

GEM LOCALITIES OF THE 2000s

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While the past decade saw some impressive discoveries of diamonds and colored stones (such as corundum, spinel, garnet, and tourmaline), it also witnessed reduced gem production in many areas as a result of high development costs, environmental considerations, and the downturn in the global economy. With legal and ethical restrictions on the trade in gems from some nations, and with premium market values paid for certain stones from particular sources, “locality of origin” determinations took on increased importance for some colored stones such as ruby, sapphire, emerald, and copper-bearing tourmaline. This article reviews the geographic sources of diamonds and colored stones, as well as the areas of production for both natural and cultured pearls, that were commercially important during the years 2001–2010. Maps of most of the important gem-producing regions of the world are included on an accompanying wall chart.

New finds of both diamonds and colored stones, along with increased production of natural and cultured pearls, have characterized the last decade. Canada rose from virtually no diamond production in 1998 to rank second in value of global production in 2009. Existing diamond mines in Botswana and Russia were expanded, and in South Africa new mines opened. A number of the old De Beers mines in South Africa were closed, but later reopened under a new operator. Some important colored stones included emeralds from Zambia, rubies from Madagascar and Tanzania, sapphires from Madagascar (e.g., figure 1), spinels from Tanzania and Myanmar, opals from Australia and Ethiopia, and copper-bearing tourmalines from Brazil as well as new sources in Mozambique and Nigeria. In cultured pearls, Chinese products have come to dominate global production by quantity and variety of new items being farmed. For most of the decade, there were signifi-

cant increases in the culturing of large white pearls from Australia, “golden” pearls from Indonesia and the Philippines, and black pearls from French Polynesia, the Cook Islands, and Mexico—although the global recession at the end of the decade has had a dampening effect on prices and production.

Following the format established in the two previous 10-year retrospective issues of this journal (see Shigley et al., 1990, 2000), this article identifies localities throughout the world that produced diamonds, colored stones, and pearls on a commercial scale during the past decade. The selection of localities included in this article was based on the published literature, Internet sources, and geologic resource maps, as well as on personal communications provided by a number of experts on particular countries (see Acknowledgments in the *G&G* Data Depository at gia.edu/gandg). The lack of gem production information, especially for colored stones, complicates the task of identifying which localities were significant during the past 10 years, as well as which are still active. Table 1, at the end of the article, lists major colored stone localities. Tables for key diamond and pearl localities can be found in the Data Depository, along with a list of sources of

See end of article for About the Authors and Acknowledgments.
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Figure 1. Madagascar was one of the largest producers of sapphires—in a variety of colors—in the 2000s. The stones shown here weigh ~3–5 ct. Courtesy of Menavi International; photo by Robert Weldon.

minor colored gemstones, and a comprehensive list of all references cited in the article and tables. Many of the key diamond and colored stone localities are plotted on several regional maps that comprise an accompanying wall chart.

While the larger gem deposits are generally well known, information on some smaller sites is less certain because no recent published reports on them could be found. Although we have attempted to make this article as complete as possible, in some cases minor productive localities may have been overlooked. The spelling of locality names is taken whenever possible from the Microsoft Encarta World Atlas and maps.nationalgeographic.com. References for specific statements made in the text below can be found where the corresponding localities are listed in the tables.

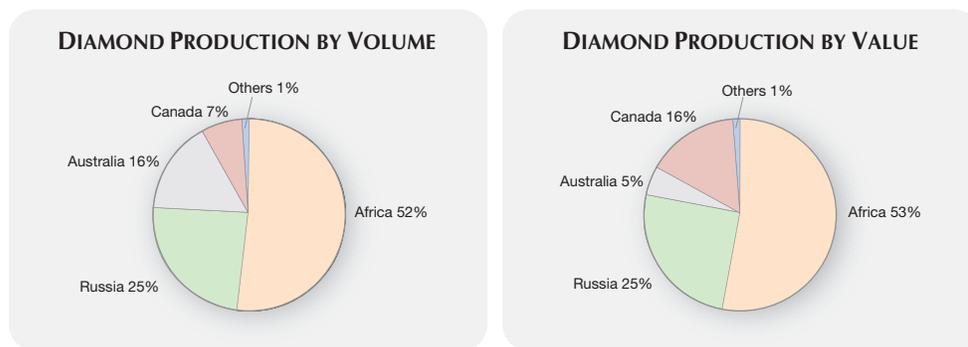
DIAMOND

The highlights of the decade were the emergence of Canada as a major diamond producer and the continued strength of diamond production in general, prior to the global financial crisis of 2008–2009. Annual rough diamond production worldwide rose from 117

million carats (Mct) in 2000, worth US\$7.9 billion, to a peak of 176 Mct in 2006, worth \$12 billion. Then, rough production declined slightly in 2007–2008 before falling sharply in 2009 to 125 Mct, worth \$8.6 billion (for data covering 2000–2005, see Janse, 2006; for 2006–2009, see Janse, 2007–2010). The increase was due to newly discovered Canadian deposits coming to market and greater production from Botswana and Russia. The decline was due to reduced production from the Argyle mine in Australia, where mining of the large open pit was coming to an end. During the past decade, 20 mines entered full production (Read and Janse, 2009), of which two (Catoca in Angola and Ekati in Canada) already had initial production at the end of the 1990s.

During the first decade of the 2000s, diamonds were mined on every continent except Antarctica, from three types of sources: (1) primary deposits developed in kimberlite pipes and dikes, and in some instances in lamproite pipes; (2) alluvial deposits, mainly from sand and gravel in river beds and river terraces; and (3) coastal deposits, from onshore beach sands and gravels and from offshore marine sediments. The *G&G* Data Depository table

Figure 2. Average global diamond production for the period 2001–2008 is reported by volume (left) and by value (right). Sources: U.S. Geological Survey, Mining Journal, and (since 2004) Kimberley Process data.



lists the commercial deposits that were active during this decade, along with an indication of their annual diamond production (ranging from “small” to “huge”; see table footnote for definitions of the size classifications) and the company responsible, as appropriate.

Diamond exploration remained vibrant until 2009, when the global financial crisis virtually eliminated such activity in most countries. Nevertheless, exploration continued at a reduced rate in the region around Canada’s Hudson Bay, resulting in the development of the Chidliak kimberlite field on southeastern Baffin Island, and in the discovery of kimberlites at Aviat, Amaruk, Nanuq North, and Churchill. Another area of interest is in the Bundelkhand region of India, where a promising lamproite field has been discovered (Janse, 2010).

Africa. During the 2000s, the African continent remained the major producer of diamonds by volume and by value (figure 2).

In **southern Africa**, *Angola* produced medium-quality diamonds from the very large Catoca kimberlite (Robles-Cruz et al., 2009) and four smaller mines. In addition, high-quality diamonds came from 12 alluvial deposits that were for the most part developed by expatriate companies and co-owned with Endiama, the national diamond company of Angola, as well as from many small deposits worked by artisanal miners (Gordon, 2004). Because of the global financial crisis, two alluvial deposits (Luarica and Faucama) stopped operating in 2009, but two others (Luana and Cassanguidi) opened in 2009–2010. The continued operation of many other alluvial deposits is uncertain. The Russian parastatal managing company, Alrosa, planned to withdraw from Angola except for their participation in Catoca.

During most of the decade, *Botswana* ranked first by value and second or third by volume (after Russia and the Democratic Republic of the Congo [DRC]) in global diamond production. There were three kim-

berlite mines with large-to-huge production, one with medium production (Damtshaa) that was closed in 2009 because of the global financial crisis, and one (Lerala) that produced relatively little and closed after only a few months due to low diamond value. Because De Beers shut its mines down for four months in 2009 to help stabilize diamond prices during the global financial crisis, and Russia did not, Botswana is now ranked third by value (after Russia and Canada) and also third by volume (after Russia and the DRC; Janse, 2010).

Although production from the kimberlites in *Lesotho* is relatively small, the mines are renowned for their large (several over 100 ct) high-quality diamonds (Bowen et al., 2009). Three kimberlites were mined: Letšeng-la-Terae since 2004, and Kao and Liqhobong intermittently during the decade. Kao was reopened in 2010, and Liqhobong is scheduled to reopen in 2012. The Mothae pipe is being developed for future production.

The main production from *Namibia* was derived from two coastal onshore mines operated by Namdeb and one offshore mine operated by De Beers Marine. However, there were also two small alluvial mines and several small coastal offshore producers.

Diamonds in *South Africa* were mainly derived from six large kimberlite pipes, while 15 other small pipes were operated intermittently during the decade and had relatively small production of 10,000–100,000 carats annually; the latter were all closed by 2009 because of the global financial crisis. The main producer was De Beers Consolidated Mines, which operated all five of the largest mines until mid-decade, when it sold three of them (Koffiefontein, Cullinan, and Kimberley; the latter includes the Bultfontein, Dutoitspan, and Wesselton pipes) to Petra Diamonds, and opened one new mine (Voorspoed). Four small kimberlite dike mines (Helam, Sedibeng, Star, and Klipspringer) survived the global financial crisis, but all others were closed in 2009. All 18 alluvial deposits were closed in 2009, and only those operated by

Rockwell, Trans Hex, Firestone, and Namakwa have been reopened. Four coastal offshore operations are still active, as are three onshore ones.

Zimbabwe derived its diamonds from one kimberlite mine at Murowa managed by Rio Tinto, and one alluvial deposit at Marange mined by local artisanal workers of disputed legal status. The Marange operation is overseen by military and police forces, who have been accused of numerous human rights abuses (Elliott, 2009), but so far the production is recognized by the Kimberley Process (KP).

In **Central Africa**, the *Central African Republic* produced only alluvial diamonds, recovered by artisanal miners. Attempts by expatriate companies to develop these deposits have failed (Dietrich, 2003). The *Democratic Republic of the Congo* derived most of its diamonds from high-quality alluvial deposits in the western Kasai worked by artisanal miners. In the eastern Kasai, medium- to low-quality alluvial diamonds have been mined by dredging the Bushimaie river by the parastatal Société Minière de Bakwanga (MIBA), and by Sengamines (now Emikor). Mwana Africa owns 20% equity in each company. Both MIBA and Emikor also recovered diamonds from kimberlite fields at Mbuji Mayi and Tschibwe in eastern Kasai (Long, 2007). Diamond exports from the *Republic of the Congo* for many years were believed to be derived from diamonds smuggled from the neighboring Democratic Republic of the Congo, but since 2007 the KP has recognized a small production from an as-yet-identified alluvial deposit in the western part of the country.

In **West Africa**, diamond production in *Ghana* was derived only from alluvial deposits (Asiedu et al., 2004) that were mainly worked by licensed artisanal miners; the parastatal Ghana Consolidated Diamonds finally stopped production in 2007 because of outdated and worn mining equipment. Although many kimberlite dikes and several small pipes are known in *Guinea*, production was derived from high-quality-diamond alluvial deposits primarily worked by artisanal miners, with four small operations run by expatriate companies. Diamond production from the *Ivory Coast* derived only from unlicensed artisanal workers, and is not recognized by the KP. Diamonds from *Liberia* were mined artisanally from alluvial deposits. Sanctions on Liberian diamonds imposed by the KP from the end of 2001 to the end of 2007 have now been lifted. Although three small kimberlite pipes and several dikes are

known in *Sierra Leone*, about 80–90% of the diamond production came from alluvial deposits in the southeastern part of the country. These were mined by artisanal workers and by two expatriate companies. Koidu Pipes 1 and 2 were mined by Koidu Diamond Holdings, which is 80% owned by the Steinmetz Group. Koidu Pipe 3 was mined by West African Diamonds (Gberie, 2004, 2006). Since 2004, the KP has recognized a small annual production from *Togo*. The diamonds allegedly come from small artisanal workings exploiting alluvial deposits, but their location is still uncertain.

In **East Africa**, numerous kimberlite pipes are known in *Tanzania*, but only the Williamson mine at Mwadui was developed by De Beers into a major operation (Stiefenhofer and Farrow, 2004). It was recently sold to Petra Diamonds, with the Tanzanian government holding a 25% equity. Local people mine alluvial deposits around the Williamson mine (Mutagwabe et al., 2007; Scalie et al., 2007).

Asia. Small quantities of diamonds have been recovered from various deposits in China, India, and Indonesia, but the giant in the area is eastern Russia.

The main producer in *China* appeared to be the small Shengli mine (also called the 701 mine; Wang et al., 2010) in the Mengyin area, though its production is not recognized by the KP. The diamonds that are recognized by the KP are of low quality and appear to come from dredging operations in the Yuan River in Hunan Province. One kimberlite with an adjacent alluvial placer in Liaoning Province also produced small quantities of low-quality diamonds (Tompkins et al., 1999). The only official diamond production in *India* during the decade came from the Majhgawan open-pit lamproite mine (Chalipathi-Rao, 2006), which was closed for environmental reasons in 2006 and reopened in 2009 (Janse, 2010). In *Indonesia*, the only diamond production recognized by the KP was derived from the Cempaka mine in southeastern Kalimantan, which is now closed and for sale. Additional small production from Kalimantan was derived from artisanal miners in the Martapura and Landak areas (Smith et al., 2009).

About 20 kimberlite fields are known in the Siberian Platform of *Eastern Russia*, in the Sakha Republic (formerly Yakutia). They contain at least 1,000 kimberlite pipes and dikes. Of this total, a dozen were developed by Russian parastatal managing company Alrosa into mines located in three fields (Anastassenko and Leybov, 2008). Most of the large,



Figure 3. Australia's Argyle mine is the world's largest single diamond producer by volume. Since the 1980s, the deposit has been mined in a large open pit; the processing plant and west pit wall are shown here. Over the next few years, mining will move underground. This 2009 photo is courtesy of Rio Tinto Diamonds.

old open-pit mines—including Mir, Internationalaya, Udachnaya, Aikhal, Zarnitsa, and Sytykanskaya—have transitioned into underground mining, entailing higher costs and lower output. The newer mines, Jubileynaya and Nyurba, are still open pits. In May 2009, Alrosa announced they were opening a large mine on a cluster of three pipes in the Upper Muna area (Janse, 2010). Kimberlites there were discovered in the late 1960s, but until now Alrosa has avoided development above the Arctic Circle.

The deposits in *Western Russia* (actually in Europe) continue to yield large quantities of diamonds. Most come from the Arkhangelskaya kimberlite pipe, the first in the Lomonosov cluster of five pipes to be developed into a very large mine (Verzhak and Garanin, 2005; Palazhchenko et al., 2008). Development of the rest of the Lomonosov cluster is planned for the future, with projected reserves of ~200–230 Mct. Small quantities of diamonds were produced intermittently from scattered alluvial deposits in the Ural Mountains (Laiginhas, 2008).

Australia. Two lamproite mines—Argyle and Ellendale—were the main producers. A small quantity of diamonds also came from the Merlin kimberlite, which closed in 2004 as Rio Tinto decided it was not economic. It is expected to be reopened in 2012 by its new owner, North Australian Diamonds (Janse, 2010).

When the Argyle mine (figure 3) began production in 1986, the open-pit reserves were calculated to last 20 years. Its life has now expired, but to keep the

Indian diamond cutting industry buoyant, Rio Tinto decided in 2005 to continue mining by going underground. Rising prices for energy, steel, and labor caused cost overruns and delays, so the open-pit mine was extended initially to the end of 2008, then to 2010, and most recently to 2012. The open pit was expanded northward into lower-grade ore, resulting in a production decline from ~30 Mct for 2005 to 15.4 Mct in 2009. Underground operations are scheduled to commence in mid-2012 and last for at least six years (Janse, 2010).

In September 2007, Gem Diamonds purchased the Ellendale mine from Kimberley Diamond Co.; the deposit has produced a total of just over 1 Mct since 2002. This included some high-quality yellow diamonds (about 7% of total production), which in 2009 sold for \$2,480/ct. In December 2009, Gem Diamonds signed a long-term contract to sell the yellows to Laurelton Diamonds, an Antwerp subsidiary of Tiffany & Co. (Janse, 2010).

All the activities mentioned above concern “old” prospects, and no new promising discoveries have been made in Australia in the last 20 years. The “Big Three” companies—De Beers, Rio Tinto, and BHP—have withdrawn from diamond prospecting there, but a few junior companies still continue to search.

North America. The 2000s marked the first full decade of Canada's position as a major diamond producer. In fact, in 2009 Canada globally ranked second in value and sixth in volume. The quality of the Canadian diamonds is high (see, e.g., figure 4), and they are not tainted by the “conflict diamond” issue. Production came from four kimberlite mines, three located in the Northwest Territories (Ekati, Diavik, and Snap Lake) and one in Ontario (Victor). A fifth kimberlite mine (Jericho, located in Nunavut) closed after an 18-month operation because the actual production was well below projections made in economic feasibility studies (Read and Janse, 2010).

South America. Although South America, especially *Brazil*, has great historical significance as a diamond producer, most of the deposits produce small quantities. All Brazilian diamonds were mined from alluvial deposits, located in many areas (Blore, 2005). About 80% were mined by local artisanal miners (*garimpeiros*), while Elkedra Diamonds and Vaal-diam Resources were the only major (foreign) companies involved. Hundreds of kimberlites are known in Brazil, but none has a producing mine.



Figure 4. The most important diamond production event of the decade was the emergence of Canada as a significant source. The diamonds shown here are from the Ekati mine in the Northwest Territories, and weigh a total of 6.73 ct (round brilliants) and 14.25 ct (crystals). Courtesy of BHP Billiton Diamonds; photo © GIA and Harold & Erica Van Pelt.

All diamond deposits in *Guyana* are also alluvial, mined by local artisanal workers. No kimberlite or other primary host rock has been found there (Blore, 2006a). Until the end of 1982, when kimberlitic dikes and sills were discovered at the Guaniamo field, all diamond production from *Venezuela* was from alluvial deposits (Blore, 2006b). Canada-based Kansai Mining Corp. tried to develop a kimberlite mine at Guaniamo, but in 2008 the Venezuelan government canceled all diamond mining concessions held by foreigners and brought all development to a halt. Recent (artisanal) production from *Venezuela* is not recognized by the KP.

COLORED STONES

Although *Brazil* remained an important gem source during the decade, most new discoveries of the major colored stones took place in two other regions. One consists of areas around the present-day Indian Ocean, consisting of East Africa and Madagascar, India, Sri Lanka, and Southeast Asia. In the geologic past, these areas were either juxtaposed or closer to one another due to plate tectonics, and they share some similar geologic environments that were conducive to gem formation. The other important region extends from Afghanistan and Pakistan in the west through northern India and Nepal to Myanmar and Vietnam in the east, along the major geologic boundaries where the Indian and Asian continental plates collided.

Some deposits were exploited by mining concerns using mechanized equipment, but many others were worked by local people using very basic tools and techniques. Localities for the major colored stones are listed in table 1 according to gem material, while the *G&G* Data Depository lists these sources according to their geographic location by country. The Depository also includes separate listings for minor colored stones, sorted by gem material and location. The tables provide literature references (where available) for the individual deposits.

Emerald and Other Beryls. As with rubies, sapphires, and some other gem materials, determination of the country of origin was a lab service for emeralds during this decade, and many localities continued producing this popular gem. Accurate production figures are not available, but the most important sources were Colombia, Brazil, Zambia (figure 5), and Zimbabwe, which each produces commercial- to fine-quality material. Other sources included eastern Madagascar, the Panjshir Valley of Afghanistan, and the Swat Valley of Pakistan.

Brazil remained an important source for aquamarine, mainly from granitic pegmatites in the states of Minas Gerais, Bahia, and Espírito Santo. Additional sources were Malawi (mainly around Mzimba), Mozambique (Nampula and Zambézia provinces),

Figure 5. Large-scale open-pit mining in Zambia, as shown here at the Grizzly mine near Kafubu, yielded major quantities of emerald during the 2000s. Photo by B. M. Laurs, August 2004.





Figure 6. Along with Russia, Namibia remained an important source of demantoid, as shown by the stones from the Green Dragon mine in this fine jewelry. The bracelet (donated to the Smithsonian Institution) contains 104 demantoids weighing a total of 18.25 ct (3.0 and 3.5 mm diameter). The brooch (from a private collection) features three demantoids with a total weight of 2.71 ct set with 100 pieces of demantoid melee (1.5–2.1 mm). Photo by Robert Weldon.

Nigeria, and Zambia. Production of morganite continued at previously known localities (e.g., Afghanistan and Brazil), and large crystals of heliodor were recovered occasionally from Volodarsk-Volynskiy in the Ukraine.

Chrysoberyl and Alexandrite. These gems were mined in Brazil, India (particularly Orissa), Madagascar, Sri Lanka, and Tanzania from primary deposits in pegmatites and associated metamorphic rocks, or from secondary alluvial deposits. The most important source of alexandrite was probably the Hematita mine in Minas Gerais, Brazil. No important new chrysoberyl or alexandrite deposits were reported during the past decade.

Garnet. Many countries produced various species and varieties of gem garnet, including India (from Andhra Pradesh, Orissa, and Rajasthan) and Sri Lanka. In Namibia, production of fine spessartine decreased from the Kunene area, while the Green Dragon mine in the Tubussis area yielded commercial amounts of demantoid (figure 6). The Taita-Taveta region of Kenya (Coast Province, near Voi) produced color-change garnets as well as tsavorite. Additional major garnet sources include Madagascar (mainly around Ilakaka and a new deposit of demantoid at Antetetzambato), Nigeria (spessartine from Oyo State), and Tanzania (tsavorite or green grossular from around Arusha and Merelani, and various garnets from the Tunduru region and Uмба Valley). A significant new spessartine deposit was found in Tanzania near the Kenyan border at Loliondo (figure 7). Both Japan and Mexico produced some interesting andradite showing iridescence.

Jade. For the most part, major sources of both jadeite and nephrite remained the same as in the previous decade. The traditional sources of jadeite in northern Myanmar (mainly around Hpakant and Hkamti) were joined by the rediscovery of jadeite deposits in the Motagua Valley of Guatemala that had archaeological significance for the ancient inhabitants of Central America. Nephrite continued to be produced from various localities in China, in Canada (mainly in British Columbia), near Cowell on Australia's Eyre Peninsula, and on the South Island of New Zealand.

Opal. Deposits in the Australian states of New South Wales, Queensland, and South Australia continued to be the main sources of play-of-color white and black opal, although overall production declined somewhat due to increased mining costs and government regulations. Classic localities in Mexico (Querétaro area) and Brazil (Piauí State) were important producers of "fire" and white opal, respectively. Commercial quantities were also mined in Ethiopia (including the large new deposit in Wollo Province; figure 8), central Europe, Honduras, Indonesia, Madagascar, Peru, Turkey, and the United States. The low cost and availability in numerous colors attracted jewelry designers to common opal from several sources.

Peridot. Gem-quality olivine continued to be produced in China, with significant amounts sold at below-market values that challenged producers of this material from the United States (Arizona). There



Figure 7. Bright orange spessartine was recovered from a new deposit near Loliondo, Tanzania. The crystal measures $27 \times 23 \times 19$ mm, the carving is $30 \times 16 \times 11$ mm, and the cut stone weighs 1.95 ct. Specimens and photo courtesy of Jason Stephenson.



Figure 8. The Wollo Province of Ethiopia is the source of this fine 23.48 ct opal. Courtesy of Opalinda (Paris) and EyaOpal (Addis Ababa, Ethiopia); photo by Robert Weldon.

was occasional production of large peridot crystals from Bernardmyo in Myanmar. Kohistan, an important source of large, high-quality peridot in northern Pakistan, saw decreased production in the latter part of the decade due to depletion of the source.

Quartz—Amethyst, Citrine, and Rose. The states of Minas Gerais, Pará, and Rio Grande do Sul in Brazil, and the Kalomo region of Zambia (figure 9), continued to supply significant quantities of amethyst. Additional sources included the Thunder Bay region of Ontario in Canada, and the Artigas region of Uruguay. The Anahí mine near Sandoval in Bolivia was still the main producer of ametrine, while pegmatite deposits in Brazil, Madagascar, and elsewhere produced bulk rose quartz.

Ruby and Sapphire. The major sources of gem corundum were Madagascar (various localities including Ilakaka and Sakaraha for sapphire, and Andilamena [figure 10] and Vatomandry for ruby), Mozambique (new deposits in Montepuez and Niassa/Lichinga), Tanzania (a new occurrence at Winza [figure 11], as well as previous deposits), Kenya (John Saul mine and a new deposit at Baringo), India, Sri Lanka, Myanmar (Mogok and, for a period of time, at Nanyaseik), Thailand, Cambodia (Pailin), and Australia (mainly areas in New South Wales and Queensland).

A decline in production of ruby from Mong Hsu

Figure 9. Zambia remains one of the most important localities for fine amethyst, as shown by these stones (4.59–14.07 ct). Courtesy of Guy Clutterbuck; photo by Robert Weldon.





Figure 10. Andilamena, Madagascar, was the site of a major ruby rush, as shown here in 2005 when about 15,000 people were living and working at the deposit. Photo by Vincent Pardieu.

in Myanmar due to decreased reserves was offset by discoveries of additional deposits in Madagascar, northern Mozambique, and central Tanzania. Production of geuda corundum in Sri Lanka continued mainly as a source of material for heat treatment,

Figure 11. Winza, Tanzania, has produced fine rubies as well as gem corundum in a variety of colors (including the rare color-zoned stones shown on the right). The sapphires shown here are heat treated and weigh 0.88–3.12 ct; the purple pear shape reportedly came from the Dodoma area (Winza region) in 2000, before the Winza deposit was discovered. The ruby is unheated and weighs 1.09 ct. Courtesy of Michael Nemeth; photo by Robert Weldon.



but the recovery of high-quality sapphires decreased because of exhaustion of some deposits and mining restrictions. A similar situation of diminished supply, government regulations, and no new ruby/sapphire discoveries occurred in Thailand, Vietnam, and Australia. For more on gem corundum localities in the 2000s, see Shor and Weldon (2009).

Spinel. Given the proliferation of ruby and sapphire treatments (e.g., beryllium diffusion and lead-glass fracture filling), spinel witnessed a surge in popularity during the 2000s with its attractive range of colors and lack of treatments except for occasional heating. Significant producers included the Mogok and Nanyaseik areas of Myanmar, the Luc Yen area of Vietnam, the Ilakaka region of Madagascar, and the Pamir Mountains in Tajikistan. In addition, the early

Figure 12. At Mahenge, Tanzania, spinel is recovered from a series of hand-dug pits that explore primary and secondary deposits. Photo by Vincent Pardieu.

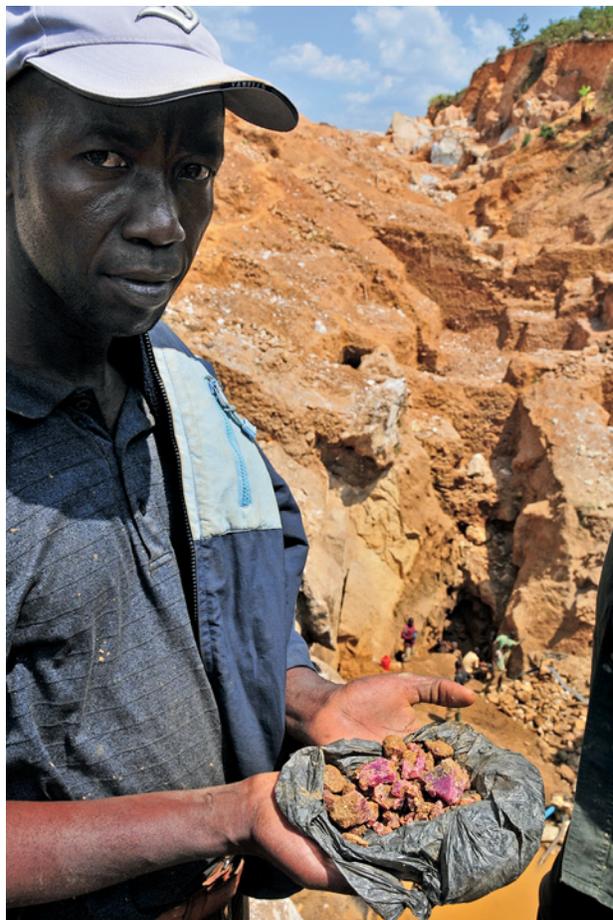




Figure 13. An important deposit of Cu-bearing tourmaline near Mavuco, Mozambique, yielded a wide variety of colors. These tumbled pieces of unheated tourmaline rough were compiled for a colorful necklace and bracelet suite; the yellow-green stone at the top weighs 23.25 ct, and the largest piece at the bottom is 61.88 ct. Courtesy of Mozambique Gems; photo by Robert Weldon.

2007 discovery of a number of large, high-quality, red-to-pink spinel crystals (some weighing 20+ kg) in the Mahenge region of east-central Tanzania (figure 12) brought renewed interest in this gem mineral.

Topaz. Pegmatite deposits in Brazil, Madagascar, Namibia, and Pakistan were the main sources of transparent colorless and blue topaz. Imperial topaz continued to originate from the Ouro Preto region of Minas Gerais in Brazil.

Tourmaline. The most significant tourmaline development was the production of copper-bearing elbaite from Mozambique (figure 13) and Nigeria (figure 14) that in some cases rivaled the “neon” blue-to-green tourmalines from Brazil’s Paraíba State. Major sources of non-Cu-bearing tourmaline were Brazil (although the production there was smaller than in the previous decade), Afghanistan (Kunar and Nuristan provinces), Mozambique (mainly Nampula and Zambézia provinces), Namibia (Karibib area), Nigeria (Kaduna, Kwara, Nassarawa, and Oyo States;

see figure 15), and Zambia (Mkushi and Lundazi; the latter was a source of distinctive “canary” yellow tourmaline).

Zoisite and Tanzanite. Underground workings in the Merelani Hills area of Tanzania remained the world’s only commercial source of tanzanite, with production increasingly coming from the TanzaniteOne mines (Block C) and from numerous smaller workings in the nearby area.

Other Gemstones. Several less-common colored stones became more prominent in the marketplace during the past decade. Gem-quality diaspore crystals were mined in the Ibir Mountains in Turkey and sold under the trade name Zultanite. Controversy over the source—and chemical diffusion color treatment—of andesine-labradorite feldspar put a spotlight on the world deposits reported for this material, especially in China. Sodalite was produced in several colors, particularly from Afghanistan (figure 16) and Myanmar. Continued production of various colors of zircon from

Figure 14. These heated Cu-bearing tourmalines from Nigeria (2.42–52.13 ct) show a range of blue-to-green colors. Courtesy of Hussain Rezayee, Rare Gems & Minerals; photo by Robert Weldon.





Figure 15. The Komu area of Nigeria produced gem tourmaline from several small pegmatite pits, such as this one near the Abuja Leather mining camp in Oyo State. Photo by Jean Claude Michelou.

Myanmar, Sri Lanka, Tanzania, Cambodia, and Thailand combined with demand from designers to raise the profile of this gem. Significant quantities of attractive, highly dispersive sphene were produced from Madagascar and elsewhere. Various transparent gems featuring unusual inclusions also gained popularity with collectors and designers, spurring demand for these products. Production of benitoite in California, rhodochrosite in Colorado, and red beryl in Utah ended, and the mine sites were closed and reclaimed.

Figure 16. Less common gem materials such as sodalite (here, from Badakhshan, Afghanistan) gained prominence as mining and exploration extended into more remote areas. Shown here are a 0.68 ct hackmanite, a 19.54 ct pale blue sodalite, and a 2.08 ct yellow sodalite. Courtesy of Herb Obodda; photo by Robert Weldon.



PEARLS

In the Winter 2000 *Gems & Gemology* retrospective gem localities article (Shigley et al., 2000), the decade of the 1990s was described as the “pearl era,” with its dramatic increase in production and diversity of cultured pearls. That diversity dominated pearls in the past decade as well (e.g., figure 17), which witnessed dramatic fluctuations in both production and pricing. Shor (2007) documented these changes in his comprehensive article. Another important pearl reference is Strack (2006), an expansion in English of the author’s German book *Perlen* from 2001. *Pearls*, by H. Bari and D. Lam (2009), is a valuable new resource.

Here we will highlight the changes in cultured pearl production during the past few years since Strack (2006) and Shor (2007). In addition, the pearls table in the *G&G* Data Depository shows sources for the major types of pearls according to their locality, and they are also listed by type of mollusk.

Saltwater Cultured Pearls. During 1999–2009, the combined value of the three major groups of saltwater cultured pearls—white South Sea (includes “golden”), black South Sea, and akoya (from China as well as Japan)—decreased from \$489 million to \$367 million, and the relative percentages of each group changed (see figure 18 and Müller, 2009). In addition, more cultured pearls (particularly South Sea) were being produced at a lower per-pearl value as a result of the global economic downturn at the end of the decade.

South Sea – Australia. In the waters around Australia, five mollusks produce natural and cultured South Sea pearls in white, “golden,” black, and other colors. The pearling area extends from north of the Tropic of Capricorn along the northern and western coasts (a distance of 3,500 km [2,150 mi.]), from the Northwest Cape in the west to Cape York in the east, and from there along the eastern coast to Cooktown (Strack, 2006).

To protect the mollusks from overharvesting, Western Australia’s Department of Fisheries established a quota system to regulate both the number of wild mollusks that could be collected for culturing and the number of licenses issued to pearl culturers. According to N. Paspaley (pers. comm., 2010), about 700,000 shell operations are expected in Australia in both 2010 and 2011—a considerable decrease from the peak operations in 2007–2008. To deal with the downturn in the market in 2009, most Australian pearl producers reduced production while some with-



Figure 17. The 2000s witnessed the popularity of multi-species cultured pearl necklaces. The natural-colored cultured pearls (8–10 mm) in this strand include pastel freshwaters from China, grays from French Polynesia, “goldens” from the Philippines, and whites from Australia. Courtesy of King’s Ransom; photo by Robert Weldon.

drew from the industry. Consequently, there may be a shortage of high-quality cultured pearls when the oysters seeded in 2009–2010 are harvested.

South Sea – French Polynesia. Since the late 1970s, French Polynesia has been the predominant producer of black South Sea cultured pearls. By the early 2000s, the government had issued about 1,500 farming licenses (Shor, 2007), but today there are fewer

than 800 licenses as a result of the overproduction of lower-quality pearls, the loss of funds for marketing, and declining sales (E. Strack, pers. comm., 2010).

However, the *Pinctada margaritifera* mollusk can be found in waters throughout the Indo-Pacific, and there are also pearl farms in the Cook Islands, Fiji, New Caledonia, Marshall Islands, and Ryukyu Islands, as well as in the Taiwan Strait (A. Müller, pers. comm., 2010).

South Sea – Southeast Asia. In Indonesia, the biggest producers are in the west Nusa Tenggara region around Lombok, which is known for its “golden” cultured pearls from *Pinctada maxima*. The popularity of this product increased dramatically over the decade (“Pearl farm information . . .,” 2009).

Through its Indonesian subsidiary, PT Cendana Indopearls, Atlas Pacific Ltd. operates pearl farms in Bali, Lombok, and West Timor. However, its main culturing operation is in Aluyi Bay on Waigeo Island near New Guinea. They produce about 240,000 white-to-“silver” cultured pearls annually (Bari and Lam, 2009).

Jewelmer International Corp. continues to dominate the culturing of pearls in the Philippines, with six farms around the island of Palawan (Bari and Lam, 2009). Recently, however, the company predicted a 30% decrease in production over the next 12–18 months (“Jewelmer gets focused,” 2010).

In Myanmar, three foreign (down from six earlier in the decade) and two local companies are conducting pearl culturing on eight islands. During the decade, the cultured pearls were sold at the Myanmar Gems, Jade and Pearl Emporium to connoisseurs

Figure 18. These pie charts show the dramatic shift in production by value of the three main saltwater cultured pearl categories. Adapted from Müller (2009).

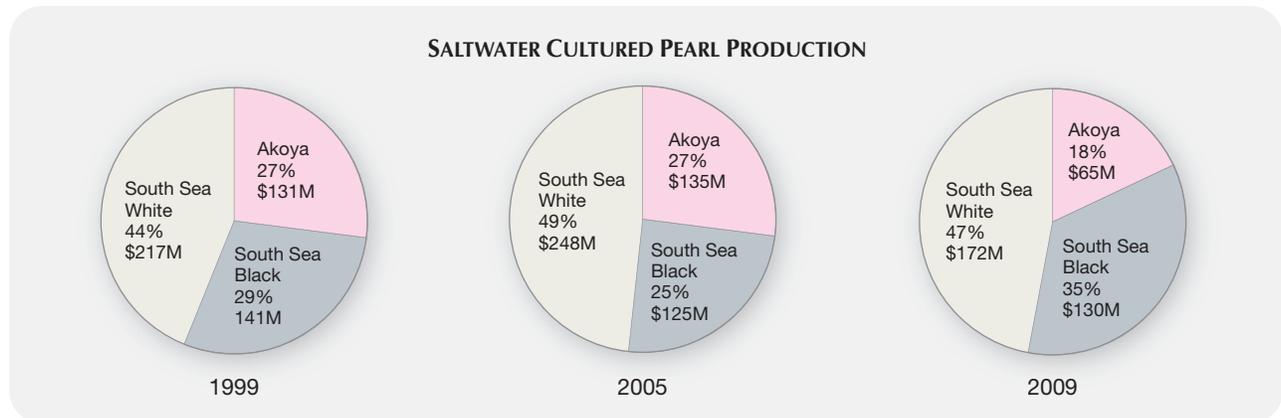




Figure 19. Hundreds of larger industrial freshwater pearl farms along with thousands of smaller family pools are active in China. The plastic bottles are used to suspend the growing mussels in the lakes. Photo taken in Zhuji, 2007, by Valerie Power.

from around the world. Myanmar produced 754 kg (201,081 mommes) of cultured pearls during the 2008–2009 fiscal year (Central Statistical Organization, 2010).

Akoya. After reaching a peak of 230 tons in 1966, disease and competition from Chinese freshwater products have reduced the current estimate for akoya cultured pearls in 2010–2011 to 12 tons (and possibly to as low as 8 tons by 2012; Müller, 2009). Müller believes that at least some of Japan’s akoya farms will survive as the sale of these cultured pearls becomes a niche business.

Akoya cultured pearls also come from China, South Korea, and Vietnam. A new farm in north-eastern Australia (Queensland) employs state-of-the-art environmental practices and has cultivated 20,000 pearls averaging 10 mm in diameter, with plans to increase the size to 12 mm.

Mexico. A pearl farm in Guaymas continues to produce commercial quantities of mabe as well as bead-nucleated full-round cultured pearls from the indigenous pearl oyster *Pteria sterna*. One indication of their natural color (and their Mexican provenance) is a red fluorescence to long-wave UV radiation (Bari and Lam, 2009). The Guaymas Pearl Farm produces about 8,000 cultured pearls per year (McLean, 2010).

Freshwater Cultured Pearls. China. Most of China’s freshwater pearl farms can be found within 300 miles (483 km) of Shanghai, in ponds and lakes (e.g., figure 19) within the valleys of the Yangtze River and its tributaries. The total production was 900 tons in 2000, and peaked in 2008 at 1,500 tons (Nucleated pearls, 2008; Bari and Lam, 2009; Canning, 2010). Since 2008, the number of farms dropped, as some went out of business and others were consolidated, resulting in about 500 large industrialized farms currently in operation (J. Shepherd, pers. comm., 2010).

Especially noteworthy during this decade are the experiments that have produced dramatically new cultured pearls. There are the colorful bead-nucleated cultured pearls called “fireballs,” which are noted for their tail. Another fascinating new product debuted in 2009 as “hollow keshi,” also referred to as “Soufflé pearls” (Sturman and Strack, 2010). By matching the implanted bead to the form of the pearl sac, farmers are better able to control the shape of the resulting cultured pearl. As a result, they are producing significant numbers of bead-nucleated rounds.

Other Freshwater Cultured Pearls. In North America, freshwater pearls are cultured in the Tennessee River in an operation that now centers on one location in Birdsong Creek (Tennessee River Pearls, 2009). The last major production was in 2002, but substantial stock remains of fancy-shaped cultured pearls—from bars and buttons to coins and crosses.

Vietnam is experimenting with some freshwater bead-cultured pearls of various hues. It is interesting to note that freshwater shells from Vietnam are also providing the bead nuclei for their domestic saltwater cultured pearls (Pardieu and Vannaxay, 2010).

In 2004, Chi Huynh, a California jewelry designer and holder of the patent on a new pearl cultivation process, developed the idea of transplanting mantle tissue along with a bead made from a gem material such as coral or turquoise into a mollusk while culturing black pearls off the coast of his homeland, Vietnam. After the cultured pearls were recovered, they were carved down to reveal the gem bead in places below. In 2010, his first crop of the summer yielded 10,000 cultured pearls. Named the “Galatea pearl,” he has also cultivated them in French Polynesia (Roskin, 2007).

Cultured Conch Pearls. For more than 25 years, attempts at culturing pearls from the queen conch (*Strombus gigas*) had been unsuccessful. In 2009, scientists at Florida Atlantic University’s Harbor



Figure 20. This two-strand necklace, which was owned by the Maharajas of Baroda in western India, consists of 68 natural pearls from 9.47 to 16.04 mm. At the April 2007 Christie's New York auction, the necklace and its accompanying ear pendants, brooch, and ring sold for \$7,096,000, setting a world auction record for natural pearl jewels. Courtesy of Christie's Images Ltd. 2010.

Branch Oceanographic Institute developed proprietary techniques to produce beaded and non-beaded cultured pearls from the queen conch. Identification criteria are being compiled to separate the cultured conch pearls from their natural counterparts (Wang et al., 2009), although this is not yet a commercial product.

Cultured Abalone Pearls. Jewelry made with cultured abalone pearls is very popular in New Zealand and Australia, in part due to the farming efforts of the Eyris Blue Pearl Co. in New Zealand. Mabe cultured pearls have been farmed in red abalone by the U.S. Abalone Co. since 2000. Other farms have been attempted in Canada and along the Pacific coast of Baja California, but they are not currently in commercial production (E. Strack, pers. comm., 2010).

Natural Pearls. The popularity of natural pearls has generated a global effort to recover them. While the mollusks that produce these pearls have suffered from overfishing, temperature changes, and pollution, protective measures have been put in place, and some areas (e.g., Arabian Gulf, Red Sea, Indian Ocean, and Guaymas and the Sea of Cortez in Mexico) are beginning to see an increase in wild

mollusk populations as well as finding more natural pearls from the existing mollusks (K. C. Bell and E. Strack, pers. comms., 2010).

During the past decade, there has been greater awareness of non-nacreous natural pearls from mollusks such as *Strombus gigas* (conch), *Melo melo* (melo), *Mercenaria mercenaria* (quahog or common hard-shelled clam), and the nautilus (K. C. Bell, pers. comm., 2010). Conch pearls are found in the waters of the Caribbean Sea from southern Florida to the northern coast of Colombia. Melo pearls are found in the South China Sea along the coasts of Vietnam, China, Myanmar, and the Philippines (Htun, 2006; Strack, 2006). According to F. Barlocher (pers. comm., 2010), during the decade about 30 melo pearls were recovered annually, but very few were perfectly round with top orange color. Quahog pearls are mainly found in waters along eastern Canada and down the eastern U.S. coast (Strack, 2006). The rarest may be nautilus pearls ("Nautilus pearls," 2010), which are reportedly found off the coast of the Philippines (Bari and Lam, 2009).

Recent sales of natural pearls reflect their high value and growing popularity. For example, on April 25, 2007, the Baroda suite of natural pearls sold for nearly \$7.1 million at the Christie's New York auction (figure 20).

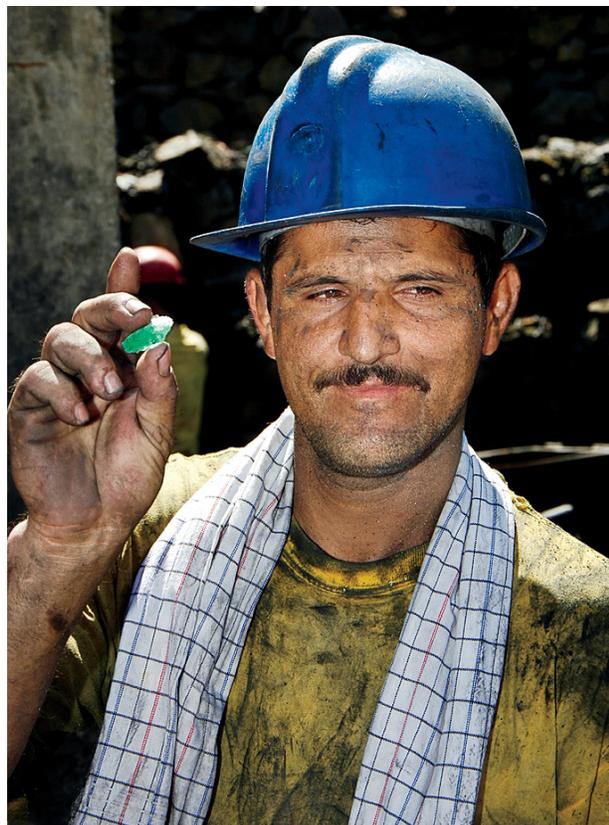
CONCLUSIONS

The past decade witnessed the continued production of diamonds and colored stones primarily from the geographic sources that had been important in the 1990s. The main diamond developments centered around the new prominence of Canadian deposits, increased production from Botswana and Russia, and a decline in output from the Argyle mine in Australia. There continued to be discoveries of colored stones, mainly in East Africa and Southeast Asia, but overall gem mining was somewhat limited by the lack of easily worked deposits, governmental restrictions, exploration and exploitation costs, and—increasingly in many countries—environmental concerns. The most notable colored stone discoveries were rubies in Tanzania and Mozambique, Cu-bearing tourmaline in Mozambique and Nigeria, spinel in Tanzania, and high-quality opal in Ethiopia. Cutbacks in pearl culturing in response to the global economic downturn will result in lower production during the early years of the next decade. An expanded awareness of the diversity of natural pearls will contribute to their popularity.

TABLE 1. Active gem localities of the 2000s for major colored stones.^a

Gem material/locality	Reference	Gem material/locality	Reference
BERYL—Emerald			
◆ Africa			
Madagascar	Schwarz and Giuliani (2001), Gründmann and Giuliani (2002), Groat et al. (2008)	Manyara—Mangola, Mayoka	Moroz et al. (2001), Cairncross (2005a), Michelou (2006)
Fianarantsoa— Mananjary : <i>Ambodibakoly, Ifanadiana, Irondro, Kianjavato, Morafeno</i>	Kanis and Schwarz (2002), F. Danet (pers. comm., 2009)	Rukwa—Sumbawanga	Moroz et al. (2001), Michelou (2006)
Toliara—Ianapera: <i>Sakalava</i>	Henn and Milisenda (2001), Moine et al. (2004), Vapnik et al. (2006)	Zambia	Kanis and Schwarz (2002)
Mozambique	Vapnik et al. (2005), Andrianjakavah et al. (2009)	Copperbelt— Luanshya-Kafubu : <i>Chantete, Grizzly, Kagem</i>	Milisenda et al. (1999), Taupitz (2003a), Laurs (2004c), Seifert et al. (2004), Cairncross (2005a), Zachariáš et al. (2005), Zwaan et al. (2005), Lees (2009b), Behling and Wilson (2010), Cook (2010a)
Zambézia—Gilé: <i>Niane, Rio Maria</i> ; Ile: <i>Maria III</i> ; Uape: <i>Maria Norte</i>	Kanis and Schwarz (2002), J. Marques (pers. comm., 2009)	Zimbabwe	Kanis and Schwarz (2002), L. F. Marsh and F. Mugumbate (pers. comm., 2009)
Nigeria	Bettencourt-Dias and Wilson (2000), Kanis and Schwarz (2002), Vapnik and Moroz (2002), Schappmann (2005)	Mashonaland West—Karo: <i>Rukomechi</i> ; Mwami: <i>Simu, Swallow</i>	Zwaan and Touret (2000), Taupitz (2003b), Zwaan et al. (2004), Zwaan (2006)
Nassarawa—Nassarawan Eggon	Kanis and Schwarz (2002), J. C. Michelou (pers. comm., 2009)	Midlands—Somabhula, Mberengwe : <i>Hyabert, Khanya Hlaza, Lodge, Machingwe, Mtombeni, Pandora, Pearzam, Sihande, Vidan East, Venus, Zeus (Sandawana)</i>	
Kaduna—Gwantu: <i>Ankara, Nandu</i>	Michelou (2007)	Masvingo—Masvingo: <i>Brentwood, Mayfield</i> ; Guta: <i>Chikwanda, Novello</i>	
Somalia	Vapnik and Moroz (2000)		
Awdal—Alihiley, Simodi	Kinnard (2001)		
South Africa			
Limpopo—Gravelotte	Kanis and Schwarz (2002)		
Tanzania	Kanis and Schwarz (2002), M. Saul and W. Balmer (pers. comm., 2009)		
		◆ Asia	
		Afghanistan	Schwarz and Giuliani (2002c), Kalukiewicz (2005), D. Blauwet (pers. comm., 2009)
		Badakhshan—Khash	
		Laghman—Shamya	Laurs (2001a)
		Nuristan—Gamitha, Korgun, Lamonda, Titin	Laurs (2001a)
		Panjshir— Panjshir Valley : <i>Bismal</i>	Sachanbinski et al. (2003), Fijat et al. (2004), Pardieu and Soubiraa (2006a)
		China	Ou Yang (2005), Smith et al. (2005), X. Yuan (pers. comm., 2009)
		Heilongjiang—Boli, Hehe, Jiamusi	B. Ottens (pers. comm., 2009)
		Yunnan—Maguan-Malipo: <i>Dayakou Mountain, Nan-Jiang, Wenshan</i>	Wu (2004), Liu (2005), Li (2009), Marshall et al. (2009)
		Xinjiang Uygur—Taxkorgan: <i>Davdar</i>	Blauwet et al. (2005), Michelou and Pardieu (2009), Schwarz and Pardieu (2009)
		India	Schwarz and Giuliani (2002c), G. Choudhary, J. Panjikar, and A. Dholakia (pers. comm., 2009)
		Orissa—Balangir, Phulabani, Sambalpur	Michelou (2006)
		Rajasthan—Ajmer, Kaliguman, Rajgarh, Udaipur	Michelou (2006)
		Tamil Nadu—Salem	
		Pakistan	Schwarz and Giuliani (2002c), D. Blauwet (pers. comm., 2009)
		Federally Administered Tribal Areas—Bajaur, Mohmand: <i>Gandao</i>	Einfalt (2002), Hammer (2004a)
		Gilgit-Baltistan—Basha Valley: <i>Doko</i>	Hammer (2004a,d)
		North-West Frontier— Swat Valley : <i>Charbagh, Gujar Kili, Makad, Mingora</i>	Einfalt (2002), Hammer (2004a), Pardieu and Soubiraa (2006b), Arif et al. (2010)
		Russia	
		Middle Ural Mountains—Asbest: <i>Marinskij</i> , Izumrudnye Kopi: <i>Cheremshansk, Krasnobolotnoe, Malyshevsk, Sverdlovsk</i>	Zolotukhin (1999), Kupriyanova (2002), Hochleitner (2005a), Kozlov (2005), Lyckberg (2005a), P. Lyckberg (pers. comm., 2009)

A miner at La Pita in Colombia displays a newly discovered emerald crystal. Photo by Robert Weldon.



^aThis table lists active mining localities of the decade for the more important colored stones, with references to publications in the contemporary literature and personal communications. The country name is followed by the province/state/region, then the district or mining area, and finally (in italics) the name of the closest town or mine/deposit/occurrence when known. Towns or mines that the authors believe were important producers during the past decade are shown in boldface text. The references cited can be found in the G&G Data Depository at gia.edu/gandg. Tables for the localities of diamonds, minor colored stones, and pearls can be found in the G&G Data Depository.

Gem material/locality	Reference	Gem material/locality	Reference
<p>◆ Australia New South Wales—New England Range: Emmaville, Torrington Queensland—Mount Surprise Western Australia—Menzies, Pilbara, Poona, Wodgina</p>	Henry (2005), Sutherland (2006)	<i>Marropino, Muiane, Naipa</i> ; Milange, Mocuba, Murrua	(2000), Schäfer and Arlt (2000), Schappmann (2005), Cairncross (2005a)
<p>◆ North America Canada Northwest Territories—Tungsten: <i>Lened</i> Ontario—Dryden: <i>Taylor</i> Yukon Territory—Finlayson Lake: <i>Tsa da Glisza (Regal Ridge)</i> United States North Carolina—Alexander: <i>Hiddenite</i></p>	Wilson (2007,2010) Marshall et al. (2004), Groat et al. (2008) Groat et al. (2002), Rohtert (2002b), Marshall et al. (2003), Wight (2003), Groat (2005) Wise (2002, 2009), Potucek (2005), Wise and Anderson (2006), Cook (2007), Mychaluk (2008), Speer (2008), White (2010)	Namibia Erongo—Erongo Mountains, Klein and Grosse Spitzkoppe, Rössing Mountain Nigeria Kaduna—Kwoi Kogi—Egbe, Okene Nassarawa—Akwanga Niger—Paikolo Ogun—Ijebu Igbo, Igbo Ora Oyo—Olode: <i>Concord, Gbayo</i> Plateau—Bomo South Africa Northern Cape—Keimoes Tanzania Arusha—Loliondo Rukwa—Sumbawanga Ruvuma—Nyamtumbo, Songea, Tunduru Zambia Central —Mkushi Eastern —Chama, Lundazi Southern—Itezhi-Tezhi Zimbabwe Mashonaland Central—Rushinga: <i>First Try, God's Gift</i> Mashonaland East—Mutoko: <i>Benson</i> Mashonaland West—Mwami: <i>Baboon Hill, Gwati, JLM, Saint Ann's, Simu, Swallow, Green Walking Stick</i> Matabeleland South—Filabusi, Zvishavane Masvingo—Gutu: <i>Novello</i>	G. Schneider (pers. comm., 2009) Jahn (2000), Jahn and Bahmann (2000), Glas (2002), Laurs (2002a), Cairncross (2005a), Cairncross and Bahmann (2006a) Michelou (2006, 2007), J. Michelou (pers. comm., 2009) Cairncross (2005a) Michelou (2006), D. Mantheakis (pers. comm., 2009) Laurs (2002b) C. Milisenda (pers. comm., 2009) Milisenda et al. (2000), Carranza et al. (2005) Cairncross (2005a), L. F. Marsh and F. Mugumbate (pers. comm., 2009) Milisenda et al. (2000), Cairncross (2005b), Wise (2005) Cairncross (2005a) Cairncross (2005a)
<p>◆ South America Brazil Bahia—Anajé, Brumado: <i>Serra das Eguas</i>, Campo Formoso: <i>Socotó</i>; Pilão Arcado: <i>Salininha</i>, Pindobaçu: <i>Carnaiba</i> Goiás—Pirenópolis, Santa Teresinha: <i>Campos Verdes, Santa Teresinha</i> Minas Gerais—Conselheiro Pena: <i>Itatiaia, Hematita, Itinga</i>, Itabira: <i>Belmont, La Rocha, Nova Era, Piteiras</i> Rio Grande do Norte—Lajes Tocantins—Monte Santo, Paraíso do Tocantins Colombia Boyacá—Chivor, Cosquez, Muzo, Pava; Maripí (La Pita): <i>Polveros</i>; San Pablo de Borbur: <i>Peñas Blancas</i> Cundinamarca—Gachalá, Yacopí</p>	Pinto and Pedrosa-Soares (2001), Schwarz and Giuliani (2002b) Couto (2000) D'el-Rey Silva and Neto (2002) Kanis (2001,2002), Levinson et al. (2001a), Mossman (2001), Preinfalk et al. (2002), Rondeau et al. (2003) Milisenda (2007) J. Hyršl (pers. comm., 2009) Banks et al. (2000), Giuliani et al. (2000), Schwarz and Giuliani (2002a) Johnson et al. (2000a), Michelou (2001,2005,2006), Boehm (2002a), Fritsch et al. (2002a), Vuillet et al. (2002), Campos-Alvarez and Roser (2007)		
BERYL—Aquamarine/Heliodor/Morganite			
<p>◆ Africa Kenya Eastern—Embu Madagascar Antananarivo—Ambohidrano, Anjanabonoina, Ankazobe, Antsirabe, Betafo, Mahaiza, Mount Bity, Vohitrankanga Antsiranana—Andapa Fianarantsoa—Ambatovita, Isahara, Voandambo Mahajanga—Andriamena, Boriziny, Mahajamba Toamasina—Ambatondrazaka Toliara—Amboasary Malawi Northern—Mzimba Mozambique Nampula—Chalaua (Moma), Lalaua: <i>Lalaua</i>; Malema: <i>Mutuáli</i> Tete—Marávia: <i>Marironguê</i>; Mutarara: <i>Nhaphali</i>; Zumbo: Mese River Zambézia—Alto Molócuê: <i>Namacotche</i>; Gilé:</p>	Cairncross (2005a) Henn and Milisenda (2001), F. Danet and F. Pezzotta (pers. comm., 2009) Pezzotta (2001b), Danet (2007) Pezzotta (2001b) Laurs and Quinn (2002a) Pezzotta (2001b) Cairncross (2005a), Michelou (2006), Dill (2007) J. Marques (pers. comm., 2009) Bettencourt-Dias and Wilson		
		<p>◆ Asia Afghanistan Kunar—Darra-i-Pech, Kala Nuristan—Grangal, Mawi, Papra, Paprowk, Waigon, Watata China Sichuan—Pingwu: Xuebaoding Mountain Yunnan—Yingjiang: Ailaoshan Mountains, Gaoligongshan Mountains Xinjiang Uygur—Altai Mountains: <i>Koktokay</i> India Jammu and Kashmir—Sunjam, Zanskar Jharkhand—Hazaribag Orissa—Balangir, Kantabanji, Phulabani, Sambalpur, Subarnapur Rajasthan—Ajmer, Panwar, Sarwad, Shahpura, Tonk Tamil Nadu—Coimbatore, Dindigul, Kadavur, Kangayam, Kanniyakumari, Karur, Kurumbapatti, Madurai, Padiyur, Salem, Sivapuram, Tarapuram, Tharagampatti, Tiruchchirappalli, Tiruppur, Varusha Nadu Myanmar Karen Mandalay—Kabaing, Kume, Mogok: <i>Sakhangyi</i></p>	D. Blauwet (pers. comm., 2009) Glas (2002) Ou Yang (2005), Smith et al. (2005), Michelou (2006), X. Yuan (pers. comm., 2009) Liu (2005) Wu (2004), Liu (2005), Marshall et al. (2009) Tang et al. (2004), Liu (2005), Li (2009) Quinn-Darenius (2008), G. Choudhary and J. Panjekar (pers. comm., 2009) Boehm (2000) Michelou (2006), Win (2009) Boehm (2000), Michelou (2006) M. Smith, K. Thu, and T. Hlaing (pers. comm., 2009) Kyí et al. (2005), Hlaing (2009a)

Gem material/locality	Reference	Gem material/locality	Reference
Shan—Molo: <i>Katchay</i> , Momeik	Kyi et al. (2005)	Rio Grande do Norte—Acari, Lajes Pintadas, São João do Sabuji, Tenente Ananias	Bhaskara-Rao (2002), Bhaskara-Rao et al. (2004), B. Cook (pers. comm., 2009)
Pakistan	D. Blauwet (pers. comm., 2009)	CHRYSOBERYL (Including cat's-eye)	
Gilgit-Baltistan—Basha Valley: <i>Bien, Biesla, Dogoro, Sibiri, Thorgu</i> ; Braidu Valley: <i>Apo Ali Gun, Baha, Byansahpi, Chhappu, Dassu, Foljo, Gone, Hoh Nala, Nyet, Nyet Bruk, Teston, Toshi</i> ; Hunza Valley: <i>Chumar Bakhoor, Nagar</i> ; Indus Valley: <i>Baluchi, Baralooma, Dassu, Drot, Haramosh, Khargulook, Raikot, Rhondu, Sabsar, Saichais, Sassi, Shengus</i> ; Shigar Valley: <i>Haiderabad, Mungo, Sildi, Yuno</i>	Hammer (2003a,2004d), Hammer and Muhammad (2004), Blauwet (2004), Blauwet and Muhammad (2004)	♦ Africa	
Russia	P. Lyckberg (pers. comm., 2009)	Madagascar	F. Danet (pers. comm., 2009)
Middle Ural Mountains—Asbest: <i>Marinskiy</i> , Yekaterinburg: <i>Aduy, Alabashka</i>		Antananarivo—Ankazobe	Henn and Milisenda (2001)
Transbaikalia—Borzya: <i>Sherlova Gora</i> ; Chita: <i>Adur-Chilor</i> ; Krasnyy Chikoy: Malkhan Mountains	Hochleitner (2005a,b), Lyckberg (2005a), Badanina et al. (2008), P. Lyckberg (pers. comm., 2009), Zaraisky et al. (2009)	Fianarantsoa—Ambositra, Ilakaka	Milisenda et al. (2001b), Pezzotta (2001f,g,h), Schmetzer et al. (2002b)
Sri Lanka	G. Zoysa (pers. comm., 2009)	Toamasina—Ambatondrazaka	Pezzotta (2001b)
Central—Halton, Nawalapitiya, Rattota		Tanzania	Michelou (2006), W. Balmer, D. Mantheakis, and M. Saul (pers. comm., 2009)
Sabaragamuwa—Balangoda, Opanayaka, Ratnapura	Dissanayake et al. (2000)	Manyara—Mayoka	
Southern—Hambantota, Lunugamwehera, Mitiyagoda	Laurs et al. (2006b), Michelou (2006)	Mtwara—Lumesule River	Pardieu (2007a)
Ukraine		Ruvuma—Muhuwesi River, Mtelesi River, Tunduru	
Zhytomyr—Zhytomyr: Volodarsk-Volynskiy	Lyckberg (2005a), Lyckberg et al. (2009)	Zambia	Žáček and Vrána (2002)
Vietnam	Pham et al. (2004a), D. Blauwet (pers. comm., 2009)	Eastern—Muyombe: Kalanga Hill	L. F. Marsh and F. Mugumbate (pers. comm., 2009)
Nghe An—Qui Phong, Qui Vinh	Michelou (2006)	Zimbabwe	
Phu Tho—Lu Phu, Phu Tho		Mashonaland West—Kadoma: <i>Rattis</i> ; Mwami: <i>Green Walking Stick, Haslemera, Pearl, Spider</i>	
Thanh Hoa—Xuan Loc		Midlands—Somabhula	
Yen Bai—Minh Tien, Luc Yen		Masvingo—Gutu: <i>Novello</i> ; Masvingo: <i>Brentwood</i>	
♦ Europe		♦ Asia	
Finland		India	G. Choudhary and J. Panjekar (pers. comm., 2009)
Kymi—Luumäk	Lyckberg (2004a,b,2005b), Wise (2005)	Andhra Pradesh—Addatigala, Araku Valley, Chintapalli, Godavari, Khammam, Paderu, Srikakulam, Vizianagaram	Michelou (2006), Sarkar and Guru (2010)
♦ North America		Kerala—Quilon	Michelou (2006)
Canada	Wilson (2010)	Orissa —Balangir, Kalahandi, Kantabanji, Koraput, Rayagada, Sambalpur	Michelou (2006), A. Dholakia (pers. comm., 2009)
British Columbia—Atlin, Bennett: <i>Mount Foster</i> , Passmore: <i>B-Q Claim</i>	Groat (2005), Wilson (2007)	Tamil Nadu—Dindigul, Kangayam, Kanniyakumari, Karur, Madurai, Tirunelveli	Michelou (2006)
Ontario—Quadeville	Wilson (2007)	Sri Lanka	G. Zoysa (pers. comm., 2009)
Yukon Territory—Watson Lake: <i>True Blue</i>	Groat (2005), Turner et al. (2007)	Sabaragamuwa—Kalawana, Niwitigala, Pelmadulla, Rakwana, Ratnapura	
United States	White (2010)	Southern—Akuressa, Deniyaya, Morawaka, Pattara	Michelou (2006)
California—Riverside: Chihuahua Valley; San Diego: Jacumba, Mesa Grande, Pala, Ramona, Rincon	Fisher (2005), Mauthner (2008)	♦ Australia	
Colorado—Chaffee: Mount Antero	Jacobsen (2005), Potucek (2005)	Western Australia—Dowerin	Downes and Bevan (2006)
Connecticut—Middlesex (East Hampton): <i>Slocum</i>	Jarnot (2005), Wise (2005)	♦ South America	
Idaho—Sawtooth Mountains	Potucek (2005)	Brazil	Pinto and Pedrosa-Soares (2001)
Maine—Oxford-Sagadahoc: <i>Buckfield, Mount Mica, Oxford, Stoneham, Topsham</i>	Jarnot (2005)	Espirito Santo—Colatina: <i>Pancas</i>	J. Hyršl (pers. comm., 2009)
New Hampshire—Grafton (Groton): <i>Palerma</i> ; Sullivan-Cheshire: <i>Keene</i>	Wise (2005)	Minas Gerais—Padre Paraíso	L. Barbosa (pers. comm., 2009)
♦ South America		CHRYSOBERYL—Alexandrite	
Brazil	César-Mendes et al. (2001), Pinto and Pedrosa-Soares (2001)	♦ Africa	
Bahia —Alcobaça: <i>Juerana</i> ; Itambé: <i>Morro da Gloria, Paraíso</i> ; Itanhém: <i>Jaquetô</i> ; Macarani: <i>Lajedinho</i> ; Maiquinique: <i>Jagarauna</i> ; Vitória da Conquista: <i>Cercadinho</i>	Couto (2000), Menezes (2005)	Madagascar	F. Danet (pers. comm., 2009)
Espirito Santo —Baixo Guandu: <i>Santa Cruz (Itapina)</i> ; Castelo: <i>Forno Grande</i> ; Itaguaçu: <i>Boa Vista</i> ; Mimoso do Sul: <i>Concórdia</i> ; Muqui: <i>São Domingos</i> ; Pancas	Menezes (2005)	Fianarantsoa— Ilakaka	Milisenda et al. (2001b), Pezzotta (2001f,g,h), Schmetzer (2002)
Minas Gerais —Conselheiro Pena-Galiléia-Resplendor; Medina-Pedra Azul; Santa Maria de Itabira-Ferros; Teófilo Otoni-Topázio-Catuji-Padre Paraíso-Caraí; Coronel Murta: <i>Paineira, Pau Alto, Terra Corrida</i>	Mossman (2001), Viana et al. (2002), Laurs (2004a), Ferreira et al. (2005), Menezes (2005), Millisenda and Bank (2005), Steger (2006), L. Barbosa (pers. comm., 2009)	Tanzania	Michelou (2006), D. Mantheakis (pers. comm., 2009)
		Manyara—Mayoka	
		Zimbabwe	L. F. Marsh and F. Mugumbate (pers. comm., 2009)
		Midlands—Somabhula	
		Masvingo—Gutu: <i>Novello</i>	
		♦ Asia	
		India	G. Choudhary and J. Panjekar (pers. comm., 2009)

Gem material/locality	Reference	Gem material/locality	Reference
Orissa —Angul, Balangir, Hinjlibahal, Kalahandi Tamil Nadu—Kangayam, Karur, Namakkal, Padiyur, Palni, Paramatti, Salem, Vellore	Michelou (2006) Sartar and Guru (2010)	◆ South America Brazil Minas Gerais—Indaiá, Malacacheta, Palmeiras, Sapuçaia	Liccardo et al. (2005)
Laos	Michelou (2006), Graham et al. (2008)	CORUNDUM—Sapphire	
Bokeo—Ban Houayxay	Sutherland et al. (2002)	◆ Africa	
Myanmar	Barley et al. (2003), Garnier et al. (2004b,2008), Thein (2008), M. Smith, K. Thu, and T. Hlaing (pers. comm., 2009)	Kenya Coast—Kisoli Eastern—Garba Tula (Dusi), Kitui: <i>Kisou</i>	Garnier et al. (2004a), C. Simonet (pers. comm., 2009)
Kachin—Nanyaseik, Nam Phyu	Smith and Bosshart (2001), Hlaing (2008), Hlaing and Win (2008)	Rift Valley— Eldoret : Baringo; Turkana: <i>Kanakurdio</i>	Sutherland and Schwarz (2001), Simonet et al. (2004)
Mandalay— Mogok , Thabeikkyin	Garnier et al. (2006), Mitchell et al. (2007), Searle et al. (2007), Yui et al. (2008)	Madagascar Antananarivo—Anjomakely, Antanifotsy, Mandrosohasina Antsiranana—Amboahangimamy, Ambondromifehy , Antserasera, Anivorano, Befotaka	Blauwet and Laurs (2005) Garnier et al. (2004a,b), Giuliani et al. (2007a,b), Rakontondrazafy et al. (2008), F. Danet (pers. comm., 2009) Rakotosamizany et al. (2009)
Shan— Mong Hsu		Fianarantsoa—Ambinda, Andranolava, Ilakaka , Marosely, Sahambano, Sakalalina, Zazafotsy	Laurs (2000, 2003a), Schwarz et al. (2000), Pardiou and Senoble (2005c), Rakotosamizany et al. (2009), Ramdohr and Milisenda (2004, 2006)
Nepal Gandaki—Ganesh Himal: <i>Dhading</i>	Garnier et al. (2006,2008)	Toamasina— Andilamena , Vatomandry	Laurs (2000, 2003a), Milisenda et al. (2001b), Pezzotta (2001f,g,h, 2006), Pardiou and Senoble (2005c), Ralantoarison et al. (2006), Cartier (2009)
Pakistan Azad Kashmir—Neelum Valley: <i>Nangimali</i>	Hammer (2003b,2004d), Garnier et al. (2005a,2008), Laurs (2007b), D. Blauwet (pers. comm., 2009)	Toliara—Amboasary, Andranondambo , Bekily, Betroka, Iankaroka, Sakarah , Voronkafatra	Pardiou and Senoble (2005c), Rakotosamizany et al. (2009) Milisenda et al. (2001a), Pardiou and Senoble (2005c)
Gilgit-Baltistan—Basha Valley: <i>Bisit</i> ; Hunza Valley: <i>Ahmedabad, Bajouri, Ganesh, Hachindar, Hassanabad</i>	Pêcher et al. (2001,2002), Chamberlain et al. (2002), Beesley (2004), Garnier et al. (2004), Pardiou and Soubiraa (2006b)	Malawi Southern—Ntcheu: <i>Chimwadzulu Hill</i>	Emmett (2000), Rankin (2002), Laurs (2004c), Dill (2005,2007), Michelou (2006), Dill and Ludwig (2008)
North-West Frontier—Bashi Valley, Battakundi	Hammer (2004a), Garnier et al. (2006)	Mozambique Manica—Chimoio: <i>Chimoio</i> Tete—Mutarara: <i>Nhaphali</i>	J. Marques (pers. comm., 2009)
Russia Northern Ural Mountains—Polyarnyy: <i>Rai-Iz</i> Middle Ural Mountains—Yekaterinburg: <i>Alabashka, Lipovka</i> Southern Ural Mountains—Plast: <i>Svetloe</i>	Pardiou et al. (2009f) P. Lyckberg (pers. comm., 2009) Grygoriev et al. (2000)	Nigeria Bauchi —Tafawa Balewa Borno—Biu-Gunda Kaduna —Antang, Gidan Waya, Godogodo Taraba—Adamawa: <i>Ganye</i> ; Gembu: <i>Karim Lamido</i>	Michelou (2006,2007), J. Michelou (pers. comm., 2009)
Tajikistan Kuhistoni-Badakhshon—Pamir Mountains: Murgab, Muzkol	Dufour et al. (2007)	Tanzania Dodoma— Winza Morogoro—Lukande, Mahenge, Matombo, Uluguru Mountains Ruvuma—Amanimakoro, Masuguru, Mtetesi River, Muhuwesi River, Ngapa, Songea, Tunduru Tanga—Kalalani, Kigwase, Umba Valley	Garnier et al. (2004a,b), W. Balmer, D. Mantheakis, and M. Saul (pers. comm., 2009, 2010) Laurs and Pardiou (2008), Schwarz et al. (2008), Schmetzer et al. (2010) Pardiou and Senoble (2005e), Michelou (2006), Pardiou (2007a) Pardiou and Senoble (2005e), Michelou (2006), Pardiou (2007a) Michelou (2006)
Thailand East —Bo Rai, Bo Waen, Khao Ploi Waen, Khao Saming, Welu Klang, Nong Bon, Tok Phrom North-East—Nong Khon, Nam Yuen	Sutthirat et al. (2001), Garnier et al. (2004b), Graham et al. (2008), P. Wathanakul (pers. comm., 2009) Yui et al. (2006)	Zimbabwe Midlands—Somabhula	L. F. Marsh and F. Mugumbate (pers. comm., 2009)
Vietnam Binh Thuan—Da Ban, Dak Ton, Ma Lam Nghe An— Qui Chau , Qui Hoop Quang Nam—Phuoc Hiep Yen Bai—An Phu, Luc Yen , Minh Xuan, Tan Huong, Thac Ba, Truc Lau, Yen Bai	Garnier et al. (2002,2004a,2005b,2005c,2006,2008), Giuliani et al. (2003), Pham et al. (2004a,b,c), Michelou (2006), Graham et al. (2008), D. Blauwet (pers. comm., 2009) Nguyen et al. (2007) Pham et al. (2004d) Nguyen et al. (2007) Pardiou and Senoble (2005a), Blauwet (2006a)	◆ Asia Afghanistan Kabul—Jegdalek Wardak—Maidan Shahr	Sutherland and Schwarz (2001) Garnier et al. (2004a,b), W. Balmer, D. Mantheakis, and M. Saul (pers. comm., 2009, 2010) Laurs and Pardiou (2008), Schwarz et al. (2008), Schmetzer et al. (2010) Pardiou and Senoble (2005e), Michelou (2006), Pardiou (2007a) Pardiou and Senoble (2005e), Michelou (2006), Pardiou (2007a) Michelou (2006)
◆ Australia New South Wales—Barrington, Bingara, Cudgong and Macquarie Rivers, Gloucester , Swanbrook, Tumarumba	Brown (2002), Sutherland (2006), Sutherland and Webb (2007), Graham et al. (2008) McClure and Smith (2001), Sutherland and Fanning (2001, 2007), Sutherland et al. (2003, 2009b), Roberts et al. (2004), Webb (2007), Graham et al. (2008), B. Birch (pers. comm., 2009), Sutherland and Abduriyim (2009)	Victoria	Sutherland and Abduriyim (2009)

Gem material/locality	Reference	Gem material/locality	Reference
Cambodia	Sutherland and Schwarz (2001)		(2004b,2008), Thein (2008), M. Smith, K. Thu, and P. Hlaing (pers. comm., 2009)
Pailin—Pailin	Sutherland et al. (2009a)		
China	Sutherland and Schwarz (2001), Liu (2004), Ou Yang (2005), Smith et al. (2005), Michelou (2006), X. Yuan (pers. comm., 2009)	Kachin—Nanyaseik	
		Mandalay—Kyauksin, Mogok , Thabeikkyin	Mitchell et al. (2007), Searle et al. (2007)
			Hlaing (2008)
Fujian—Mingxi: <i>Gaiyang</i>	Li (2009)	Shan—Mong Hkak, Mong Hsu	Garnier et al. (2008)
Hainan—Wenchang: <i>Penglai</i>	Li (2009)	Nepal	
Jiangsu—Liuhe: <i>Lianshan</i>	Li (2009)	Gandaki—Ganesh Himal: <i>Dhading</i>	
Shandong—Changle: Wutu	Li (2009)	Pakistan	Hammer (2003b,2004d), Henn and Milisenda (2005), Garnier et al. (2008), D. Blauwet (pers. comm., 2009)
Xinjiang—Taxkorgan	Tang et al. (2004)		Hammer (2004a)
India	Garnier et al. (2004a,2008), G. Choudhary and J. Panjikar (pers. comm., 2009)	Gilgit-Baltistan—Astora Valley: <i>Batwash Gahr</i> ; Hunza Valley: <i>Ganesh</i>	Quinn and Laurs (2004a), Pardieu et al. (2009f)
Andhra Pradesh—Anantapur, Hindupur, Ratnagiri Hills		North-West Frontier—Battakundi, Kohistan: <i>Sapat</i>	
Jammu and Kashmir—Doda, Sunjam	Michelou (2006)	Russia	
Kerala—Quilon, Trivandrum	Santosh et al. (2002)	Far East—Primorsky: <i>Kedrovka River, Krasno-armeisky, Nezametnoye</i>	Khanchuk (2002), Pakhomova et al. (2006), Nechaev et al. (2009)
Orissa —Balangir, Nawapara, Sambalpur		Sri Lanka	Dharmaratne (2003), Garnier et al. (2004a,b), Pardieu and Senoble (2005b), G. Zoysa (pers. comm., 2009)
Tamil Nadu—Kangayam, Kanniyakumari, Karur, Padiyur, Venkatapuram	McClure et al. (2005a), Michelou (2006)		Dissanayake et al. (2000), Pardieu and Senoble (2005b)
Laos	Sutherland and Schwarz (2001), Garnier et al. (2004a), Michelou (2006)	Central—Elaheha, Lunugala, Passara, Polonnaruwa	Dissanayake et al. (2000), Pardieu and Senoble (2005b)
		Sabaragamuwa—Balangoda, Eheliyagoda, Embilipitiya, Niwitigala, Pelmadulla, Rakwana, Ratnapura	Dissanayake et al. (2000), Pardieu and Senoble (2005b)
		Southern—Kataragama, Matara, Ridiyagama	
		Uva—Bibile, Haputale, Moneragala, Okkampitiya, Wellawaya	
		Western—Akurana, Horana, Ingiriya, Kiriella, Pelpola, Pugoda	
Myanmar	Sutherland et al. (2002a) Barley et al. (2003), Garnier et al.	Thailand	Sutherland and Schwarz (2001), Garnier et al. (2004a,b), Graham et al. (2008), P. Wathanakul (pers. comm., 2009)
			Promptrat et al. (2003), Yui et al. (2006)
		East —Khao Ploi Waen	Wathanakul et al. (2007)
		North-East—Nong Khon, Nam Yuen	Limtrakun et al. (2001), Yui et al. (2003)
		North—Chiang Khong, Den Chai, Wang Chin	Choowong (2002)
		West —Bo Phloi, Kanchanaburi	Sutherland and Schwarz (2001), Garnier et al. (2004a,b,2005b, 2005c,2008), Pham et al. (2004a,b), Michelou (2006), Graham et al. (2008), D. Blauwet (pers. comm., 2009)
		Vietnam	Nguyen et al. (2007)
		Binh Thuan—Da Ban, Dak Ton, Ma Lam, Phan Thiet	
		Dak Lak—Dak Nong	
		Dong Nai—Xa Gia Kiem, Xuan Loc	
		Lam Dong—Bao Lac, Di Linh	
		Nghe An— Qui Chau , Qui Hoop	
		Quang Nam—Phuoc Hiep	Nguyen et al. (2007)
		Yen Bai—An Phu, Bai Da Lan, Luc Yen , Yen Bai	Pardieu and Senoble (2005a), Blauwet (2006)
		♦ Australia	Sutherland and Schwarz (2001), Brown (2002), Garnier et al. (2004a,b), Jaques and Milligan (2004), Sutherland (2006), Sutherland and Webb (2007), Graham et al. (2008)
		New South Wales—Barrington, Bingara, Cudgegong and Macquarie Rivers, Gloucester , New England Range: <i>Glen Innes, Inverell, Tumberumba, Yarrowitch</i> ; Oberon, Vulcan State Forest	McClure and Smith (2001), Sutherland and Fanning (2001), Sutherland et al. (2002b, 2003, 2009b), Roberts et al. (2004), Zaw et al. (2006), Webb (2007), Sutherland and Abduriyim (2009)
		Queensland—Anakie, Rubyvale	Sutherland and Abduriyim (2009)

These sapphire crystals from Sri Lanka (yellow 6.8 g, blue 8.4 g) show a typical bipyramidal habit. Courtesy of Bill Larson, Palagems.com; photo by Robert Weldon.



Gem material/locality	Reference	Gem material/locality	Reference
Tasmania—Weldborough	Zaw et al. (2006), Sutherland and Abduriyim (2009)	Sangwa, Sarwad, Tonk, Udaipur	
Victoria	Sutherland and Abduriyim (2009)	Tamil Nadu—Karur, Madurai, Nilgiri, Salem, Tiruchchirappalli	
New Zealand		Myanmar	
South Island—Dunedin	Kiefert et al. (2006)	Shan—Mong Hsat	T. Hlaing (pers. comm., 2009)
◆ North America		Russia	
Canada	Wilson (2010)	Karelia—Sortavala: <i>Kitelskoe</i>	P. Lyckberg (pers. comm., 2009)
British Columbia—Slocan Valley near Passmore: <i>Blu Moon, Blu Starr, Sapphire Hill</i>	Coenraads and Laird (2000), Wilson (2007)	Sri Lanka	G. Zoysa (pers. comm., 2009)
Nunavut—Baffin Island: Kimmirut	LeCheminant et al. (2004), Wilson (2007)	Central—Elaheera, Kongahawela, Maskeliya, Polonnaruwa	
Ontario—Bancroft	Wight (2004)	Sabaragamuwā—Ratnapura	
United States		◆ Europe	
Montana —Deer Lodge: <i>Dry Cottonwood Creek</i> ; Granite: <i>Rock Creek</i> ; Judith: <i>Yogo Gulch</i> ; Lewis and Clark: <i>American Bar, Dana Bar, Eldorado Bar, Emerald Bar, French Bar, Magpie Gulch, Metropolitan Bar, and Spokane Bar</i> along the Missouri River	Mychaluk (2001), Berg (2004), Garnier et al. (2004a), Berger and Berg (2006), White (2010)	Austria	
◆ South America		Tirol—Ziller Valley	Staebler and Pohwat (2008)
Brazil		◆ Oceania	
Minas Gerais—Indaia, Malacacheta, Manhuaçu, Palmeiras, Sapucaia	Henn and Petsch (2000), Liccardo et al. (2005)	Solomon Islands	
Colombia		Malaita	Thirangoon (2010)
Cauca—Mercaderes: Rio Mayo	Johnson et al. (2000c), Romero-Ordóñez and Rodríguez-Vargas (2002), Duroc-Danner (2003), Sutherland et al. (2008)	◆ North America	
GARNET—Almandine/Rhodolite		Canada	Wilson (2010)
◆ Africa		British Columbia—Passmore: <i>B-Q Claim</i>	Wilson (2007)
Ethiopia		Nunavut—Baffin Island	Wilson (2007)
Sidamo—Agere Maryam, Chumba	Quinn and Laurs (2005a)	United States	White (2010)
Kenya	C. Simonet (pers. comm., 2009)	Alaska—Wrangell Mountains: <i>Wrangell</i>	Crawford et al. (2005), Staebler and Pohwat (2008)
Coast—Chawia, Kamtonga, Kisoli, Kuranze, Mangara, Manoa, Mgama, Mukongonyi, Mwachango: <i>Kambanga</i>		Idaho—Benawah: <i>Emerald Creek</i>	Ream (2000), Gunter (2008)
Rift Valley—Kajiado		◆ South America	
Madagascar	Henn and Milisenda (2001), F. Danet (pers. comm., 2009)	Brazil	
Antananarivo—Betafo		Rio Grande do Norte—Carnaúba dos Dantas: <i>Marimbondo</i>	Ferreira et al. (2007)
Fianarantsoa—Ambositra, Ankaditany, Ilakaka , Ranohira		Tocantins—Peixe: <i>Fazenda Balisto</i>	Eeckhout et al. (2004)
Toamasina—Ambatondrazaka, Andreba, Marolambo	Schmetzer et al. (2002c)	GARNET—Andradite/Demantoid	
Toliara—Ambovombe, Ampanihy, Bekily, Betioky, Betroka, Fotodrevo, Sakaraha , Taolagnaro, Tranoroa	Schmetzer et al. (2001, 2002b)	◆ Africa	
Mozambique	J. Marques (pers. comm., 2009)	Eritrea	
Niassa—Cuamba: <i>Cuamba</i>		Northern Red Sea—Sciumagalle	Milisenda and Hundziker (1999), Furuya (2007b)
Tanzania	W. Balmer, D. Mantheakis, and M. Saul (pers. comm., 2009, 2010)	Madagascar	F. Danet (pers. comm., 2009)
Arusha—Komolo, Merelani Hills		Antsirana— Antetezambato	Danet (2009a), Mocquet et al. (2009), Rondeau and Fritsch (2009), Rondeau et al. (2009b), Schmetzer and Karampelas (2009), Pezzotta (2010), Praszkiar and Gajowniczek (2010)
Kilimanjaro—Hedaru, Mwembe		Namibia	
Lindi—Namungo	Quinn-Darenus and Laurs (2008)	Erongo—near Erongo Mountain, Tubussis: <i>Green Dragon</i>	Lauris (2002e), Cairncross and Bahmann (2006a), Fritz et al. (2007c), Furuya (2007b), Stephenson and Kouznetsov (2009)
Manyara—Lelatema Mountains		◆ Asia	
Morogoro—Mahenge, Matombo, Mvuha, Uluguru Mountains		China	Renfro and Laurs (2010)
Mtwara—Namaputa		Iran	
Ruvuma—Mtetesi River, Muhuwesi River, Tunduru		Kerman—Jiroft: <i>Sogdan</i>	Lauris (2002f), Douman and Dirlam (2004), Furuya (2007b), Karampelas et al. (2007), Zang (2008a), Stephenson and Kouznetsov (2009)
Tanga—Kalalani, Kigwase, Mwakijembe, Umba Valley	Blodgett et al. (2007)	Japan	
◆ Asia		Nara—Tenkawa: <i>Kouse</i>	Hainschwang and Notari (2006)
Afghanistan		Pakistan	D. Blauwet (pers. comm., 2009)
Kunar—Darra-i-Pech	Quinn and Laurs (2004b)	Baluchistan	Fritz and Laurs (2007b)
India	G. Choudhary and J. Panjkar (pers. comm., 2009)	Federally Administered Tribal Areas—Bajaur: <i>Mana</i>	Milisenda et al. (2001a), Quinn and Laurs (2005b)
Andhra Pradesh —Bhadrachalam, Chittoor		Gilgit-Baltistan—Nanga Parbat	Furuya (2007b)
Orissa —Angul, Balangir, Deogarh, Kalahandi, Koraput, Phulabani, Nuapada, Sambalpur, Subarnapur		North-West Frontier—Kaghan Valley	Milisenda et al. (2001a), Quinn and Laurs (2005b)
Rajasthan —Ajmer, Bendria, Bhilwara, Kakaoria,			

Gem material/locality	Reference	Gem material/locality	Reference
Russia Middle Ural Mountains—Nizhniy-Tagil: <i>Bobrowka River</i> ; Verkhniy Ufaley: <i>Karkodino, Kladovka, Poldenevaya</i>	Laurs (2003b), Hochleitner (2005a), Korchevskaya (2006), Furuya (2007b), Zang (2008a), P. Lyckberg (pers. comm., 2009), Stephenson and Kouznetsov (2009)	Myanmar Mandalay—Kume	T. Hlaing (pers. comm., 2009)
Turkey Erzincan—Erzincan	Inns and Laurs (2009)	Pakistan North-West Frontier—Mohmand: <i>Ungade</i>	D. Blauwet (pers. comm., 2009)
◆ Europe		Sri Lanka Sabaragamuwa—Eheliyagoda, Ratnapura Southern—Kamburupitiya, Kataragama, Lunugamwehera, Matara, Tanamalwila, Thelioya, Tissamaharama Uva—Okkampitiya	G. Zoysa (pers. comm., 2009)
Italy Lombardy—Sondrio: <i>Malenco Valley</i>	Zang (2008a), Adamo et al. (2009b), Stephenson and Kouznetsov (2009)	◆ North America	
◆ North America		Canada Quebec—Asbestos: <i>Jeffrey</i> ; Bancroft: York River, Black Lake: <i>Lac d'Amiante</i> ; St.-Denis-de-Brompton: <i>Orford</i>	Wilson (2010) Amabili et al. (2004,2008), Wilson (2007), Horváth and Spertini (2008), Zang (2008b)
Canada Quebec—Black Lake: <i>Lac D'Amiante</i> Yukon Territory—Swift River	Wilson (2010) Wilson (2007), Amabili et al. (2009) Wilson (2007)	◆ South America	
Mexico Sonora—Hermosillo	Boehm (2006)	Brazil Minas Gerais—Galiléia: <i>Barra do Cuieté</i> Paraíba—Santa Luzia: <i>Água Fria</i>	Eeckhout et al. (2004) Eeckhout et al. (2004), Ferreira et al. (2006)
GARNET—Grossular/ Hessonite/Tsavorite			
◆ Africa			
Kenya Coast—Chawia, Kamtonga, Kisoli, Kuranze, Mangare, Manoa, Mgama, Mukongonyi, Mwachango: <i>Kambanga</i>	C. Simonet (pers. comm., 2009) Levinson et al. (2001d), Pardieu and Senoble (2005d), Michelou (2006), Pardieu (2008), Pardieu and Hughes (2009), Jang-Green and Beaton (2009)	Madagascar Toamasina—Marolambo Toliara—Ampanihy, Antaratra, Bekily, Fotodrevo, Sakoandroa, Tranoroa	F. Danet (pers. comm., 2009) Schmetzer et al. (2001,2002b), Krzemnicki et al. (2001), Laurs (2003a), Schmetzer (2003)
Rift Valley—Kajiado		Tanzania Lindi—Namtamba Tanga— Umba Valley	Laurs and Quinn (2006a) Blodgett et al. (2007)
Madagascar Toliara—Behara, Bekily, Berenty, Ejeda, Gogogogo	F. Danet (pers. comm., 2009) Henn and Milisenda (2001), Laurs (2003a), Pardieu and Hughes (2009)	Zambia Eastern—Sangu	Seifert and Vrána (2003)
Mali Kayes—Sandaré	Dameron (2008)	◆ Asia	
Nigeria Cross River Kogi—Makutu Kwara—Babana Plateau	J. Michelou (pers. comm., 2009)	China Heilongjiang—Shuangyashan	Ou Yang (2005) Li (2009)
Tanzania Arusha—Komolo: <i>Lemeshuko</i> ; Loliondo, Merelani Hills Lindi—Mbekenyeru, Namungu Hill Manyara—Lelatema Mountains, Naberera, Namalulu	Levinson et al. (2001d), W. Balmer, D. Mantheakis, S. Merisheki, and M. Saul (pers. comm., 2009) Pardieu (2007b), Pardieu and Hughes (2009) Pardieu (2007a), Pardieu and Hughes (2009) Mayerson and Laurs (2004), Pardieu and Hughes (2009), Zang (2008b), Beaton (2009c), Pardieu et al. (2010)	India Andhra Pradesh —Bhadrachalam, Chittoor Orissa —Angul, Balangir, Deogarh, Kalahandi, Koraput, Phulabani, Sambalpur Rajasthan —Bendria, Kakaoria, Sangwa, Sarwad, Udaipur Tamil Nadu—Karur, Madurai, Nilgiri, Salem, Tiruchchirappalli	J. Panjekar (pers. comm., 2009)
Ruvuma—Mtetesi River, Muhuwesi River, Tunduru Tanga—Kalalani	Pardieu and Hughes (2009)	Mongolia Khangai Mountains—Shavryn Tsaram	Dill et al. (2004,2006)
◆ Asia			
Afghanistan Nuristan—Kantiwa, Munjalag	Laurs and Quinn (2004), Blauwet (2008)	Russia Yakutia: Sakha Republic—Mirnyy: <i>Mir</i> , Udachnyy: <i>Udachnaya</i>	P. Lyckberg (pers. comm., 2009)
India Andhra Pradesh—Nellore Jharkhand—Hazaribag Karnataka—Hassan, Mysore, Shimoga Orissa—Angul, Balangir, Deogarh, Ghatpara, Jharposi, Kalahandi, Koraput, Phulabani Rajasthan—Ajmer, Shahpura Tamil Nadu—Nilgiri	J. Panjekar (pers. comm., 2009)	◆ Europe	
		Czech Republic Bohemia—České Středohoří Mountains: Podsedice Moravia—Krkonoše Mountains: Vestřev	Novák (2001), Seifert and Vrána (2005), Kouřimský and Hyršl (2008), Zang and Gilg (2008)
GARNET—Spessartine			
◆ Africa			
Kenya Coast—Kamtonga	Beaton (2009a)	Italy Piedmont—Ala Valley, Varaita Valley	Guastoni et al. (2001), Simon (2008)
Madagascar	F. Danet (pers. comm., 2009)		

Gem material/locality	Reference	Gem material/locality	Reference
◆ Oceania			
New Caledonia—Tiwaka River	Adams and Beck (2009)	Lempira—Erandique: <i>San Andres, Tablon</i> ; Sosual: <i>Las Colinas</i>	
◆ North America			
Canada	Wilson (2010)	Mexico	Fritsch et al. (2002b), Cruz-Ocampo et al. (2007), Schütz (2007), Gaillou et al. (2008)
British Columbia —Cassiar, Cry Lake, Dease Lake, Mount Ogden	Nichol (2000), Harlow and Sorensen (2001), Simandl et al. (2001), Makepeace and Simandl (2004), Kim (2007), Adams and Beck (2009)	Hidalgo—Zimápán: <i>Leopard</i>	Coenraads and Zenil (2006)
		Jalisco—Magdalena	Michelou (2006)
		Querétaro	Michelou (2006)
		United States	Gaber (2007), White (2010)
		Louisiana—Vernon	
		Mississippi—Claiborne	
		Nevada—Humboldt: <i>Virgin Valley</i> ; Pershing: <i>Black Rock Desert</i>	Castor and Henry (2000), Clark (2005), Huber (2008)
		Oregon—Lake: <i>Juniper Ridge</i> ; Morrow: <i>Opal Butte</i>	Laurs and Quinn (2003)
		Wyoming—Granite Mountains	
		◆ South America	
		Argentina	Fritsch et al. (2009)
		Brazil	Pinto and Pedrosa-Soares (2001), Caucia et al. (2008b), Gaillou et al. (2008)
		Bahia	Hyršl (2002a)
◆ Africa			
Ethiopia	Gaillou et al. (2008)		
Shewa—Mezezo	Mazzero (2003), Gauthier et al. (2004a), Tucci (2005), Staebler and Neumeier (2007)		
Wollo—Wegel Tena	Mazzero et al. (2009), Rondeau et al. (2009a)		
Madagascar	Simoni and Caucia (2009)		
Toliara—Beraketa, Tsivory	Holzhey (2000), Henn and Millisenda (2001)		
Somalia	Kinnaird (2002)		
Jodha—Qabri Baxar			
◆ Asia			
Indonesia			
Java—Jawa Barat: <i>Banten, Labak</i>	Laurs (2001b), Millisenda and Wild (2004), Sujatmiko et al. (2004,2005), Staebler and Neumeier (2007), Sun et al. (2009)		
Iran			
Kerman—Shahr-e-Babak	Nagle (2007)		
Myanmar			
Mandalay—Natogyi	T. Hlaing (pers. comm., 2009)		
Sri Lanka			
Uva—Wellawaya	G. Zoysa (pers. comm., 2009)		
Turkey			
Anatolia—Kütahya: <i>Simav</i>	Esenli et al. (2001,2003), Mutlu et al. (2005), Fischer (2007), Hatipoğlu (2009)		
◆ Australia			
	Townsend (2001), Brown (2002), Horton (2002), Sutherland (2006), Thiry et al. (2006), Pecover (2007), Gaillou et al. (2008)		
New South Wales— Lightning Ridge, White Cliffs	Thomas et al. (2006), Frasier and Frasier (2007), Smith (2007), Roskin (2008)		
Queensland—Bulgroo, Davenport-Palpara, Eromanga, Jundah, Koroit, Kynuna, Opalton, Quilpie , Toompine, Yaraka, Yowah	Cooper and Neville (2007)		
South Australia— Andamooka, Coober Pedy, Lambina, Mintabie , Stuart Creek	Townsend (2006,2009), Cody (2007), R. Coenraads (pers. comm., 2009)		
◆ Europe			
Hungary			
Zemplén Mountains	Rondeau et al. (2004)		
Slovakia			
Košice—Prešov: <i>Dubník</i>	Huber (2007)		
◆ North America			
Canada	Wilson (2010)		
British Columbia—Vernon: <i>Klinker</i>	Downing (2003), Wilson (2005), Michelou (2006), Gaber (2007)		
Honduras	Banerjee and Wenzel (1999), Vogt (2004), Michelou (2006), Dabdouh (2007), Gaillou et al. (2008)		
Gracias—San Antonio	Viti and Gemmi (2009)		

The diversity of colored stones mined during the 2000s is shown in these butterfly brooches. Top—Vietnamese spinel (8.47 ct in body) with Namibian jeremejevite for the eyes; center—natural pearls from Mexico’s Sea of Cortez (11.77 ct), with “rainbow” feldspars from Madagascar and diamonds in the wings, and Colombian emeralds for the eyes; and bottom—sphene from Madagascar (center stone 13.83 ct) with haiyiye from Germany for the eyes. Courtesy of Bernadine Johnston and Buzz Gray; photo by Robert Weldon.



Gem material/locality	Reference	Gem material/locality	Reference
Pará—São Geraldo do Araguaia	Collyer and Kotschoubey (2000), Gauthier et al. (2004b), Farrar (2007)	Mahajanga—Boriziny, Tsaratanana	
Piauí— Pedro II: <i>Boi Morto</i>	Hyršl (2002a), Laurs (2007a), Caucia et al. (2009)	Toamasina—Antanimbohobe, Didy, Vatamandry	E. Granon (pers. comm., 2009)
Peru	Gaillou et al. (2008)	Toliara—Ilotaka	
Arequipa—Nazca: <i>Acari</i>	Hyršl (2001a, 2007), Quinn and Laurs (2003), Henn (2006a), Brajkovic et al. (2007), Caucia et al. (2008a)	Morocco	
Ica—Ica: <i>Monte Rosa</i>	Hyršl (2006)	Tata—Tata	Beaton (2009b)
PERIDOT (Olivine)		Mozambique	J. Marques (pers. comm., 2009)
♦ Africa		Nampula—Namapa: <i>Namapa</i>	
Egypt		Tete—Zumbo: <i>Catizane River</i>	Bettencourt-Dias and Wilson (2000)
Red Sea—Zabargad Island	Brooker et al. (2004)	Zambézia—Alto Molócuè: <i>Molócuè</i> , Milange: <i>Milange</i> ; Murrua	
♦ Asia		Namibia	G. Schneider (pers. comm., 2009)
China	Liu (2004), Ou Yang (2005), Smith et al. (2005), Michelou (2006), X. Yuan (pers. comm., 2009)	Erongo—Erongo Mountains, Goboboseb Mountains, Otjiwarongo: <i>Platveld</i>	Cairncross and Bahmann (2006a), Michelou (2006)
Hebei—Zhangjiakou: <i>Damaping</i>	Henn (1999), Li (2009)	Kunene—Namib Desert: <i>Sarusas</i>	Laurs (2005a)
Jilin—Jiaohe		Nigeria	Michelou (2006, 2007)
Mongolia		Bauchi	
Khangai Mountains—Shavryn Tsaram	Dill et al. (2004, 2006)	Cross River	
Myanmar		Gombe	
Mandalay— Bernardmyo	Krzemnicki and Groenenboom (2008), T. Hlaing (pers. comm., 2009)	Kaduna	
Pakistan		Kano	
North-West Frontier— Kohistan: <i>Sapat</i>	Hammer (2004c), Bouilhol et al. (2009)	Oyo	
Russia		Taraba—Jalingo	Laurs and Koivula (2003)
Kola Peninsula—Kovdor	Sokolov et al. (2006)	Zambia	C. Milisenda (pers. comm., 2009)
Sri Lanka		Central—Mumbwa	
Sabaragamuwa—Kolonne	Graziani et al. (2002), G. Zoysa (pers. comm., 2009)	Southern— Kalomo: <i>Mapatizya</i>	Milisenda et al. (2001c), Anckar (2006)
Tajikistan		Zimbabwe	
Kuhistoni-Badakhshon—Pamir Mountains: <i>Kuh-i-Lal</i>	Kondo (2008)	Bulawayo—Nyamandlovu: <i>Chikodzi</i> , <i>Manzinyama</i>	L. F. Marsh and F. Mutugumbate (pers. comm., 2009)
Vietnam		♦ Asia	
Gia Lai—Bien Ho, Ham Rong	Pham et al. (2004a), D. Blauwet (pers. comm., 2009)	Afghanistan	
♦ Europe		Ghazni—Zarkishen Mountain: Moqor	Laurs (2002g)
Italy		Russia	P. Lyckberg (pers. comm., 2009)
Sardinia—Pozzomaggiore	Adamo et al. (2009a)	Far East—Magadan: <i>Kedon</i>	
♦ North America		Northern Ural Mountains—Khasavarka	
Canada	Wilson (2010)	Middle Ural Mountains—Yekaterinburg: <i>Aduy</i>	
British Columbia—Cherryville, Hendrix Lake, Lumby, Williams Lake	Wilson (2005, 2007)	Yakutia (Sakha Republic)—Aldan: <i>Obman</i>	
United States		South Korea	
Arizona— Gila: <i>San Carlos</i>	White (2010)	Kangwŏn—Eonyang	Yang et al. (2001)
♦ QUARTZ—Amethyst/Citrine/Ametrine		♦ North America	
♦ Africa		Canada	
Democratic Republic of the Congo	Fritz and Laurs (2007a)	Ontario— Thunder Bay	Garland (2004), Kerr (2006), Wilson (2007, 2010)
Kenya		Mexico	
Eastern—Kitui	C. Simonet (pers. comm., 2009)	Guerrero—Amatitlan	Ontiveros et al. (2004)
Madagascar	Henn and Milisenda (2001), F. Danet (pers. comm., 2009)	United States	White (2010)
Antananarivo—Andongologo, Bevitsika Mountain, Mahasolo, Soavinandriana	Danet (2009)	Arizona—Maricopa: <i>Four Peaks</i>	Lowell and Koivula (2004)
Antsiranana—Ambakirano, Andapa		Georgia—Wilkes: Jackson's Crossroads	Laurs (2005b), Bowling et al. (2005)
Fianarantsoa—Ambatofinandrahana, Ambositra, Isahara, Mangataboahangy, Vondrozo, Vorondolo	Pezzotta (2001e)	♦ South America	
		Bolivia	
		Santa Cruz— Sandoval: <i>Anahí, Ayoreita, Mina Pobre</i>	Laurs (2001g, 2010a), Hyršl and Petrov (2009), Weldon (2009)
		Brazil	Pinto and Pedrosa-Soares (2001)
		Bahia—Caetité: <i>Brejinho das Ametistas</i>	Couto (2000)
		Minas Gerais—Coronel Murta-Itinga: <i>Jenipapo, Morro Redondo, Piauí</i> ; Galiléia-Conselheiro Pena-São Geraldo do Baixo: <i>Macaco, Sapo</i>	Macri et al. (2006)
		Pará— Marabá: <i>Alto Bonito, Pau d'Arco: <i>Villa Esperança</i></i>	
		Rio Grande do Sul— Paraná Basin	Mossman and Juchem (2000), Gilg et al. (2003), Proust and Fontaine (2007a,b), Duarte et al. (2009), Commin-Fischer et al. (2010)

Gem material/locality	Reference	Gem material/locality	Reference
Nuristan —Chatrus, Diwaneh Baba, Gamitha, Golmata, Kalaigal, Kanalook, Kantiwa, Kurgal, Konquwa, Masey, Mawi, Nilaw-Kolum, Nishai, Papra, Paprowk, Rhodisht, Wama	Glas (2002), Natkaniec-Nowak et al. (2009)	Maine—Oxford: Mount Apatite, <i>Mount Mica</i> , <i>Newry</i> , <i>Paris</i>	Simmons et al. (2001,2005a,b), Freeman (2005), Laurs and Freeman (2005)
Kunar —Gur-Salak, Kala, Khana-Khana, Paroon Valley		◆ South America	
China	Liu (2004), Ou Yang (2005), Smith et al. (2005), Michelou (2006), X. Yuan (pers. comm., 2009)	Brazil	César-Mendes et al. (2001), Pinto and Pedrosa-Soares (2001), Neves (2009)
Guangxi—Huangbao	Glas (2002)	Ceará—Solonópole-Quixeramobim	
Inner Mongolia—Jiaoligetai	Glas (2002)	Minas Gerais —Araçuaí-Itinga-Santa Clara: <i>Baixão</i> , <i>Jenipapo</i> , <i>Piauí</i> , <i>Pirineus</i> , <i>Teixeirinha</i> , <i>Urubú</i> ; Coronel Murta: <i>Aqua Branca</i> , <i>Barra de Salinas</i> , <i>Baixa Grande</i> , <i>Lavrinha</i> , <i>Lorena</i> , <i>Morro Redondo</i> , <i>Ouro Fino</i> , <i>Paineira</i> , <i>Pau Alto</i> ; Salinas: <i>Salinas</i> ; Virgem da Lapa: <i>Campinho</i> , <i>Manoel Mutuca</i> ; Conselheiro Pena-Divino das Laranjeiras-Governador Valadares-Galiléia: <i>Jairo</i> , <i>Pamaro</i> , <i>Sapo</i> ; Malacacheta—Franciscópolis-Resplendor-Santa Rosa: <i>Mutuca</i> , <i>Nova Santa Rosa</i> ; São José da Safira-Agua Boa: <i>Aricanga</i> , <i>Chιά</i> , <i>Cruzeiro</i> , <i>Pederneira</i> , <i>Santa Rosa</i>	Bilal et al. (2000), Mossman (2001), Bastos (2002), Karfunkel et al. (2002), Steger (2006), Viana et al. (2007), Menezes (2009)
Shanxi—Wutaishan Mountains, Yunzhongshan Mountains	Glas (2002)	Paraíba —Frei Martinho: <i>Alto Quixaba</i> ; Pedra Lavrada: <i>Serra Branca</i> ; Salgado: <i>Mina da Batalha</i> , <i>Mineração Batalha</i>	Shigley et al. (2001b), Cook (2002), Wilson (2002), Ferreira et al. (2005), Abduriyim et al. (2006), Michelou (2006), Furuya (2007a), Beurlen et al. (2009a,b)
Sichuan—Kangding, Wenchuan, Xiaojin		Rio Grande do Norte —Parelhas: <i>Alto da Cabeça</i> , <i>Bulandeira</i> , <i>Mulungu</i> (<i>Boqueirãozinho/Capoeira</i>), <i>Quintos do Baixo</i>	Johnson et al. (2000b), Laurs and Shigley (2000), Shigley et al. (2001b), Milisenda (2005), Abduriyim et al. (2006), Baumgartner et al. (2006), Michelou (2006), Furuya (2007a), Soares et al. (2008), Beurlen et al. (2009a,b)
Yunnan—Gaoligongshan Mountains: <i>Fugong</i> , <i>Gongshan</i> , <i>Lushui</i>	Wu (2004)		
Xinjiang Uygur—Altai Mountains: <i>Koktokay</i>	Tang et al. (2004), Wang et al. (2007), Zhang et al. (2008), Li (2009)		
India	G. Choudhary and J. Panjikar (pers. comm., 2009)		
Andhra Pradesh—Araku Valley, Borra, Vishakhapatnam	Sarkar and Guru (2010)		
Orissa—Boudh, Jharsuguda, Sambalpur			
Myanmar	Kane (2002), T. Hlaing (pers. comm., 2009)		
Karen			
Kayah—Pawm Chaung	Hlaing (2008)		
Mandalay—Singu: <i>Letpanthla</i>	Hlaing (2007)		
Shan—Makmai, Molo, Mong Hsu, Mong Long, Mong Pan, Momeik	Glas (2002), Kyi et al. (2005)		
Pakistan	Obodda (2003), Hammer and Muhammad (2004), Blauwet (2004), Blauwet and Muhammad (2004), D. Blauwet (pers. comm., 2009)		
Azad Kashmir—Neelum Valley: <i>Dongar Nar</i>	Beesley (2004)		
Gilgit-Baltistan—Astora Valley: <i>Harchoo Nirai</i> , <i>Mir Malik</i> , <i>Nanga Parbat</i> ; Braldu Valley: <i>Dassu</i> , <i>Hoh Nala</i> , <i>Tosho</i> ; Hunza Valley: <i>Nagar</i> ; Indus Valley: <i>Baluchi</i> , <i>Baralooma</i> , <i>Gochalay</i> , <i>Kaotoonery</i> , <i>Khargulook</i> , <i>Shengus</i> , <i>Stak Nala</i>	Laurs (2001d), Glas (2002)		
Russia			
Transbaikalia—Chita: <i>Adun-Chilon</i> , <i>Borschevochniye Mountains</i> , <i>Sherlova Gora</i> ; Krasnyy Chikoy: <i>Malkan Mountains</i>	Simmons et al. (2001), Glas (2002), Smirnov et al. (2003), Peretyazhko et al. (2004), Hochleitner (2005b), Lyckberg (2005b), Zagorsky et al. (2005), Zagorsky and Peretyazhko (2006), Badanina et al. (2008), Zagorsky (2010)		
Sri Lanka	G. Zoysa (pers. comm., 2009)		
Central—Badulla, Elahera, Passara, Polonnaruwa			
Sabaragamuwu—Balangoda, Embilipitiya, Kolonne, Ratnapura			
Uva—Okkampitiya			
Western—Avisawella			
Vietnam			
Yen Bai—An Phu, Khai Trung, Luc Yen, Minh Tien, Tan Lap	Pham et al. (2004a), D. Blauwet (pers. comm., 2009)		
◆ North America			
Canada			
Northwest Territories—O'Grady Lake	Ercit et al. (2003), Wilson (2007, 2010)		
United States	White (2010)		
California—San Diego—Pala: <i>Pala Chief</i> , <i>Stewart</i> , <i>Ramona</i> ; <i>Little Three</i> ; Warner Springs: <i>Cryo-Genie</i>	Morgan and London (1999), Laurs (2001f, 2001i, 2002, 2004b), Simmons et al. (2001), Fisher (2002,2008), Swoboda and Larson (2006), Symons et al. (2009), Ertl et al. (2010)		

ZOISITE (Includes tanzanite)

◆ Africa

Tanzania

Arusha—**Merelani Hills**

Malisa (2003), Scheepers and Scheepers (2003), Pardieu and Senoble (2005e), Zancanella (2004,2006,2007), Smuts (2005), Michelou (2006), Pardieu (2007b), Giuliani et al. (2008), Pardieu et al. (2009a), Wilson et al. (2009), Schroeder (2010)

◆ Asia

Afghanistan

Nuristan—Shinwari

Beaton and Lu (2009)

Pakistan

Gilgit-Baltistan—Shigar Valley: Alchuri

D. Blauwet (pers. comm., 2009)

Blauwet (2006b)

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