in Laos and Cambodia suggest the possible greater availability of sapphires from those historic localities. Perhaps the most exciting prospects are in the hitherto closed territories of the Soviet Union, which historically produced some of the finest amethysts, alexandrites, demantoid garnets, and other gem materials from long-inactive deposits. The recent identification of large pink spinels from the Pamir region is just one indication of the riches that may be found in the future (see, e.g., Root, 1986).

Another force in the 1980s that is likely to have an impact on gem mining and distribution in the years to come is the environmental destructiveness of certain mining techniques. For example, strip mining for emeralds in the Muzo district of Colombia destroyed mountains and clogged local rivers. The desire to reduce the damage of such

Figure 21. The 1980s witnessed the rise in popularity of another East African gemstone, tanzanite. Although production was erratic for most of the decade, toward the end large stones of intense color again entered the market. Both this 43-cm-high crystal and the 22-ct faceted stone are from Tanzania. Courtesy of Pala International; photo © Harold & Erica Van Pelt.

mining techniques was a contributing factor in the decision to begin a major tunneling operation there. In 1989, environmentalists promised to physically block earth-moving vehicles at Arkansas's Crater of Diamonds if any commercial mining was undertaken (B. Videto, pers. comm., 1990). In East Africa, mining of rubies and green garnets in the Taita Taveta area of Kenya was halted by the government because ivory poachers were posing as miners (Barot, 1989).

The 1980s will be remembered as a decade of development of many new localities throughout Africa—and particularly East Africa—as well as Australia. It will be remembered for important discoveries in historical producers such as Brazil and Southeast Asia, and for the potential glimpsed in once-"closed" areas such as China and the Soviet Union. Finally, it will be remembered for the global response to environmental issues related to mining. The decade of the '80s has provided a window to a very exciting future in gem exploration and mining worldwide.

TABLE 1. Important gem localities of the 1980s with references to the contemporary literature.[a]

Gem material/locality	Reference
BERYL—Emerald	
Africa	
Madagascar (Malagasy)	Sinkankas (1981)
Ankadilalana district	Hänni and Klein (1982a,b)
Mozambique	Sinkankas (1981), Pers. knowl. of author (KS)[b]
Murrua mine	Bank (1986f)
Nigeria—Jos district	Lind et al. (1986)
South Africa—Transvaal: Gravelotte district	Mumme (1982), Webster (1983)
Tanzania—Lake Manyara district	Pers. knowl. of author (KS), Bank (1986f)
Zambia	Bank (1981), Kanis (1986)
Kitwe district: Miku mine	Mumme (1982), Graziani et al. (1983), Sliwa and Nguluwe (1984)
Kafubu district, Kamakanga mine	Mumme (1982)
Zimbabwe	Sinkankas (1981), Webster (1983), Kanis (1986), Bank (1986f), Ncube (1988)
Bikita district: Chikwanda mine	
Mberengwa district: Adriadne, Filabusi, Machingwe, and Sandawana mines	
Victoria district: Novello mine	
Asia	
Afghanistan—Panjshir Valley district	Bowersox (1985)
India—Orissa district	Pers. knowl. of author (KS)
Pakistan	Kazmi and Snee (1989)
Swat Valley district: Charbagh, Khaltaro, Makhad, and Mingora mines	Gübelin (1982), Kazmi et al. (1986), Bank (1986a), Henn (1988)
Gujar Killi mine	Bowersox and Anwar (1989)
Mohmand district	Rafiq and Qasim-Jan (1985)
Soviet Union—Ural Mountains region: Sverdlovsk district	Sinkankas (1981), Mumme (1982)
Australia	
Western Australia: Poona district	Mumme (1982), Webster (1983), Kazmi and Snee (1989)
South America	
Brazil	Franco (1981), Sinkankas (1981), Sauer (1982), Kazmi and Snee (1989)
Bahia: Brumado and Salininha mines	
Carnaíba mine	Cassedanne (1985a), Eidt and Schwarz (1988), Schwarz and Eidt (1989)
Socotó mine	Cassedanne (1985a), Schwarz et al. (1988b)
Ceará: Fazenda Boa Esperança, Tauá	Schwarz et al. (1988c)
Goiás: Fazenda das Lajes, Mara Rosa, Pela Ema, Pirenópolis, and Porangatu mines	Cassedanne and Barros (1986)
Santa Terezinha de Goiás mine	Hänni and Kerez (1983), Cassedanne and Sauer (1984), Cassedanne (1985a), Bank (1986c), Cassedanne and Barros (1986), Miyata et al. (1987)
Minas Gerais	Schwarz et al. (1988a), Epstein (1989), Schwarz (1989)
Nova Era district: Capoeirana mine	
Itabira district: Belmont mine	Hänni et al. (1987)
Colombia	Keller (1981, 1990), Sinkankas (1981), Barot (1987)
Boyacá	
Muzo district: El Chulo, Peñas Blancas, Santa Barbara, and Tequendama mines	
Coscuez mine	Ringsrud (1986)
Chivor district: Buena Vista, Chivor, Las Vegas de San Juan (Gachalá), and Mundo Nuevo mines	
Somondoco mine	Kozlowski et al. (1988)
BERYL—Aquamarine	
Africa	
Madagascar (Malagasy)—Ankazobe, Berere-Tsarantanana, Lac Itasy, and Sahatany River Valley-Mont Bity regions	Sinkankas (1981), Webster (1983)
Betafo-Antsirabe region: Tongafeno district	Duroc-Danner (1989)
Mozambique—Alto Ligonha (Muiane mine) and Mocuba districts	Sinkankas (1981), Kanis (1986)
Namibia—Karibib, Klein, Spitzkopje, and Swakopmund districts	Sinkankas (1981), Kanis (1986)
Nigeria—Jos district	Lind et al. (1986), Bank (1984, 1986d)
Zambia—Luangwa Valley	Kanis (1986)
Zimbabwe—Miami district	Kanis (1986), Ncube (1988)
Asia	
Afghanistan—Nuristan region: Kolum River district	Bariand and Poullen (1978), Bowersox (1985)
India—Orissa district	Pers. knowl. of author (KS)
Pakistan—Gilgit region: Dusso and Shingus districts	Kazmi et al. (1985)
Soviet Union—Altai Mountains, Transbaikalia, and Ural Mountains regions	Sinkankas (1981)
Sri Lanka	Sinkankas (1981)
South America	
Brazil—Bahia, Ceará, Espíritu Santo, and Rio Grande do Norte	Franco (1981), Sinkankas (1981), Bank (1983)

Independent miners sort rough rubies at Bo Rai in Thailand. Note the bottle of "ruby oil," a temporary coloring agent. Photo by Peter C. Keller.

Gem material/locality	Reference
Minas Gerais: Araçuaí River-Capelinha-Malacacheta, Governador Valadares, Jequitinhonha River, and Teófilo Otoni-Marambaia districts	Proctor (1984), Cassedanne (1986a)
BERYL—Morganite	
Africa	
Madagascar (Malagasy)	Sinkankas (1981), Webster (1983)
Mozambique—Alto Ligonha district: Muiane mine	Kanis (1986), Barot (1989)
South America	
Brazil	Sinkankas (1981)
Minas Gerais: Calisto and Jequitinhonha River districts; Minas Novas, Salinas, and Sapucaia mines	Proctor (1984)
Bananal mine	Kampf and Francis (1989)
Urucum mine	Cassedanne (1986b)
BERYL—Red	
North America	
United States	Sinkankas (1981)
Utah: Wah Wah Mountains	Shigley and Foord (1984)
BERYL—Yellow (Heliodor)	
South America	
Brazil	Sinkankas (1981)
Minas Gerais: Marambaia district; Sapucaia and Urubu mines	Proctor (1984), Cassedanne (1988b)
CHRYSOBERYL	
Asia	
India—Orissa and Sinapoli districts	Bank (1987a), Pers. knowl. of author (KS)
Sri Lanka—Sabaragamuwa Province: Ratnapura district	Zoysa (1981), Zwaan (1982), Webster (1983)
Central Province: Elahera district	Gunawardene and Rupasinghe (1986)
South America	
Brazil	Webster (1983), Cassedanne (1984a,b)
Bahia: Teixeira de Freitas district	
Espirito Santo: Colatina district	
Minas Gerais: Coimbras, Fogo Valley, Jacinto, and Lambuza districts	Bank (1986e)
Americana Valley district	Proctor (1988)
Santana Valley district	Proctor 1988)
CHRYSOBERYL—Alexandrite	
Africa	
Tanzania—Lake Manyara district	Bridges (1982)
Zimbabwe—Masvingo district	Kanis (1986), Ncube (1988)
Victoria district: Novello mine	Sinkankas (1981)
Asia	
India—Orissa district	Pers. knowl. of author (KS), Bank (1987a)
Soviet Union—Ural Mountains region: Sverdlovsk district	Bancroft (1984)
Sri Lanka	Pers. knowl. of author (KS)
South America	
Brazil—Minas Gerais: Lavra de Hematita and Malacacheta districts	Bank (1986e), Proctor (1988), Bank et al. (1988)
CORUNDUM—Ruby	
Africa	
Kenya—Amboseli and Mangari districts	Bridges (1982), Bank and Henn (1988), Barot (1989)

Lapis lazuli has long been treasured for its remarkable color. This 19th-century piece is 3 cm long and inscribed in gold. Courtesy of Paris School of Mines; photo © Nelly Bariand.

Gem material/locality	Reference
Malawi—Lake Nyassa district	Bank et al. (1988), Barot (1989), Pers. knowl. of author (KS)
Tanzania	Bank and Henn (1988)
Lake Manyara district	
Longido district	Bridges (1982)
Morogoro district	Schmetzer (1986)
Ngorongoro district	Althier et al. (1982), Bank and Henn (1988)
Umba Valley district	Hänni (1987a)
Asia	
Afghanistan—Sorobi district, Jegdalek	Bowersox (1985)
Burma (Myanmar)—Mogok district	Keller (1983b, 1990)
Cambodia (Kampuchea)—Pailin district	Jobbins and Berrangé (1981)
India—Orissa district	Bank and Henn (1987)
Nepal—Taplejung district	Harding and Scarratt (1986), Kiefert and Schmetzer (1987a), Bank et al. (1988)
Pakistan—Hunza Valley district	Bank and Okrusch (1976), Okrusch et al. (1976), Gübelin (1982)

[a]This chart includes key producing localities of the decade and references to their description. Where no reference accompanies a district or mine, refer to those listed for the respective country or region. Localities are listed in alphabetical order by continent, country, and then state, region, or district.
[b]Pers. knowl. of author = personal knowledge of author followed by initials of author involved.

Gem material/locality	Reference
Sri Lanka	Zoysa (1981), Zwaan (1982), Barot (1989)
Thailand	Jobbins and Berrangé (1981)
Chanthaburi-Trat Provinces: Nong Bon-Khong Phaya-Bo Rai and Welu Klang-Bo Nawong districts	Keller (1982, 1990), Hoskin (1987)
CORUNDUM—Sapphire	
Africa	
Burundi	C. Bridges (pers. comm., 1989)
Kenya—Lodwar district	Barot et al. (1989), Pers. knowl. of author (KS)
Malawi—Lake Nyassa district	Kanis (1986), Barot (1989)
Nigeria—Kaduna district	Kiefert and Schmetzer (1987b)
Tanzania—Umba Valley district	Jobbins et al. (1978), Schmetzer and Bank (1981a), Bridges (1982), Gunawardene (1984), Hänni (1987a)
Zimbabwe	Mumme (1988)
Asia	
Burma (Myanmar)—Kyankpyathat and Mogok districts	Mumme (1988), Barot (1989)
Cambodia (Kampuchea)—Chamnop, Khum Samlot, Pailin, and Phnum Chnom districts	Jobbins and Berrangé (1981), Mumme (1988)
China	Keller and Wang (1986), Chikayama (1986)
Fujian Province: Mingxi district	Liu (1981), Keller and Keller (1986)
Hainan Island: Penglai district	Wang (1988)
India	
Kashmir: Paddar district	Atkinson and Kothavala (1983)
Madras: Kangyam district	Mumme (1988)
Nepal	Kiefert and Schmetzer (1987a)
Sri Lanka	Zoysa (1981), Zwaan (1982), Schmetzer (1988), Mumme (1988), Barot (1989), Keller (1990)
Central Province: Elahera district	Gunawardene and Rupasinghe (1986)
Sabaragamuva Province: Ratnapura district	Gunaratne (1981)
Thailand	Jobbins and Berrangé (1981), Mumme (1988), Barot (1989)
Chanthaburi-Trat Provinces: Khao Wao-Khao Ploi Waen-Bang Kha Cha, Welu Klang-Bo Nawong, and Nong Bon-Khong Phaya-Bo Rai districts	Keller (1982), Hoskin (1987)
Chiang Rai Province: Mae Sai district	
Kanchanaburi Province: Bo Phloi district	Gunawardene and Chawla (1984)
Phrae Province	
Australia	Mumme (1988)
New South Wales: New England district	Broughton (1979), Coldham (1985)
Queensland: Anakie district	Broughton (1979), Coldham (1985)
North America	
United States—Montana: Missouri River and Rock Creek districts	Austin (1990)
Yogo Gulch district	Baron (1982)
South America	
Colombia—Mercaderes district	Keller et al. (1985)
DIAMOND	
Africa	
Angola—Luanda Norte region: Andrada, Camafuca-Camazombo, Cuango, and Lucapa districts	Webster (1983), Mitchell (1986), Endiama (1990)
Botswana—Jwaneng and Letlhakane mines	De Beers Annual Report (1988), J. Harris (pers. comm., 1988)
Orapa mine	Furney (1982)
Central African Republic	Mitchell (1986)
Ghana—Birim River region	Webster (1983)
Guinea—Aredor mine and Baule Basin district	Webster (1983)
Ivory Coast	Webster (1983)
Lesotho	Mitchell (1986)
Liberia	Webster (1983)
Namibia—Consolidated Mines Ltd. Complex; and Elizabeth Bay and Orange River districts	De Beers Annual Report (1988), J. Harris (pers. comm., 1988)
South Africa	De Beers Annual Report (1988), J. Harris (pers. comm., 1988), Boyajian (1988)
Cape of Good Hope Province: Finsch mine	
Kimberley district: Bultfontein, De Beers, Dutoitspan and Wesselton mines	
Namaqualand district, Kleinzee: Buffels Marine and Koingmaas Complexes; Langhoogte mine	
Orange Free State Province: Koffiefontein mine	
Transvaal Province: Pretoria district, Premier mine	
Sierra Leone	Webster (1983), Mitchell (1986)
Swaziland—Dokolwayo mine	Webster (1983), Mitchell (1986)
Tanzania—Mwadui mine	Webster (1983), Mitchell (1986)
Zaire—Kasai Province	Webster (1983), Mitchell (1986)
Asia	
China	Chikayama (1986)
Hubei Province: Ying Chen district	
Hunan Province: Yuan Jiang River district	
Laoning Province: Bin Hai district	

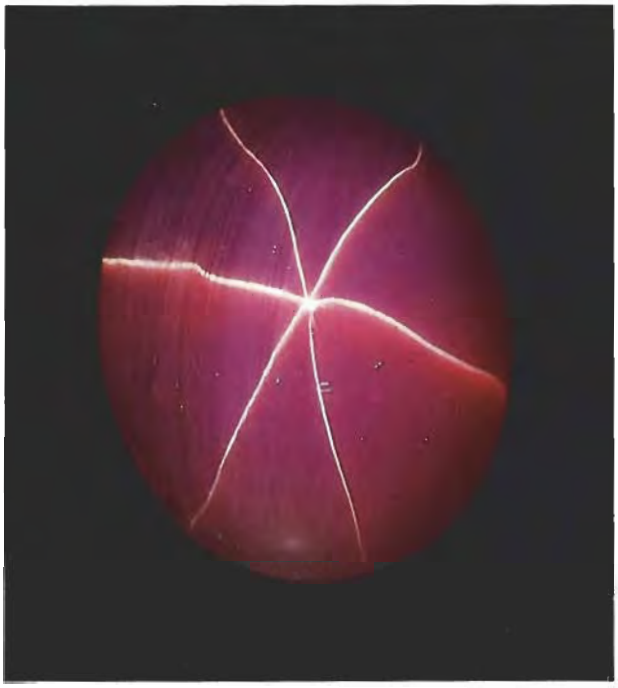
This 4.94-ct spessartine is an example of the exciting garnets now emerging from Madagascar. Courtesy of Pala International; photo by Robert Weldon.

Gem material/locality	Reference
Mengying Province: Xiyu mine	
Shandong Province: Changma district	Liu (1981), Keller and Wan (1986)
India	Webster (1983), Scalisi and Cook (1983)
Andhra Pradesh: Golconda district	
Madhya Pradesh: Bundalkhand district	
Indonesia—Borneo, Kalimantan	Spencer et al. (1988)
Soviet Union—Siberia: Yakutia, Aikhal, Mirny, and Udatchnyy mines; Vilyuy River district	Sobolev and Sobolev (1981), Huddlestone (1984), Mitchell (1986)
Australia	
Western Australia: Ellendale district	Hofer (1985), Geach (1986), Mitchell (1986), Atkinson (1987), Jaques (1989), Keller (1990)
Argyle district	Harris and Collins (1985), Fumey (1985)
North America	
United States—Arkansas, Colorado, and Wyoming	Mitchell (1986)
South America	
Brazil	Cassedanne (1985b, 1989b)
Bahia: Chapada Diamantina district	
Goiás: Coromandel district	
Mato Grosso: Alto Paraguai, Diamantino, Nortelandia, and Poxoreú districts	
Minas Gerais: Diamantina district	
Pará: Tocantins River district	
Paraná: Tibagi River district	
Roraima: Tepequém district	
Guyana—Cuyuni, Mazaruni and Potaro River districts	Lee (1981), Webster (1983)
Venezuela—Cuyuni and Mazaruni rivers; Guaniamo, Mahdia, Pacaraima, and Roraima districts	Webster (1983), Themelis (1987)
GARNET	
Africa	
Kenya—Voi district, Tsavo	Bridges (1974), Key and Hill (1989), Heppe (1989)
Madagascar (Malagasy)	Rouse (1986)
Mozambique—Cuamba district	Kanis (1986)
Tanzania—Kangala and Komolo mines	Bridges (1974)
Umba Valley district	Jobbins et al. (1978), Schmetzer and Bank (1981b), Bridges (1982), Hänni (1987b), Heppe (1989)
Zambia	Pers. knowl. of author (KS)
Asia	
China	Chikayama (1986)
Jiangsu Province: Donghai district	Keller and Wang (1986)
India—Orissa district	Rouse (1986), Pers. knowl. of author (KS)
Pakistan—Gilgit Regions Dusso and Shingus districts	Kazmi et al. (1985)
Sri Lanka	Zoysa (1981), Zwaan (1982)
Central Province: Kataragama district	
Elahera district	Gunawardene and Rupasinghe (1986)
North America	
Canada—Quebec: Asbestos; Jeffrey mine	Rouse (1986)
United States—California: Ramona district	Stern et al. (1986)
South America	
Brazil—Bahia and Minas Gerais	Rouse (1986)

Gem material/locality	Reference
JADE (Jadeite/Nephrite)	
Asia	
Burma (Myanmar)	Desautels (1986)
Mogaung Region: Hpakan district	
Tawmaw district	Khin (1987), Keller (1990)
China	Chikayama (1986)
Australia	
South Australia: Eyre Peninsular region	
Central America	
Guatemala	Desautels (1986)
North America	
Canada—British Columbia	Desautels (1986)
United States	Desautels (1986)
Alaska: Kobuk River region	
California: Monterey district	
Wyoming: Lander district	
LAPIS LAZULI	
Asia	
Afghanistan—Badakhshan: Sar-e-Sang district	Bariand and Poullen (1978), Wyart et al. (1981), Yurgenson and Sukharev (1985)
OPAL	
Africa	
Tanzania	Koivula and Fryer (1984)
Australia	E. R. Segnit (pers. comm., 1990), Keller (1990)
New South Wales: Lightning Ridge and White Cliffs districts	Broughton (1979), Segnit (1981), Dabek (1985), Barot (1989)
Queensland: Eromanga, Quilpie, and Winton districts	Broughton (1979), Segnit (1981), Dabek (1985), Barot (1989)
South Australia: Andamooka district	Broughton (1979), Segnit (1981), Dabek (1985), Barot (1989)
Coober Pedy district	Robertson and Scott (1988)
Mintabie district	Townsend (1981)
North America	
Mexico	Webster (1983), Gübelin (1986)

Ruby is one of many important gem materials being mined in East Africa. At the Tsavo National Park, in Kenya, most mining is still done with rudimentary tools. Photo courtesy of ICA/E. J. Petsch.

Gem material/locality	Reference
United States—Oregon: Opal Butte district	Smith (1988)
South America	
Brazil—Piauí	Webster (1983)
PERIDOT—Olivine	
Africa	
Egypt—Zabargad Island	Gübelin (1981), Keller (1990)
Asia	
Burma (Myanmar)—Mogok district	Scalisi and Cook (1983), Keller (1990)
China—Hebei Province	Keller and Wang (1986)
Sri Lanka—Sabaragamuva Province: Ratnapura district	Gunawardene (1985)
North America	
United States—Arizona: San Carlos district	Koivula (1981)
QUARTZ—Amethyst, Citrine and Ametrine	
Africa	
Namibia—Platveld district	Kanis (1986), Barot (1987, 1989), E. Petsch (pers. comm., 1990)
Tanzania	E. Petsch (pers. comm., 1990)
Zambia—Kalomo district	Kanis (1986), Barot (1989)
Asia	
India—Orissa district	E. Gübelin (pers. comm., 1990)
Australia	
Western Australia: Port Hedland district	R. Kane and W. L. Cotton (pers. comm., 1990)
South America	
Bolivia—Rincón del Tigre district	R. Weldon (pers. comm., 1989)
Brazil	Franco (1981), Cassedanne (1988a)
Bahia: Bom Jesus dos Meiras district	
Espírito Santo: Baixo Guandu district	
Goías: Catalao, Cristalina, Santa Luzia, Serra Dos Cristais, and Xamboiá districts	
Pará: Marabá district (Alto Bonito mine); Pau d'Arco district (Villa Esperança mine)	Epstein (1988)
Rio Grande do Sul: Santa Maria district	Epstein (1988)
Iraí district	Cassedanne and Cassedanne (1977)
Uruguay	Webster (1983)
QUARTZ—Rose	
Africa	
Madagascar (Malagasy)	Barot (1989)
Mozambique—Alto Ligonha district	E. Gübelin (pers. comm., 1990)
Namibia—Warmbad district	Kanis (1986), G. Becker (pers. comm., 1990)
South America	
Brazil—Paraíba: Alto Feio, Picuí	Cassedanne and Cassedanne (1978)
SPINEL	
Africa	
Kenya—Amboseli district	Barot (1989)
Nigeria—Jemaa district	Jackson (1982)
Tanzania—Matombo district	Barot (1989), Schmetzer et al. (1989)
Umba Valley district	Bank and Henn (1989b)
Asia	
Burma (Myanmar)	Webster (1983)
Cambodia (Kampuchea)	Webster (1983)
Pakistan—Hunza Valley	Gübelin (1982), Harding and Wall (1987)
Soviet Union—Pamir Range	Bank and Henn (1989a), Koivula and Kammerling (1989a)



Phenomenal stones such as this 42.84-ct star sapphire from Sri Lanka were significant in the 1980s. Courtesy of Leon Mason Co.; photo by Shane McClure.

Although mining of Imperial topaz at Capão do Lana, near Ouro Preto, is among the most sophisticated in Brazil, garimpeiros *continue to work the streams below the mining operation in the hopes of recovering a few stones. Photo by D. Vincent Manson.*

Gem material/locality	Reference
Sri Lanka	Anderson (1972), Schmetzer and Gübelin (1980), Zoysa (1981), Zwaan (1982), Schmetzer and Bank (1985)
Central Province: Elahera district	Gunawardene and Rupasinghe (1986)
Sabaragamuva Province: Ratnapura district	Shigley and Stockton (1984), Harder (1986)
Thailand	Webster (1983)
SPODUMENE	
Asia	
Afghanistan—Nuristan region: Kolum River district	Rossovskii et al. (1978), Bowersox (1985), Barot (1989)
Burma (Myanmar)—Mogok district	Webster (1983)
South America	
Brazil	
Minas Gerais	Proctor (1985b), Cassedanne (1986b,c)
Governador Valadares district: Kunzita, Urucum, and Urupuca mine	
Resplendor mine	E. Fritsch (pers. comm., 1990)
TOPAZ	
Africa	
Nigeria—Jos district	Pers. knowl. of author (KS)
Zimbabwe—Miami district	Webster (1983), Bancroft (1984)
Asia	
Pakistan	
Gilgit Region	Kazmi et al. (1985)
Katlang Valley district	Spengler (1985)
Swat Valley district	Gübelin et al. (1986)
Sri Lanka—Matale district	Pers. knowl. of author (KS)
South America	
Brazil	Ruplinger (1983)
Minas Gerais	
Ouro Preto district	Keller (1983a), Nassau (1985), Cassedanne and Sauer (1987), Cassedanne (1989a)
Virgem da Lapa district	Cassedanne and Lowell (1982)
TOURMALINE	
Africa	
Kenya	Dietrich (1985)
Narok district: Osarara	Bank (1987b)
Voi district	Hänni et al. (1981)
Madagascar (Malagasy)—Mount Bity region	Dietrich (1985)
Betafo-Antsirabe region: Anjanabonoina mine	Strunz (1979), Wilson (1989), S. Salerno (pers. comm. 1989)
Mozambique—Alto Ligonha (Muiane mine) and Nacala districts	Dietrich (1985), Kanis (1986)
Namibia—Karibib, Klein Spitzkopje, and Usakos districts	Dietrich (1985), G. Austin (pers. comm. 1990)
Nigeria	Barot (1989)
Zambia—Chipata, Lundazi, and Nyimba districts	Bank (1982), Thomas (1982), Schmetzer and Bank (1984), Koivula and Fryer (1985), Kanis (1986)
Asia	
Afghanistan	Dietrich (1985)
Nuristan region: Kolum River district	Bariand and Poullen (1978), Bowersox (1985)
Nepal	Dietrich (1985)
Sankhuwa Sabha district	Bassett (1985)
Pakistan—Gilgit region: Dusso and Shingus districts	Kazmi et al. (1985)
Soviet Union— Transbaikalia and Ural Mountains regions	Dietrich (1985)
North America	
United States	
California: Mesa Grande district	Marcussen (1985)
Maine: Androscoggin and Oxford counties	Francis (1985)
South America	
Brazil	Cassedanne and Lowell (1982)
Minas Gerais:	Proctor (1985a,b), Keller (1990)
Araçuaí-Salinas district (Salinas mines)	
Virgem da Lapa district	Cassedanne and Lowell (1982)
Araçuaí-Itinga district	
Governador Valadares district: Golconda, Jonas-Itatiaia, and Santa Rosa mines	
Cruzeiro-Aricanga mine	Cassedanne et al. (1980)
Paraíba: São Jose da Batalha mine	Koivula and Kammerling (1989b)
ZOISITE—Tanzanite	
Africa	
Tanzania—Arusha: Mererani district	Bridges (1982)

As more localities are discovered in Pakistan, beautiful gem mineral specimens such as this 4.6-cm aquamarine crystal with muscovite are being recovered. Courtesy of L. Wagner; photo by Jeffrey Scovil.

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Additional information (sometimes in the form of yearly country-by-country production data) can be found in sources such as:

1. The gemstone chapter of the Bureau of Mines *Minerals Yearbook*, published annually by the United States Department of the Interior.
2. *Mining Annual Review*, published by the Mining Journal.
3. For diamond information, *Proceedings of the Kimberlite Conference*, published quadrennially in the country where the conference is held.
4. *Proceedings of the International Gemmological Conference*, published approximately every two years in the country where the conference is held.

Following are other general texts suggested as additional reading on the key gem sources of the decade.

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