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GEMSTONES

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In 2009, the estimated value of natural gemstones produced in the United States was more than $8.41 million, and the estimated value of U.S. laboratory-created gemstone production was more than $27.2 million. The total estimated value of U.S. gemstone production was about $35.6 million. The value of U.S. gemstone imports was $13.3 billion, and the value of combined U.S. gemstone exports and reexports was estimated to be $10.5 billion.

In this report, the terms "gem" and "gemstone" mean any mineral or organic material (such as amber, pearl, petrified wood, and shell) used for personal adornment, display, or object of art because it possesses beauty, durability, and rarity. Of more than 4,000 mineral species, only about 100 possess all these attributes and are considered to be gemstones. Silicates other than quartz are the largest group of gemstones in terms of chemical composition; oxides and quartz are the second largest (table 1). Gemstones are subdivided into diamond and colored gemstones, which in this report designates all natural nondiamond gems. In addition, laboratory-created gemstones, cultured pearls, and gemstone simulants are discussed but are treated separately from natural gemstones (table 2). Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data. Current information on industrial-grade diamond and industrial-grade garnet can be found in the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals, chapters on industrial diamond and industrial garnet, respectively.

Gemstones have fascinated humans since prehistoric times. They have been valued as treasured objects throughout history by all societies in all parts of the world. Amber, amethyst, coral, diamond, emerald, garnet, jade, jasper, lapis lazuli, pearl, rock crystal, ruby, serpentine, and turquoise are some of the first stones known to have been used for making jewelry. These stones served as symbols of wealth and power. Today, gems are worn more for pleasure or in appreciation of their beauty than to demonstrate wealth. In addition to jewelry, gemstones are used for collections, decorative art objects, and exhibits.

Legislation and Government Programs

No industrial diamond remained in the National Defense Stockpile (NDS), which is managed by the Defense National Stockpile Center (DNSC), Defense Logistics Agency. The last stocks of industrial diamond stones were completely sold during 2008 (Lough, 2008). At yearend 2009, DNSC had no plans to stockpile any inventory of industrial diamond in the NDS.

Production

U.S. gemstone production data were based on a survey of more than 230 domestic gemstone producers conducted by the USGS. The survey provided a foundation for projecting the scope and level of domestic gemstone production during the year. However, the USGS survey did not represent all gemstone activity in the United States, which includes thousands of professional and amateur collectors. Consequently, the USGS supplemented its survey with estimates of domestic gemstone production from related published data, contacts with gemstone dealers and collectors, and information gathered at gem and mineral shows.

Commercial mining of gemstones has never been extensive in the United States. More than 60 varieties of gemstones have been produced commercially from domestic mines, but most of the deposits are relatively small compared with those of other mining operations. In the United States, much of the current gemstone mining is conducted by individual collectors, gem clubs, and hobbyists rather than by businesses.

The commercial gemstone industry in the United States consists of individuals and companies that mine gemstones or harvest shell and pearl, firms that manufacture laboratory-created gemstones, and individuals and companies that cut and polish natural and laboratory-created gemstones. The domestic gemstone industry is focused on the production of colored gemstones and on the cutting and polishing of large diamond stones. Industry employment is estimated to be between 1,000 and 1,200.

Most natural gemstone producers in the United States are small businesses that are widely dispersed and operate independently. The small producers probably have an average of less than three employees, including those who only work part time. The number of gemstone mines operating from year to year fluctuates because the uncertainty associated with the discovery and marketing of gem-quality minerals makes it difficult to obtain financing for developing and sustaining economically viable operations.

The total value of natural gemstones produced in the United States during 2009 was estimated to be about $8.41 million (table 3). This production value was a 27% decrease from that of 2008, owing to a 69% decrease in shell production.

Natural gemstone materials indigenous to the United States are collected, produced, and (or) marketed in every State. During 2009, all 50 States produced at least $1,330 worth of gemstone materials. There were 10 States that accounted for 79% of the total value, as reported by survey respondents. These States were, in descending order of production value, Arizona, Oregon, Utah, California, Idaho, Colorado, Arkansas, Montana, North Carolina, and Tennessee. Some States were known for the production of a single gemstone material—Tennessee for freshwater pearls, for example. Other States produced a variety of gemstones; for example, Arizona's gemstone deposits included agate, amethyst, azurite, chrysocolla, garnet, jade, jasper, malachite, obsidian, onyx, opal, peridot, petrified wood, smithsonite, and turquoise. There was also a wide variety of gemstones found and produced in California, Idaho, Montana, and North Carolina.

In August 2009, a 310-carat emerald crystal was found at Adams Emerald Mine, Hiddenite District, North Carolina. A 64.83-carat gem, named the Carolina Emperor, was cut from the crystal. The Carolina Emperor is North America's largest faceted emerald, and its value was estimated to be more than $1.5 million. Of all emeralds found in North America, the 20 largest were found in North Carolina, and the emeralds that have been found in North Carolina are the most valuable that have been found in North America (McClatchy-Tribune News Service, 2010; Speer, 2011).

In 2009, the United States had only one active operation in a known diamond-bearing area in Crater of Diamonds State Park near Murfreesboro in Pike County, AR. The State of Arkansas maintains a dig-for-fee operation for tourists and rockhounds at the park; Crater of Diamonds is the only diamond mine in the world that is open to the public. The diamonds occur in a lamproite breccia tuff associated with a volcanic pipe and in the soil developed from the lamproite breccia tuff. In 2009, 918 diamond stones with an average weight of 0.199 carats were recovered at the Crater of Diamonds State Park. Of the 918 diamond stones recovered, 29 weighed more than 1 carat. Since the diamond-bearing pipe and the adjoining area became a State park in 1972, 28,745 diamond stones with a total carat weight of 5,700.22 have been recovered (Waymon Cox, park interpreter, Crater of Diamonds State Park, written commun., July 19, 2010). Exploration has demonstrated that there is about 78.5 million metric tons (Mt) of diamond-bearing rock in this diamond deposit (Howard, 1999, p. 62). An Arkansas law enacted early in 1999 prohibits commercial diamond mining in the park (Diamond Registry Bulletin, 1999).

No diamond mines have operated commercially in the United States since 2002. Diamond was produced at the Kelsey Lake diamond mine, located close to the Colorado-Wyoming State line near Fort Collins, CO, for several years until April 2002. The Kelsey Lake property has been fully reclaimed.

There has been some interest in exploration for diamond deposits in areas of the United States with geologic settings and terrain that are similar to Canadian diamond mining areas. These areas are in Alaska, Colorado, Minnesota, Montana, and Wyoming (Associated Press, 2002, 2004; Diamond Registry Bulletin, 2005). Even though some exploration has taken place in these States, they remain largely underexplored for diamonds (Iron Range Resources & Rehabilitation Board, 2010). Although exploration and field studies have found many diamond indicators and a number of large diamond deposits, none have attracted long-term investors or been opened as commercially feasible mines thus far.

In addition to natural gemstones, laboratory-created gemstones and gemstone simulants were produced in the United States in 2009. Laboratory-created or synthetic gemstones have the same chemical, optical, and physical properties as the natural gemstones. Simulants have an appearance similar to that of a natural gemstone material, but they have different chemical, optical, and physical properties. Laboratory-created gemstones that have been produced in the United States include alexandrite, diamond, emerald, garnet, moissanite, ruby, sapphire, spinel, turquoise, and zirconia. However, during 2009, only cubic zirconia, diamond, moissanite, and turquoise were produced commercially. Simulants of coral, lapis lazuli, malachite, and turquoise also are manufactured in the United States. In addition, certain colors of laboratory-created sapphire and spinel, used to represent other gemstones, are classified as simulants.

Laboratory-created gemstone production in the United States was valued at more than $27.2 million during 2009, which was a 47% decrease compared with that of 2008. This was owing to a very large decrease in laboratory-created moissanite production. The value of U.S. simulant gemstone output was estimated to be more than $100 million. Five companies in five States, representing virtually the entire U.S. laboratory-created gemstone industry, reported production to the USGS. The States with reported laboratory-created gemstone production were, in descending order of production value, Florida, New York, Massachusetts, North Carolina, and Arizona.

Since the 1950s, when scientists manufactured the first laboratory-created bits of diamond grit using a high-pressure, high-temperature (HPHT) method, this method of growing diamonds has become relatively commonplace in the world as a technology for laboratory-created diamonds, so much so that thousands of small plants throughout China were using the HPHT method and producing laboratory-created diamonds suitable for cutting as gemstones. Gem-quality diamonds of one carat or more are harder to manufacture because at that size it is difficult to consistently produce diamonds of high quality, even in the controlled environment of a lab using the HPHT method. After more than 50 years of development, that situation has changed, and several laboratory-created diamond companies were producing high-quality diamonds that equal those produced from mines (Park, 2007).

Gemesis Corp., Sarasota, FL, consistently produced gem-quality laboratory-created diamond and reported a 10th year of production in 2009. The laboratory-created diamonds are produced using equipment, expertise, and technology developed by a team of scientists from Russia and the University of Florida. The weight of the laboratory-created diamond stones ranges from 1½ to 2 carats, and most of the stones are yellow, brownish yellow, colorless, and green. Gemesis uses diamond-growing machines, each machine capable of growing 3-carat rough diamonds by generating HPHT conditions that recreate the conditions in the Earth's mantle where natural diamonds form (Davis, 2003). Gemesis could be producing as many as 30,000 to 40,000 stones each year, and annual revenues may reach $70 million to $80 million. Gemesis diamonds are available for retail purchase in jewelry stores and on the Internet, and the prices of the Gemesis laboratory-created diamonds are 30% to 50% less than those of comparable natural diamond but above the prices of simulated diamond (Gemesis Corp., 2010).

In the early 2000s, Apollo Diamond, Inc., near Boston, MA, developed and patented a method for growing single, extremely pure, gem-quality diamond crystals by chemical vapor deposition (CVD). The CVD technique transforms carbon into plasma, which is then precipitated onto a substrate as diamond. CVD had been used for more than a decade to cover large surfaces with microscopic diamond crystals, but in developing this process Apollo discovered the temperature, gas composition, and pressure combination that resulted in the growth of a single diamond crystal. These CVD diamonds may not be distinguishable from natural diamond by some tests (Davis, 2003). In 2007, Apollo Diamond produced laboratory-created stones that ranged from 1 to 2 carats and expected to expand to larger stones in the future. Growth of CVD diamonds is limited only by the size of the seed placed in the diamond growing chamber. In 2008, the company increased its production of large stones. Apollo diamonds sell at prices that average 15% less than those of comparable natural diamonds (Apollo Diamond, Inc., 2008). Both Apollo and Gemesis prefer to call their diamonds "cultured" rather than laboratory-created, referring to the fact that the diamonds are grown much like a cultured pearl is grown. In addition to their use as gemstones, CVD diamond could be used to make extremely powerful lasers; to create frictionless medical replacement joints; to create windows on spacecraft; to create surgical diamond blades and scalpels; or as coatings for car parts that would not scratch or wear out. The greatest potential use for CVD diamond is as a material for high-tech uses in computers and other electronic devices that utilize processors (Maney, 2005; Park, 2007).

In the mid-2000s, the Carnegie Institution of Washington Geophysical Laboratory and the University of Alabama jointly developed and patented a faster CVD process and apparatus to produce ½-inch thick 10-carat single diamond crystals using microwave plasma technology. This method has up to 100 times faster growth rates (averaging 100 micrometers per hour) than previous CVD methods and allows multiple crystals to be grown simultaneously. This crystal size is about five times that of commercially available laboratory-created diamonds produced by HPHT methods and other CVD techniques (Willis, 2004; Carnegie Institution of Washington, 2005; Science Blog, 2005). Apollo and the Carnegie Institution have noted that diamonds produced by the CVD method are harder than natural diamonds and diamonds produced by HPHT methods.

Research at the Carnegie Institution continued improving the microwave plasma CVD method, developing a process to anneal the diamonds at temperatures up to 2000 °C using a microwave plasma below atmospheric pressure. In this process, the diamond crystals, which are originally yellow-brown if produced at very high growth rates, are turned colorless or light pink. This low-pressure/high-temperature annealing process enhances the optical properties of this rapid-grown CVD single crystal diamond, and the size of the crystals that can be treated is not limited. This process is thought to produce better synthetic diamonds for high pressure devices and window materials with improved optical properties in the ultraviolet to infrared range. These high-quality, single-crystal diamonds likely will have a variety of applications in addition to their use as gems, such as using the diamond crystals as anvils in high-pressure research or optical uses that take advantage of the outstanding transparency of diamond. Another application might be in quantum computing, by utilizing vacancy centers in the diamond's crystal lattice for storing quantum information (Carnegie Institution for Science, 2008).

In 2009, Charles & Colvard, Ltd. in North Carolina entered its 12th year as the world's only manufacturer of moissanite, a gem-quality laboratory-created silicon carbide. Moissanite is also an excellent diamond simulant, but it is being marketed for its own gem qualities. Moissanite exhibits a higher refractive index (brilliance) and higher luster than diamond. Its hardness is between those of corundum (ruby and sapphire) and diamond, which gives it durability (Charles & Colvard, Ltd., 2010b). Charles & Colvard reported that production and sales were down in 2009 compared with those of the previous year as a result of the effects of the economic recession. However, this trend did begin to reverse in the fourth quarter and net sales increased 10% compared with net sales in the third quarter of 2009 (Charles & Colvard, Ltd., 2010a).

U.S. shell production decreased by 69% in 2009 compared with that of 2008. U.S. mussel shells are used as a source of mother-of-pearl and as seed material for culturing pearls. Pearl producers in Japan have begun using manmade seed materials or seed materials from China and other sources in addition to stockpiled material. In addition, the popularity of darker and colored pearls and freshwater pearls that do not use U.S. seed material has increased. In some regions of the United States, shell from mussels was being used more as a gemstone based on its own merit rather than as seed material for pearls. This shell material was being processed into mother-of-pearl and used in beads, jewelry, and watch faces.

Consumption

Historically, diamond gemstones have proven to hold their value despite wars or economic depressions (Schumann, 1998, p. 8), but this did not hold true during the recent worldwide economic recession. Diamond and colored gemstones value and sales decreased during the economic downturn in 2008 and continued into 2009. Gemstone production, trade, and consumption demonstrated significant decreases during 2008, mostly concentrated in the last 4 months of the year, and continued through most of 2009. U.S. gemstone consumption and sales increased in December 2009.

Although the United States accounted for little of the total global gemstone production, it was the world's leading diamond and nondiamond gemstone market. It was estimated that U.S. gemstone markets accounted for more than 35% of world gemstone demand in 2009. The U.S. market for unset gem-quality diamond during the year was estimated to be about $12.7 billion, a decrease of 35% compared with that of 2008. Domestic markets for natural, unset nondiamond gemstones totaled approximately $779 million in 2009, which was a 30% decrease from that of 2008. These large declines in domestic markets were a reflection of the impact of the global recession on luxury spending.

In the United States, about two-thirds of domestic consumers designate diamond as their favorite gemstone when surveyed (Wade, 2006). The popularity of diamonds with domestic consumers is also evidenced by the U.S. diamond market making up 94% of the total U.S. gemstone market. Colored natural gemstones, colored laboratory-created gemstones, and "fancy" colored diamonds remained popular in 2009, but the values of the domestic markets for almost all types of colored natural, unset nondiamond gemstones decreased from the 2008 values (table 10), also owing to the impact of the recession on luxury spending. The largest demand for colored stones was in the American and Asian colored diamond markets with strong sales of champagne, cognac, grey, black, pink, orange, and yellow stones (Diamond Registry Bulletin, 2007). This trend was first evident in 2007 and has remained through the present.

There were about 200,000 diamond jewelry retail outlets worldwide in 2009. From these retail outlets, about 45% of diamond jewelry was sold in the United States, 33% in Asia, and 11% in Europe. An estimated 32,000 retail outlets specialize in fine jewelry in the United States. The estimated U.S. retail jewelry sales were $59 billion in 2009, down slightly from sales of $60 billion in 2008 (National Jeweler, 2010c). U.S. jewelry sales showed an increase of 5.6% more than that of the previous year during the 2009 holiday shopping season (National Jeweler, 2009).

Prices

Gemstone prices are governed by many factors and qualitative characteristics, including beauty, clarity, defects, demand, durability, and rarity. Diamond pricing, in particular, is complex; values can vary significantly depending on time, place, and the subjective valuations of buyers and sellers. There are more than 14,000 categories used to assess rough diamond and more than 100,000 different combinations of carat, clarity, color, and cut values used to assess polished diamond.

Colored gemstone prices are generally influenced by market supply and demand considerations, and diamond prices are supported by producer controls on the quantity and quality of supply. Values and prices of gemstones produced and (or) sold in the United States are listed in tables 3 through 5. In addition, customs values for diamonds and other gemstones imported, exported, or reexported are listed in tables 6 through 10.

De Beers Group companies remain a significant force, influencing the price of about 40% of gem-quality diamond sales worldwide during 2009 because the companies mine a significant portion of the world's gem-quality diamond produced each year, and they also purchase diamonds from Russia. In 2009, De Beers companies produced 23.6 million carats, a 49% decrease from 2008 production. De Beers companies also sorted and valuated a large portion (by value) of the world's annual supply of rough diamond through De Beers' subsidiary Diamond Trading Co. (DTC), which had marketing agreements with other producers. In 2009, De Beers had diamond sales of $3.84 billion, which was a decrease of 44.3% from diamond sales of $6.89 billion in 2008 (De Beers Group, 2009, p. 17; 2010; National Jeweler, 2010a).

Foreign Trade

During 2009, total U.S. gemstone trade with all countries and territories was valued at about $23.8 billion, which was a decrease of 34% from that of 2008. Diamond accounted for about 94% of the 2009 gemstone trade total. In 2009, U.S. exports and reexports of diamond were shipped to 94 countries and territories, and imports of all gemstones were received from 100 countries and territories (tables 6–10). In 2009, U.S. import quantities in cut diamond decreased by 16%, compared with those of 2008. U.S. imports in rough and unworked diamond decreased by 4% (table 7). The United States remained the world's leading diamond importer and was a significant international diamond transit center as well as the world's leading gem-quality diamond market. In 2009, U.S. export quantities of gem-grade diamond decreased by 54% compared with those of 2008. The large volume of reexports shipped to other centers revealed the significance that the United States had in the world's diamond supply network (table 6). These decreases in trade were owing to the impact of the recession on luxury spending.

Import values of laboratory-created gemstone decreased by 21% for the United States in 2009 compared with those of 2008 (table 10). Again, this decrease in imports was owing to the impact of the recession on luxury spending.

Laboratory-created gemstone imports from Austria, China, Germany, India, Switzerland, and Thailand, with more than $500,000 in imports each, made up about 82% (by value) of the total domestic imports of laboratory-created gemstones during the year (table 9). The marketing of imported laboratory-created gemstones and enhanced gemstones as natural gemstones, and the mixing of laboratory-created materials with natural stones in imported parcels, continued to be problems for some domestic producers in 2009. There also were continuing problems with some simulants being marketed as laboratory-created gemstones during the year.

World Review

The gemstone industry worldwide has two distinct sectors—diamond mining and marketing and colored gemstone production and sales. Most diamond supplies are controlled by a few major mining companies; prices are supported by managing the quality and quantity of the gemstones relative to demand, a function performed by De Beers through DTC. Unlike diamond, colored gemstones are primarily produced at relatively small, low-cost operations with few dominant producers; prices are influenced by consumer demand and supply availability.

In 2009, world natural diamond production totaled about 129 million carats—74.1 million carats gem quality and 54.6 million carats industrial grade (table 11). Most production was concentrated in a few regions—Africa [Angola, Botswana, Congo (Kinshasa), Namibia, and South Africa], Asia (northeastern Siberia and Yakutia in Russia), Australia, North America (Northwest Territories in Canada), and South America (Brazil and Venezuela). In 2009, Russia led the world in total natural diamond output quantity (combined gemstone and industrial) with 25% of the world estimated production. Botswana was the world's leading gemstone diamond producer, followed by Russia, Canada, Angola, Congo (Kinshasa), Guinea, South Africa, and Namibia in descending order of quantity. These eight countries produced 96% (by quantity) of the world's gemstone diamond output in 2009.

In 2002, the international rough-diamond certification system, the Kimberley Process Certification Scheme (KPCS), was agreed upon by United Nations (UN) member nations, the diamond industry, and involved nongovernmental organizations to prevent the shipment and sale of conflict diamonds. Conflict diamonds are diamonds that originate from areas controlled by forces or factions opposed to legitimate and internationally recognized governments, and are used to fund military action in opposition to those governments, or in contravention of the decisions of the U.N. Security Council. The KPCS includes the following key elements: the use of forgery-resistant certificates and tamper-proof containers for shipments of rough diamonds; internal controls and procedures that provide credible assurance that conflict diamonds do not enter the legitimate diamond market; a certification process for all exports of rough diamonds; the gathering, organizing, and sharing of import and export data on rough diamonds with other participants of relevant production; credible monitoring and oversight of the international certification scheme for rough diamonds; effective enforcement of the provisions of the certification scheme through dissuasive and proportional penalties for violations; self regulation by the diamond industry that fulfills minimum requirements; and sharing information with all other participants on relevant rules, procedures, and legislation as well as examples of national certificates used to accompany shipments of rough diamonds (Weldon, 2001). Namibia assumed the chair of KPCS for the period from January 1 through December 31, 2009. Namibia was the seventh in succession to hold the chair after India, South Africa, Canada, Russia, Botswana, and the European Commission (Kimberley Process, 2008a; 2008b). The list of 49 participants, represented 75 nations (including the 27 member nations of the European Community) plus the rough diamond-trading entity of Taipei. During 2009, Cote d' Ivoire was under UN sanctions and was prohibited from trading in rough diamonds; and Venezula voluntarily separated from the KPCS and ceased certification for export of its rough diamonds. In 2009, the KPCS also monitored the diamond sector in Zimbabwe after a diamond rush in 2007 threatened the country's KPCS system, and there were indications of smuggling and reports of violence. The KPCS had engaged Zimbabwean authorities and were working with them to strengthen their certification scheme and help Zimbabwe meet their obligations to the KPCS. The participating nations in the KPCS account for approximately 98% of the global production and trade of rough diamonds (Kimberley Process, 2009a; 2009b).

Globally, the value of production of natural gemstones other than diamond was estimated to be about $2 billion in 2009. Most nondiamond gemstone mines are small, low-cost, and widely dispersed operations in remote regions of developing nations. Foreign countries with major gemstone deposits other than diamond are Afghanistan (aquamarine, beryl, emerald, kunzite, lapis lazuli, ruby, and tourmaline), Australia (beryl, opal, and sapphire), Brazil (agate, amethyst, beryl, ruby, sapphire, topaz, and tourmaline), Burma (beryl, jade, ruby, sapphire, and topaz), Colombia (beryl, emerald, and sapphire), Kenya (beryl, garnet, and sapphire), Madagascar (beryl, rose quartz, sapphire, and tourmaline), Mexico (agate, opal, and topaz), Sri Lanka (beryl, ruby, sapphire, and topaz), Tanzania (garnet, ruby, sapphire, tanzanite, and tourmaline), and Zambia (amethyst and beryl). In addition, pearls are cultured throughout the South Pacific and in other equatorial waters; Australia, China, French Polynesia, and Japan were key producers in 2009.

Worldwide in 2009, three small diamond mines and two expansion projects started up. Three of the startups were in Russia, and two were in Guinea (Metals Economics Group, 2010, p. 14).

Burma.—Gemstone sanctions against Burma by the international community, which began in 2008, seemed to be having an effect. Total Burmese gemstone production in 2009 was reported to have decreased by 46% from that of 2008. There was not an increase in gem production in any category except for pearls. Burmese jade production decreased 18% in 2009 from that of 2008, pearl production increased by 5%, peridot production decreased by 66%, ruby decreased by 10%, sapphire decreased by 30%, and spinel decreased by 48%. Gemstone trade was down with all countries participating in the sanctions. Burmese gemstone trade with China, which was not participating in the sanctions, increased in 2009 by 10% from that of 2008. In the United States, the Burmese gemstone sanctions were brought about by the Burma Jade Act of 2008, which was enacted and reported on in the 2008 Gemstone Minerals Yearbook report (Sapora, 2010).

Canada.—Canadian diamond production was more than 10.9 million carats (Mct) with an estimated value of $1.7 billion during 2009, a decrease of about 26% compared with that of 2008. Diamond exploration continued in Canada, with several commercial diamond projects and additional discoveries in Alberta, British Columbia, the Northwest Territories, Nunavut, Ontario, and Quebec. In 2009, Canada produced 15% of the world's natural gemstone diamond output.

The Ekati Diamond Mine, Canada's first operating commercial diamond mine, completed its 11th full year of production in 2009. Ekati produced 4.2 Mct of diamond from 5.10 million metric tons (Mt) of ore. BHP Billiton Ltd. has an 80% controlling ownership in Ekati, which is in the Northwest Territories. Ekati has estimated remaining reserves of 38.5 Mt of ore in kimberlite pipes that contain 18.3 Mct of diamond. BHP Billiton projected the remaining mine life to be 13 years. Approximately 79% of the Ekati 2009 diamond production was gem-grade material (BHP Billiton Ltd., 2010, p. 10; Perron, 2011, p. 1).

The Diavik Diamond Mine, Canada's second diamond mine, also located in the Northwest Territories, completed its seventh full year of production. In 2009, Diavik produced 5.6 million carats of diamond, a decrease of 40% from the previous year's production. This lower production was a consequence of a reduced operating level at the mine intended to balance production with lower market demand that resulted from the downturn in the economy that began in mid-2008. Diavik reacted by temporarily ceasing diamond production at the Diavik Mine between July 14 and August 24, 2009. During this time period, the Diavik Mine was placed on a care-and-maintenance schedule. At yearend 2009, Diavik Diamond Mines estimated the mine's remaining proven and probable reserves to be 19.7 Mt of ore in kimberlite pipes containing 59.1 million carats of diamond and projected the total mine life to be 16 to 22 years. During 2009, Diavik began developing an underground mine, and construction on the underground project was substantially completed during 2009. First ore was expected during the first quarter of 2010, with full production expected in 2013. The mine is an unincorporated joint venture between Diavik Diamond Mines Inc. (60%) and Harry Winston Diamond Mines Ltd. (40%) (Diavik Diamond Mines Inc., 2010; Perron, 2011, p. 2).

Canada's third diamond mine, the Jericho Diamond Mine, is located in Nunavut and was owned by Tahera Diamond Corp. Tahera estimated the Jericho Diamond Mine's reserves to be about 5.5 Mt of ore grading 0.85 carats per ton. The Jericho Diamond Mine experienced startup problems related to ore mining and processing. The mine also suffered financial problems owing to the cost of transporting supplies to the mine site, higher operational costs, higher oil prices, and appreciation of the Canadian dollar versus the U.S. dollar. All of these problems combined to force the company to enter into protection under Canada's "Companies' Creditors Arrangement Act" on January 16, 2008, and the mine suspended production on February 6, 2008. As a result, the mine's 2008 production was only 118,000 carats. At yearend 2009, Tahera was finalizing arrangements to sell all its Jericho mine assets (Perron, 2011, p. 2).

The Snap Lake Mine, which is wholly owned by De Beers Canada Inc., is in the Northwest Territories. The Snap Lake deposit is a tabular-shaped kimberlite dike rather than the typical kimberlite pipe. The dike is 2.7 meters thick and dips at an angle of 15°. The deposit was mined using a modified room and pillar underground mining method in 2009. The Snap Lake Mine started mining operations in October 2007, reached commercial production levels in the first quarter of 2008, and officially opened June 25, 2008. The mine was expected to produce 1.4 Mct per year of diamond, and the mine life was expected to be about 20 years. De Beers suspended production for 6 weeks in July and August 2009. This production suspension was scheduled to align production levels with market demand. The mine's production for the year was 440,000 carats, for a recovered grade of 1.25 carats per ton (Perron, 2011, p. 2–3).

The Victor Mine, which also is wholly owned by De Beers Canada, is in northern Ontario on the James Bay coast. The Victor kimberlite consists of two pipes with surface area of 15 hectares (37.1 acres). The Victor Mine initiated mining operations at the end of December 2007 and officially opened on July 26, 2008. The Victor deposit reportedly holds 27.4 Mt of ore with average ore grade of 0.23 carats per ton. At full capacity, the open pit mine was expected to produce 600,000 carats per year, and the mine life was expected to be about 12 years. De Beers also suspended production at this mine for 6 weeks in July and August. In 2009, the mine's production was 696,000 carats valued at $244 million and had an average recovery grade of 0.33 carats per ton (Perron, 2011, p. 3).

China.—During 2009, China became the world's second largest diamond market, following the United States and replacing Japan. The Chinese Government reported that 2009 diamond imports were more than $1.5 billion (National Jeweler, 2010b).

Guinea.—The Mandala alluvial mine, owned by Stellar Diamonds Plc, was producing with positive cash flow at 60% of capacity by yearend 2009. During 2010, the mine's output was expected to be 140,000 carats. Stellar estimated that the deposit contains 536,000 carats of diamond in 1.41 Mt of resources, grading 0.38 carats per ton (Metals Economics Group, 2010, p. 14–15).

Another alluvial mine, Bomboko, owned by West African Diamonds Plc, had increased production to 1,500 carats per month from 35,000 tons per month of ore by October 2009. Visual inspection of stones produced indicated that about 60% was gem quality and 40% was industrial grade. West African estimated that the deposit contains 750,000 carats of diamond in 25 Mt of resources grading 0.03 carats per ton (Metals Economics Group, 2010, p. 14–15).

Russia.—In 2009, Russia was again the world's leading producer of combined natural gemstone and industrial diamonds as it has been every year since 2004. Russian natural diamond production was 32.8 Mct with an estimated value of $2.34 billion, a decrease of about 11% compared with that of the previous year (Metals Economics Group, 2011, p. 12).

The largest mine that came online in 2009 was the underground development of the Arkangelskaya pipe at the Lomonosov Mine in northwestern Russia. Lomonosov started mining the Arkangelskaya pipe in September at 1 million tons per year (Mt/yr) of ore and was estimated to have an optimum production capacity of 4 Mt/yr of ore. Lomonosov is 95% owned by ALROSA Co. Ltd. and 5% owned by the Government of Russia. Lomonosov was estimated to have 27.3 Mct of diamonds contained in 54.8 Mt of ore, grading at an estimated 0.5 carats per ton. The estimated mine life was 17 years, with materials coming from the Arkangelskaya and Karpinskogo-1 pipes (Metals Economics Group, 2010, p. 14–15).

The Mirny Division of Alrosa in Yakutia officially opened the Mir underground mine in August. The Mir was expected to yield 500,000 carats of diamonds from 1 Mt/yr of ore during a projected 50-year mine life. Alrosa had future plans for two additional underground operations parallel to Mir, that would provide an additional 4.5 Mt/yr of ore (Metals Economics Group, 2010, p. 14–15).

A third new mine owned by Alrosa was the Aikhal underground mine in Yakutia. Aikhal began commercial production in December 2009. The mine was estimated to contain 1.25 Mct of diamonds in 12.5 Mt of ore grading 0.10 carats per ton. Aikhal had an estimated 25-year mine life (Metals Economics Group, 2010, p. 14–15).

South Africa.—On September 24, 2009, a rough 507.55-carat (just more than 100 grams) white diamond was mined at the historic Cullinan Mine, where the famous Cullinan diamond (the largest diamond found in recorded history) was discovered in 1905. The Cullinan Mine is owned by Petra Diamonds Cullinan Consortium, whose spokesman said that the gemstone was among the world's 20 largest diamonds ever discovered. Initial examinations of the stone indicated that it is of exceptional color and clarity, and most likely a Type I diamond. The diamond was found with three other exceptionally valuable diamonds, a 168-carat gemstone and two other stones that weighed 58.5 and 53.3 carats. The Cullinan Mine is also the world's primary source for blue diamonds. In May 2009, a fancy vivid blue diamond weighing 7.03 carats (cut from 26.58-carat rough diamond) found at the Cullinan Mine sold for $9.4 million. This was the highest price ever paid for a gemstone sold at auction (Maclean, 2009; Reinke, 2009).

Outlook

As the domestic and global economy improves, Internet sales of diamonds, gemstones, and jewelry were expected to continue to grow and increase in popularity, as were other forms of e-commerce that emerge to serve the diamond and gemstone industry. This is likely to take place as the gemstone industry and its customers become more comfortable with and learn the applications of new e-commerce tools (Profile America, Inc., 2008).

Independent producers, such as Ekati and Diavik in Canada, will likely continue to bring a greater measure of competition to global markets. More competition presumably will bring more supplies and lower prices. Further consolidation of diamond producers and larger quantities of rough diamond being sold outside DTC is expected to continue as the diamond industry adjusts to De Beers' reduced influence on the industry.

More laboratory-created gemstones, simulants, and treated gemstones are likely to enter the marketplace and necessitate more transparent trade industry standards to maintain customer confidence.

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TABLE 1
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Amber	Hydrocarbon	Yellow, red, green, blue	Any	Low to medium	2.0–2.5	1.0–1.1	Single	1.54	Synthetic or pressed plastics, kaurigum	Fossil resin, color, low density, soft, insects.
Apatite	Chlorocalcium phosphate	Colorless, pink, yellow, green, blue, violet	Small	Low	5.0	3.16–3.23	Double	1.63–1.65	Amblygonite, andalusite, brazilianite, precious beryl, titanite, topaz, tourmaline	Crystal habit, color, hardness, appearance.
Azurite	Copper carbonate hydroxide	Azure, dark blue, pale blue	Small to medium	do.	3.5–4.0	3.7–3.9	do.	1.72–1.85	Dumortierite, hauynite, lapis lazuli, lazulite, sodalite	Color, softness, crystal habits, associated minerals.
Benitoite	Barium titanium silicate	Blue, purple, pink, colorless	do.	High	6.0–6.5	3.64–3.68	do.	1.76–1.80	Sapphire, tanzanite, blue diamond, blue tourmaline, cordierite	Strong blue in ultraviolet light.
Beryl:										
Aquamarine	Beryllium aluminum silicate	Blue-green to light blue	Any	Medium to high	7.5–8.0	2.63–2.80	do.	1.58	Synthetic spinel, blue topaz	Double refraction, refractive index.
Bixbite	do.	Red	Small	Very high	7.5–8.0	2.63–2.80	do.	1.58	Pressed plastics, tourmaline	Refractive index.
Emerald, natural	do.	Green	Medium	do.	7.5	2.63–2.80	do.	1.58	Fused emerald, glass, tourmaline, peridot, green garnet doublets	Emerald filter, dichroism, refractive index.
Emerald, synthetic	do.	do.	Small	High	7.5–8.0	2.63–2.80	do.	1.58	Genuine emerald	Lack of flaws, brilliant fluorescence in ultraviolet light.
Golden (heliodor)	do.	Yellow to golden	Any	Low to medium	7.5–8.0	2.63–2.80	do.	1.58	Citrine, topaz, glass, doublets	Weak-colored.
Goshenite	do.	Colorless	do.	Low	7.5–8.0	2.63–2.80	do.	1.58	Quartz, glass, white sapphire, white topaz	Refractive index.
Morganite	do.	Pink to rose	do.	do.	7.5–8.0	2.63–2.80	do.	1.58	Kunzite, tourmaline, pink sapphire	Do.
Calcite:										
Marble	Calcium carbonate	White, pink, red, blue, green, or brown	do.	do.	3.0	2.72	Double (strong)	1.49–1.66	Silicates, banded agate, alabaster gypsum	Translucent.
Mexican onyx	do.	do.	do.	do.	3.0	2.72	do.	1.60	do.	Banded, translucent.
Charoite	Hydrated sodium calcium hydroxi-fluoro-silicate	Lilac, violet, or white	Small to medium	do.	5.0–6.0	2.54–2.78	XX	1.55–1.56	Purple marble	Color, locality.

See footnotes at end of table.

TABLE 1—Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Chrysoberyl:										
Alexandrite	Beryllium aluminate	Green by direct sunlight, or encandescent light, red by indirect sunlight or fluorescent light	Small to medium	High	8.5	3.50–3.84	Double	1.75	Synthetic	Strong dichroism, color varies from red to green, hardness.
Cat's eye	Beryllium aluminate	Greenish to brownish	Small to large	High	8.5	3.50–3.84	Double	1.75	Synthetic, shell	Density, translucence, chatoyance.
Chrysolite	do.	Yellow, green, and (or) brown	Medium	Medium	8.5	3.50–3.84	do.	1.75	Tourmaline, peridot	Refractive index, silky.
Chrysocolla	Hydrated copper silicate	Green, blue	Any	Low	2.0–4.0	2.0–2.4	XX	1.46–1.57	Azurite, dyed chalcedony, malachite, turquoise, variscite	Lack of crystals, color, fracture, low density, softness.
Coral	Calcium carbonate	Orange, red, white, black, purple, or green	Branching, medium	do.	3.5–4.0	2.6–2.7	Double	1.49–1.66	False coral	Dull translucent.
Corundum:										
Ruby	Aluminum oxide	Rose to deep purplish red	Small	Very high	9.0	3.95–4.10	do.	1.78	Synthetics, including spinel, garnet	Inclusions, fluorescence.
Sapphire, blue	do.	Blue	Medium	High	9.0	3.95–4.10	do.	1.78	do.	Inclusions, double refraction, dichroism.
Sapphire, fancy	do.	Yellow, pink, colorless, orange, green, or violet	Medium to large	Medium	9.0	3.95–4.10	do.	1.78	Synthetics, glass and doublets, morganite	Inclusions, double refraction, refractive index.
Sapphire or ruby, stars	do.	Red, pink, violet, blue, or gray	do.	High to low	9.0	3.95–4.10	do.	1.78	Star quartz, synthetic stars	Shows asterism, color side view.
Sapphire or ruby, synthetic	do.	Yellow, pink, blue, green, orange, violet, or red	Up to 20 carats	Low	9.0	3.95–4.10	do.	1.78	Synthetic spinel, glass	Curved striae, bubble inclusions.
Cubic zirconia	Zirconium and yttrium oxides	Colorless, pink, blue, lavender, yellow	Small	do.	8.25–8.5	5.8	Single	2.17	Diamond, zircon, titania, moissanite	Hardness, density, lack of flaws and inclusions, refractive index.
Diamond	Carbon	White, blue-white, yellow, brown, green, red, pink, blue	Any	Very high	10.0	3.516–3.525	do.	2.42	Zircon, titania, cubic zirconia, moissanite	High index, dispersion, hardness, luster.
Feldspar:										
Amazonite	Alkali aluminum silicate	Green-blue	Large	Low	6.0–6.5	2.56	XX	1.52	Jade, turquoise	Cleavage, sheen, vitreous to pearly, opaque, grid.
Labradorite	do.	Gray with blue and bronze sheen color play (schiller)	do.	do.	6.0–6.5	2.56	XX	1.56	do.	Do.

See footnotes at end of table.

TABLE 1—Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Moonstone	do.	Colorless, white, gray, or yellow with white, blue, or bronze schiller	do.	do.	6.0–6.5	2.77	XX	1.52–1.54	Glass, chalcedony, opal	Pale sheen, opalescent.
Sunstone	do.	Orange, red brown, colorless with gold or red glittery schiller	Small to medium	do.	6.0–6.5	2.77	XX	1.53–1.55	Aventurine, glass	Red glittery schiller.
Garnet	Complex silicate	Brown, black, yellow, green, red, or orange	Small to medium	Low to high	6.5–7.5	3.15–4.30	Single strained	1.79–1.98	Synthetics, spinel, glass	Single refraction, anomalous strain.
Hematite	Iron oxide	Black, black-gray, brown-red	Medium to large	Low	5.5–6.5	5.12–5.28	XX	2.94–3.22	Davidite, cassiterite, magnetite, neptunite, pyrolusite, wolframite	Crystal habit, streak, hardness.
Jade:										
Jadeite	Complex silicate	Green, yellow, black, white, or mauve	Large	Low to very high	6.5–7.0	3.3–3.5	Crypto-crystalline	1.65–1.68	Nephrite, chalcedony, onyx, bowenite, vesuvianite, grossularite	Luster, spectrum, translucent to opaque.
Nephrite	Complex hydrous silicate	do.	do.	do.	6.0–6.5	2.96–3.10	do.	1.61–1.63	Jadeite, chalcedony, onyx, bowenite, vesuvianite, grossularite	Do.
Jet (gagate)	Lignite	Deep black, dark brown	do.	Low	2.5–4.0	1.19–1.35	XX	1.64–1.68	Anthracite, asphalt, cannel coal, onyx, schorl, glass, rubber	Luster, color.
Lapis lazuli	Sodium calcium aluminum silicate	Dark azure-blue to bright indigo blue or even a pale sky blue.	do.	do.	5.0–6.0	2.50–3.0	XX	1.50	Azurite, dumortierite, dyed howlite, lazulite, sodalite, glass	Color, crystal habit, associated minerals, luster, localities.
Malachite	Hydrated copper carbonate	Light to black-green banded	do.	do.	3.5–4.0	3.25–4.10	XX	1.66–1.91	Brochantite, chrysoprase, opaque green gemstones	Color banding, softness, associated minerals.
Moissanite	Silicon carbide	Colorless and pale shades of green, blue, yellow	Small	Low to medium	9.25	3.21	Double	2.65–2.69	Diamond, zircon, titania, cubic zirconia	Hardness, dispersion, lack of flaws and inclusions, refractive index.
Obsidian	Amorphous, variable (usually felsic)	Black, gray, brown, dark green, white, transparent	Large	Low	5.0–5.5	2.35–2.60	XX	1.45–1.55	Aegirine-augite, gadolinite, gagate, hematite, pyrolusite, wolframite	Color, conchoidal fracture, flow bubbles, softness, lack of crystal faces.
Opal	Hydrated silica	Reddish orange, colors flash in white gray, black, red, or yellow	do.	Low to high	5.5–6.5	1.9–2.3	Single	1.45	Glass, synthetics, triplets, chalcedony	Color play (opalescence).

See footnotes at end of table.

TABLE 1—Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Peridot	Iron magnesium silicate	Yellow and (or) green	Any	Medium	6.5–7.0	3.27–3.37	Double (strong)	1.65–1.69	Tourmaline, chrysoberyl	Strong double refraction, low dichroism.
Quartz:										
Agate	Silicon dioxide	Any	Large	Low	7.0	2.58–2.64	XX	XX	Glass, plastic, Mexican onyx	Cryptocrystalline, irregularly banded, dendritic inclusions.
Amethyst	do.	Purple	Large	Medium	7.0	2.65–2.66	Double	1.55	Glass, plastic, fluorite	Macrocrystalline, color, refractive index, transparent, hardness.
Aventurine	do.	Green, red-brown, gold-brown, with metallic iridescent reflection	do.	Low	7.0	2.64–2.69	do.	1.54–1.55	Iridescent analcime, aventurine feldspar, emerald, aventurine glass	Macrocrystalline, color, metallic iridescent flake reflections, hardness.
Cairngorm	do.	Smoky orange or yellow	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Carnelian	do.	Flesh red to brown red	do.	do.	6.5–7.0	2.58–2.64	do.	1.53–1.54	Jasper	Cryptocrystalline, color, hardness.
Chalcedony	do.	Bluish, white, gray	do.	do.	6.5–7.0	2.58–2.64	do.	1.53–1.54	Tanzanite	Do.
Chrysoprase	do.	Green, apple-green	do.	do.	6.5–7.0	2.58–2.64	do.	1.53–1.54	Chrome chalcedony, jade, prase opal, prehnite, smithsonite, variscite, artifically colored green chalcedony	Do.
Citrine	do.	Yellow	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Jasper	do.	Any, striped, spotted, or sometimes uniform	do.	do.	7.0	2.58–2.66	XX	XX	do.	Cryptocrystalline, opaque, vitreous luster, hardness.
Onyx	do.	Many colors	do.	do.	7.0	2.58–2.64	XX	XX	do.	Cryptocrystalline, uniformly banded, hardness.
Petrified wood	do.	Brown, gray, red, yellow	do.	do.	6.5–7.0	2.58–2.91	Double	1.54	Agate, jasper	Color, hardness, wood grain.
Rock crystal	do.	Colorless	do.	do.	7.0	2.65–2.66	do.	1.55	Topaz, colorless sapphire	Do.

See footnotes at end of table.

TABLE 1—Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Rose	do.	Pink, rose red	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Tiger's eye	do.	Golden yellow, brown, red, blue-black	do.	do.	6.5–7.0	2.58–2.64	XX	1.53–1.54	XX	Macrocrystalline, color, hardness, hatoyancy.
Rhodochrosite	Manganese carbonate	Rose-red to yellowish, stripped	Large	Low	4.0	3.45–3.7	Double	1.6–1.82	Fire opal, rhodonite, tugtupite, tourmaline	Color, crystal habit, reaction to acid, perfect rhombohedral cleavage.
Rhodonite	Manganese iron calcium silicate	Dark red, flesh red, with dendritic inclusions of black manganese oxide	do.	do.	5.5–6.5	3.40–3.74	do.	1.72–1.75	Rhodochrosite, thulite, hessonite, spinel, pyroxmangite, spessartine, tourmaline	Color, black inclusions, lack of reaction to acid, hardness.
Shell:										
Mother-of-pearl	Calcium carbonate	White, cream, green, blue-green, with iridescent play of color	Small	do.	3.5	2.6–2.85	XX	XX	Glass and plastic imitation	Luster, iridescent play of color.
Pearl	do.	White, cream to black, sometimes with hint of pink, green, purple	do.	Low to high	2.5–4.5	2.6–2.85	XX	XX	Cultured and glass or plastic imitation	Luster, iridescence, x-ray of internal structure.
Spinel, natural	Magnesium aluminum oxide	Any	Small to medium	Medium	8.0	3.5–3.7	Single	1.72	Synthetic, garnet	Refractive index, single refraction, inclusions.
Spinel, synthetic	do.	do.	Up to 40 carats	Low	8.0	3.5–3.7	Double	1.73	Spinel, corundum, beryl, topaz, alexandrite	Weak double refraction, curved striae, bubbles.
Spodumene:										
Hiddenite	Lithium aluminum silicate	Yellow to green	Medium	Medium	6.5–7.0	3.13–3.20	do.	1.66	Synthetic spinel	Refractive index, color, pleochroism.
Kunzite	do.	Pink to lilac	do.	do.	6.5–7.0	3.13–3.20	do.	1.66	Amethyst, morganite	Do.
Tanzanite	Complex silicate	Blue to lavender	Small	High	6.0–7.0	3.30	do.	1.69	Sapphire, synthetics	Strong trichroism, color.
Topaz	do.	White, blue, green, pink, yellow, gold	Medium	Low to medium	8.0	3.4–3.6	do.	1.62	Beryl, quartz	Color, density, hardness, refractive index, perfect in basal cleavage.
Tourmaline	do.	Any, including mixed	do.	do.	7.0–7.5	2.98–3.20	do.	1.63	Peridot, beryl, garnet corundum, glass	Double refraction, color, refractive index.
Turquoise	Copper aluminum phosphate	Blue to green with black, brown-red inclusions	Large	Low	6.0	2.60–2.83	do.	1.63	Chrysocolla, dyed howlite, dumortierite, glass, plastics, variscite	Difficult if matrix not present, matrix usually limonitic.
Unakite	Granitic rock, feldspar, epidote, quartz	Olive green, pink, and blue-gray	do.	do.	6.0–7.0	2.60–3.20	XX	XX	XX	Olive green, pink, gray-blue colors.

See footnotes at end of table.

TABLE 1—Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Zircon	Zirconium silicate	White, blue, brown, yellow, or green	Small to medium	Low to medium	6.0–7.5	4.0–4.8	Double (strong)	1.79–1.98	Diamond, synthetics, topaz, aquamarine	Double refraction, strongly dichroic, wear on facet edges.

Do., do. Ditto. XX Not applicable.

[1]Small: up to 5 carats; medium: 5 to 50 carats; large: more than 50 carats.

[2]Low: up to $25 per carat; medium: up to $200 per carat; high: more than $200 per carat.

TABLE 2
LABORATORY-CREATED GEMSTONE PRODUCTION METHODS

Gemstone	Production method	Company/producer	Date of first production
Alexandrite	Flux	Creative Crystals Inc.	1970s.
Do.	Melt pulling	J.O. Crystal Co., Inc.	1990s.
Do.	do.	Kyocera Corp.	1980s.
Do.	Zone melt	Seiko Corp.	Do.
Cubic zirconia	Skull melt	Various producers	1970s.
Emerald	Flux	Chatham Created Gems	1930s.
Do.	do.	Gilson	1960s.
Do.	do.	Kyocera Corp.	1970s.
Do.	do.	Lennix	1980s.
Do.	do.	Russia	Do.
Do.	do.	Seiko Corp.	Do.
Do.	Hydrothermal	Biron Corp.	Do.
Do.	do.	Lechleitner	1960s.
Do.	do.	Regency	1980s.
Do.	do.	Russia	Do.
Ruby	Flux	Chatham Created Gems	1950s.
Do.	do.	Douras	1990s.
Do.	do.	J.O. Crystal Co., Inc.	1980s.
Do.	do.	Kashan Created Ruby	1960s.
Do.	Melt pulling	Kyocera Corp.	1970s.
Do.	Verneuil	Various producers	1900s.
Do.	Zone melt	Seiko Corp.	1980s.
Sapphire	Flux	Chatham Created Gems	1970s.
Do.	Melt pulling	Kyocera Corp.	1980s.
Do.	Verneuil	Various producers	1900s.
Do.	Zone melt	Seiko Corp.	1980s.
Star ruby	Melt pulling	Kyocera Corp.	Do.
Do.	do.	Nakazumi Earth Crystals Co.	Do.
Do.	Verneuil	Linde Air Products Co.	1940s.
Star sapphire	do.	do.	Do.

Do., do. Ditto.

TABLE 3

ESTIMATED VALUE OF U.S. NATURAL GEMSTONE PRODUCTION, BY GEM TYPE[1]

(Thousand dollars)

Gem materials	2008	2009
Beryl	18	18
Coral, all types	150	150
Diamond	(2)	(2)
Garnet	130	148
Gem feldspar	916	858
Geode/nodules	91	105
Opal	357	225
Quartz:		
Macrocrystalline[3]	334	231
Cryptocrystalline[4]	344	216
Sapphire/ruby	556	256
Shell	2,290	713
Topaz	(2)	(2)
Tourmaline	112	112
Turquoise	508	531
Other	5,670	4,850
Total	11,500	8,410

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Included with "Other."

[3]Macrocrystalline quartz (crystals recognizable with the naked eye) includes amethyst, aventurine, blue quartz, citrine, hawk's eye, pasiolite, prase, quartz cat's eye, rock crystal, rose quartz, smoky quartz, and tiger's eye.

[4]Cryptocrystalline quartz (microscopically small crystals) includes agate, carnelian, chalcedony, chrysoprase, fossilized wood, heliotrope, jasper, moss agate, onyx, and sard.

TABLE 4

PRICES PER CARAT OF U.S. CUT ROUND DIAMONDS, BY SIZE AND QUALITY IN 2009

Carat weight	Description, color[1]	Clarity[2] (GIA terms)	Representative prices		
			January[3]	June[4]	December[5]
0.25	G	VS1	$1,495	$1,430	$1,430
Do.	G	VS2	1,350	1,325	1,325
Do.	G	SI1	1,200	1,125	1,125
Do.	H	VS1	1,400	1,300	1,300
Do.	H	VS2	1,300	1,190	1,190
Do.	H	SI1	1,070	1,050	1,050
0.50	G	VS1	3,200	2,775	2,775
Do.	G	VS2	2,800	2,350	2,350
Do.	G	SI1	2,400	1,875	1,875
Do.	H	VS1	2,800	2,400	2,400
Do.	H	VS2	2,400	2,050	2,050
Do.	H	SI1	2,200	1,725	1,725
1.00	G	VS1	6,500	6,075	6,075
Do.	G	VS2	6,100	5,400	5,400
Do.	G	SI1	5,000	4,575	4,575
Do.	H	VS1	5,500	5,100	5,100
Do.	H	VS2	5,300	4,650	4,650
Do.	H	SI1	4,600	4,350	4,350
2.00	G	VS1	12,300	12,300	12,300
Do.	G	VS2	10,900	10,900	10,900
Do.	G	SI1	9,400	9,400	9,400
Do.	H	VS1	10,200	10,200	10,200
Do.	H	VS2	9,400	9,400	9,400
Do.	H	SI1	7,900	7,900	7,900

Do. Ditto.

[1]Gemological Institute of America (GIA) color grades: D-colorless; E-rare white; G, H, I-traces of color.

[2]Clarity: IF—no blemishes; VVS1—very, very slightly included; VS1—very slightly included; VS2—very slightly included, but not visible; SI1—slightly included.

[3]Source: Jewelers' Circular Keystone, v. 180, no. 2, February 2009, p. 59.

[4]Source: Jewelers' Circular Keystone, v. 180, no. 7, July 2009, p. 41.

[5]Source: Jewelers' Circular Keystone, v. 181, no. 1, January 2010, p. 54.

TABLE 5

PRICES PER CARAT OF U.S. CUT COLORED GEMSTONES IN 2009

Gemstone	Price range per carat	
	January[1]	December[2]
Amethyst	$10–25	$10–25
Blue sapphire	825–1,650	900–1,650
Blue topaz	5–10	5–10
Emerald	2,400–4,000	2,400–4,000
Green tourmaline	50–70	50–70
Cultured saltwater pearl[3]	5	5
Pink tourmaline	60–135	70–150
Rhodolite garnet	20–40	20–40
Ruby	1,850–2,200	1,850–2,200
Tanzanite	300–475	300–375

[1]Source: The Gem Guide—Color, spring/summer 2009, p. 22, 37, 51, 65, 74, 85, 96, 98, 104, and 119. These figures are approximate wholesale purchase prices paid by retail jewelers on a per stone basis for 1-to-less than 1 carat, fine-quality stones.

[2]Source: The Gem Guide, November/December 2009, p. 44, 47, 51, 55, 57, 59, 62, 63, 64, and 65. These figures are approximate wholesale purchase prices paid by retail jewelers on a per stone basis for 1-to-less than 1 carat, fine-quality stones.

[3]Prices are per 4.5 to 5-millimeter pearl.

TABLE 6

U.S. EXPORTS AND REEXPORTS OF DIAMOND (EXCLUSIVE OF INDUSTRIAL DIAMOND), BY COUNTRY[1]

	2008		2009	
Country	Quantity (carats)	Value[2] (millions)	Quantity (carats)	Value[2] (millions)
Exports:				
Australia	103,000	$18	37,600	$21
Belgium	1,600,000	685	300,000	150
Canada	79,700	116	46,600	70
Costa Rica	55,200	6	8,470	2
France	136,000	136	49,200	25
Hong Kong	1,340,000	814	807,000	380
India	1,480,000	1,220	962,000	477
Israel	2,650,000	2,130	960,000	482
Japan	54,800	12	17,800	5
Mexico	678,000	110	504,000	79
Netherlands	19,000	3	561	1
Netherlands Antilles	16,200	35	10,600	23
Singapore	98,500	19	31,200	13
South Africa	31,400	4	829	2
Switzerland	99,400	270	152,000	146
Taiwan	15,000	12	12,900	5
Thailand	226,000	54	86,700	40
United Arab Emirates	165,000	115	108,000	46
United Kingdom	121,000	84	27,400	58
Other	248,000	103	156,000	133
Total	9,210,000	5,940	4,280,000	2,160
Reexports:				
Armenia	13,400	(3)	1,670	(3)
Australia	33,800	14	59,600	19
Belgium	5,790,000	1,890	4,130,000	1,110
Canada	230,000	195	139,000	127
Dominican Republic	61,400	12	15,300	3
France	30,500	23	80,800	43
Guatemala	104,000	14	50,300	5
Hong Kong	2,680,000	1,350	3,220,000	1,190
India	2,250,000	482	2,350,000	959
Israel	10,200,000	3,400	6,940,000	2,750
Japan	178,000	39	117,000	24
Malaysia	20,100	3	9,860	1
Mexico	4,590	2	2,990	2
Singapore	190,000	22	193,000	50
South Africa	65,700	108	66,500	55
Switzerland	530,000	551	584,000	492
Thailand	152,000	26	145,000	29
United Arab Emirates	1,390,000	250	749,000	198
United Kingdom	499,000	229	383,000	204
Other	331,000	134	1,710,000	534
Total	24,800,000	8,750	20,900,000	7,780
Grand total	34,000,000	14,700	25,200,000	9,940

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Customs value.

[3]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF DIAMOND, BY KIND, WEIGHT, AND COUNTRY[1]

	2008		2009	
Kind, range, and country of origin	Quantity (carats)	Value[2] (millions)	Quantity (carats)	Value[2] (millions)
Rough or uncut, natural:[3]				
Angola	62,300	$34	359,000	$48
Australia	1,620	1	17,700	2
Botswana	108,000	147	88,100	35
Brazil	760	1	443	(4)
Canada	19,900	31	27,300	32
Congo (Kinshasa)	37,100	138	11,600	7
Ghana	1,400	2	250	(4)
Guyana	6,590	1	212	(4)
India	120,000	4	32,700	1
Namibia	6,550	5	10,000	6
Russia	90,200	19	16,500	3
South Africa	119,000	296	104,000	112
Other	153,000	73 r	32,000	43
Total	725,000	752	700,000	289
Cut but unset, not more than 0.5 carat:				
Belgium	295,000	118	344,000	127
Canada	10,900	13	7,910	7
China	110,000	34	25,800	18
Dominican Republic	65,800	20	38,200	10
Hong Kong	157,000	25	239,000	24
India	6,520,000	1,430	5,760,000	1,150
Israel	512,000	267	400,000	198
Mauritius	8,410	14	6,920	15
Mexico	52,600	10	65,900	10
South Africa	12,400	4	1,780	10
Thailand	72,200	21	60,800	17
United Arab Emirates	69,400	18	153,000	30
Other	72,400	25	57,400	38
Total	7,960,000	2,000	7,160,000	1,650
Cut but unset, more than 0.5 carat:				
Belgium	929,000	3,130	640,000	2,130
Canada	22,800	78	20,200	60
Hong Kong	76,800	361	26,800	76
India	1,440,000	2,450	1,110,000	1,930
Israel	2,210,000	9,120	1,670,000	5,350
Mexico	389	(4)	1,810	3
Russia	57,600	178	57,800	137
South Africa	55,200	759	34,700	533
Switzerland	19,200	383	23,500	238
Thailand	11,700	22	3,980	9
United Arab Emirates	33,100	124	33,900	60
Other	101,000	400	53,200	256
Total	4,960,000	17,000	3,670,000	10,800

[r]Revised.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Customs value.

[3]Includes some natural advanced diamond.

[4]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES, OTHER THAN DIAMOND, BY KIND AND COUNTRY[1]

Kind and country	2008 Quantity (carats)	2008 Value[2] (millions)	2009 Quantity (carats)	2009 Value[2] (millions)
Emerald:				
Belgium	529	$2	1,980	$1
Brazil	106,000	6	500,000	7
Canada	2,830	(3)	434	(3)
China	2,210	(3)	4,150	(3)
Colombia	530,000	155	314,000	120
France	130,000	9	315	2
Germany	13,800	3	8,470	2
Hong Kong	877,000	10	334,000	23
India	1,800,000	29	2,410,000	18
Israel	162,000	25	181,000	20
Italy	4,240	2	2,380	1
Switzerland	23,900	24	7,980	8
Thailand	564,000	13	292,000	8
United Kingdom	1,050	2	356	1
Other	83,300	17	38,000	3
Total	4,300,000	297	4,090,000	214
Ruby:				
Belgium	9	(3)	10	(3)
China	7,360	1	2,100	(3)
Dominican Republic	994	(3)	--	--
France	1,210	1	37	(3)
Germany	12,400	1	8,370	(3)
Hong Kong	851,000	10	420,000	1
India	2,350,000	5	2,500,000	2
Israel	1,370	1	5,560	1
Italy	6,030	1	1,330	(3)
Kenya	(3)	(3)	16,700	(3)
Sri Lanka	7,260	1	2,020	1
Switzerland	10,600	11	933	3
Thailand	1,980,000	59	1,750,000	14
United Arab Emirates	1,760	1	64	2
Other	43,300	8	179,000	13
Total	5,280,000	100	4,880,000	37
Sapphire:				
Australia	1,550	(3)	2,340	(3)
Austria	124	(3)	472	(3)
Belgium	110	1	283	1
China	269,000	2	122,000	1
Dominican Republic	882	(3)	600	(3)
Germany	36,200	5	33,200	5
Hong Kong	972,000	9	610,000	13
India	1,150,000	12	2,140,000	6
Israel	28,800	4	9,780	1
Italy	2,340	2	15,000	1
Singapore	3,630	(3)	3,010	(3)
Sri Lanka	316,000	46	240,000	31
Switzerland	17,800	19	14,700	14
Thailand	2,900,000	75	1,730,000	48

See footnotes at end of table.

TABLE 8—Continued

U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES, OTHER THAN DIAMOND, BY KIND AND COUNTRY[1]

Kind and country	2008 Quantity (carats)	2008 Value[2] (millions)	2009 Quantity (carats)	2009 Value[2] (millions)
Sapphire—Continued:				
United Arab Emirates	8,140	$5	2,530	$2
United Kingdom	1,100	4	504	1
Other	384,000	7	68,200	3
Total	6,090,000	191	4,990,000	127
Other:				
Rough, uncut:				
Australia	NA	3	NA	(3)
Brazil	NA	7	NA	(3)
Canada	NA	1	NA	1
China	NA	3	NA	1
Colombia	NA	1	NA	--
Czech Republic	NA	2	NA	2
Germany	NA	1	NA	1
India	NA	2	NA	1
Japan	NA	1	NA	1
Pakistan	NA	2	NA	(3)
Tanzania	NA	3	NA	(3)
Other	NA	16	NA	1
Total	NA	42	NA	8
Cut, set and unset:				
Australia	NA	15	NA	(3)
Austria	NA	4	NA	1
Brazil	NA	19	NA	(3)
Canada	NA	1	NA	(3)
China	NA	35	NA	8
France	NA	1	NA	(3)
Germany	NA	34	NA	11
Hong Kong	NA	32	NA	1
India	NA	74	NA	2
Israel	NA	8	NA	(3)
Italy	NA	1	NA	(3)
South Africa	NA	1	NA	--
Sri Lanka	NA	5	NA	(3)
Switzerland	NA	8	NA	1
Taiwan	NA	1	NA	(3)
Tanzania	NA	5	NA	1
Thailand	NA	58	NA	1
United Arab Emirates	NA	1	NA	(3)
United Kingdom	NA	1	NA	--
Other	NA	15	NA	3
Total	NA	319	NA	29

NA Not available. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Customs value.

[3]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

VALUE OF U.S. IMPORTS OF LABORATORY-CREATED AND IMITATION GEMSTONES, BY COUNTRY[1, 2]

(Thousand dollars)

Country	2008	2009
Laboratory-created, cut but unset:		
Austria	2,330	1,430
Brazil	645	374
Canada	24	9
China	9,860	7,600
Czech Republic	55	42
France	298	284
Germany	12,700	11,100
Hong Kong	898	455
India	1,040	2,180
Italy	48	95
Japan	251	61
Korea, Republic of	207	46
Netherlands	5	5
South Africa	281	--
Sri Lanka	1,300	315
Switzerland	620	797
Taiwan	174	161
Thailand	1,330	975
United Arab Emirates	146	98
Other	1,960	3,390
Total	34,200	29,500
Imitation:[3]		
Austria	73,100	47,100
Brazil	25	2
China	21,000	13,300
Czech Republic	7,510	5,080
France	25	--
Germany	723	566
Hong Kong	46	358
India	83	302
Italy	148	123
Japan	58	--
Korea, Republic of	198	131
Russia	15	--
Taiwan	183	--
Thailand	10	39
United Kingdom	193	3
Other	275	208
Total	104,000	67,200

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Customs value.

[3]Includes pearls.

Source: U.S. Census Bureau.

TABLE 10

U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES[1]

(Thousand carats and thousand dollars)

Stones	2008 Quantity	2008 Value[2]	2009 Quantity	2009 Value[2]
Diamonds:				
Rough or uncut	725	$752,000	700	$289,000
Cut but unset	12,900	19,000,000	10,800	12,400,000
Emeralds, cut but unset	4,300	297,000	4,090	214,000
Coral and similar materials, unworked	5,320	12,200	4,430	10,500
Rubies and sapphires, cut but unset	11,400	291,000	9,880	164,000
Pearls:				
Natural	NA	14,100	NA	21,100
Cultured	NA	34,600	NA	26,900
Imitation	NA	4,190	NA	4,150
Other precious and semiprecious stones:				
Rough, uncut	1,620,000 r	20,900 r	1,080,000	15,000
Cut, set and unset	NA	285,000	NA	NA
Other	NA	9,200	NA	NA
Laboratory-created:				
Cut but unset	60,300	34,200	8,730	29,500
Other	NA	13,500	NA	8,240
Imitation gemstone[3]	NA	104,000	NA	67,200
Total	XX	20,900,000	XX	13,300,000

r Revised. NA Not available. XX Not applicable.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Customs value.

[3]Does not include pearls.

Source: U.S. Census Bureau.

TABLE 11

NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE[1, 2, 3]

(Thousand carats)

Country and type[4]	2005	2006	2007	2008	2009
Gemstones:					
Angola	6,371	8,258	8,732	8,016 r	8,100
Australia	8,577	7,305	231	273	60 e
Botswana[e]	23,900	24,000	25,000	25,000	24,000
Brazil[e]	208	181	182	182 r	182 [5]
Canada	12,314	13,278	17,144	14,803	10,946
Central African Republic[e]	300	340	370	302 r	300
China[e]	100	100	100	100	100
Congo (Kinshasa)	7,000	5,800 r	5,700 r	4,200 r	3,600
Côte d'Ivoire[e]	210	210	210	210	210
Ghana	810	780	720 e	520 e	500 e
Guinea	440	380	815	2,500	2,400
Guyana	357	341	269	169 r	179
Lesotho	52	231	454	450 e	450 e
Namibia	1,902	2,400	2,266 r	2,435 r	2,300
Russia[e]	23,000	23,400	23,300	21,925 [5]	17,791 [5]
Sierra Leone	401 r	362 r	362 r	223 r	200 e
South Africa[e]	6,400	6,100	6,100	5,200	2,400
Tanzania[e]	185	230	239	202 r	150
Venezuela[e]	46	45	45	45	45
Zimbabwe[e]	160	160	100	100	100
Other[6]	109	70	65	105 r	126
Total	92,800	94,000 r	92,400 r	87,000	74,100
Industrial:					
Angola[e]	708	918	970	900	900
Australia	25,730	21,915	18,960	15,397 r	10,700
Botswana[e]	8,000	8,000	8,000	8,000	7,000
Brazil[e]	600	600	600	600	600
Central African Republic[e]	80	85	93	75 r	60
China[e]	960	965	970	1,000	1,000
Congo (Kinshasa)	28,200	23,100 r	22,600 r	16,700 r	14,400
Côte d'Ivoire[e]	90	90	90	90	90
Ghana[e]	200	190	180	130 r	120
Guinea	100	95	200	600	600 e
Russia[e]	15,000	15,000	15,000	15,000	15,000
Sierra Leone	267 r	241 r	241 r	149 r	100 e
South Africa[e]	9,400	9,100	9,100	7,700	3,100
Tanzania[e]	35	42	44	31 r	27
Venezuela[e]	69	70	70	70	70
Zimbabwe[e]	900	900 r	600 r	700 r	700
Other[7]	94	67	72	115 r	140
Total	90,400	81,400 r	77,800 r	67,300 r	54,600
Grand total	183,000	175,000 r	170,000 r	154,000 r	129,000

[e]Estimated. [r]Revised.

[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through May 19, 2010.

[3]In addition to the countries listed, Nigeria and the Republic of Korea produce natural diamond and synthetic diamond, respectively, but information is inadequate to formulate reliable estimates of output levels.

[4]Includes near-gem and cheap-gem qualities.

[5]Reported figure.

[6]Includes Cameroon, Congo (Brazzaville), Gabon (unspecified), India, Indonesia, Liberia, and Togo (unspecified).

[7]Includes Congo (Brazzaville), India, Indonesia, and Liberia.