GEMSTONES

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Gemstones have been used as symbols of beauty, wealth, and status since prehistoric times (Schumann, 1998). Amber, for example, has been mined for use as a gem since before 25,000 B.C. The oldest names for gems can be traced back to ancient China, Greece, and Rome.

Regardless of their long history, however, gems and gemstones have no single, precise definition that is generally accepted. According to Webster's New International Dictionary (1961, p. 1,042), a gem is "Any jewel, whether stone, pearl or the like, having value and beauty that are intrinsic and not derived from its setting; a precious or, sometimes, a semiprecious stone cut and polished for ornament. A semiprecious stone of value because it is carved or engraved, as a cameo or intaglio." Additionally, the dictionary states that a gemstone is "Any mineral or petrified material which can, when cut and polished, be used in jewelry" (Webster's New International Dictionary, 1961, p. 1,043).

For this report, the terms "gem" and "gemstone" mean any mineral or organic material (e.g., pearl and petrified wood) used for personal adornment, display, or object of art because it possesses beauty, rarity, and durability. Of the 2,700 mineral species, only about 100 possess all these attributes. Silicates compose the largest group of gemstones; oxides and quartz compose the second largest (table 1). A further refinement of "gemstone" is "colored gemstone," which in this report designates all nondiamond gems, including amber, coral, and shell. In addition, synthetic gems, cultured pearl, and gem simulants are discussed below but are treated separately from natural gemstones (table 2).

Production

Commercial mining of gemstones has never been extensive in the United States. More than 60 different gemstones have been produced commercially from domestic mines, but most of the deposits have been relatively small compared with many other mining operations. In many instances, moreover, contemporary gemstone mining in the country is conducted by hobbyists, collectors, and gem clubs rather than business organizations.

The commercial gemstone industry in the United States consists of several distinct sectors: (1) individuals and companies that mine gemstones or harvest shell and pearl, (2) firms that manufacture synthetic gemstones, and (3) individuals and companies that cut natural and synthetic gemstones. The domestic gemstone industry is focused on the production of colored gemstones and the cutting of large diamonds. Industry employment is estimated to range from 1,000 to 1,500 workers (U.S. International Trade Commission, 1997, p. 1).

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 inherent uncertainty associated with the discovery and marketing of gem-quality minerals makes it difficult to obtain financing for developing and sustaining economically viable deposits (U.S. International Trade Commission, 1997, p. 23).

The total value of natural gemstones produced in the United States during 1998 was estimated to be at least $14.3 million (table 3). This production value was significantly less than that of the preceding year primarily because foreign markets for U.S. shell material decreased, particularly in Japan where the operations of cultured pearl producers that use the shell for pearl nuclei were adversely affected by declining markets in Southeast Asia, high mortality of pearl oysters, and competition from China (Jewelers' Circular Keystone, 1998c; Jewellery News Asia, 1998b). Unless new markets are acquired, shell production in the United States may not recover for many years; China, however, has the potential to become a larger U.S. market and, thereby, could help to offset the losses in Japan (Jewelers' Circular Keystone, 1998b).

The estimate of 1998 U.S. gemstone production was based on a survey of more than 200 domestic gemstone producers conducted by the U.S. Geological Survey (USGS). The survey provided a foundation for projecting the scope and level of domestic gemstone production during the year. The survey, however, did not represent all gemstone activity in the United States, including thousands of professional and amateur collectors. Consequently, the USGS supplemented its survey with estimates of domestic gemstone production from related published data, contacts with gem dealers and collectors, and information garnered at gem and mineral shows.

Natural gem materials indigenous to the United States are collected, produced, and/or marketed in every State. Only four States, however, accounted for more than two-thirds of the total value of production in 1998, as reported by survey respondents. These States were (in descending order of reported production value) Tennessee, Arizona, California, and Oregon. Certain States are best known for the production of a single gem material; for example, Kentucky and Tennessee (for freshwater shell). Other States, however, have a wide array of gemstones. For example, Arizona gemstone deposits include agate, amethyst, azurite, chrysocolla, fire agate, garnet, jade, malachite, obsidian, onyx, peridot, petrified wood, opal, smithsonite, and turquoise. A great variety of gemstones also are found in California, Idaho, Montana, and North Carolina. High-quality emeralds reportedly were discovered in North Carolina during 1998 (Jewelers' Circular Keystone, 1999a).

Following considerable attention in recent years, new U.S. diamond production declined and was virtually nonexistent in 1998. During the year, Colorado's Kelsey Lake diamond mine, which became North America's first commercial diamond producer in almost a century when it opened in 1995, ceased production and was offered for sale (Shor, 1998; Maria Musso, Redaurum Limited, oral commun., 1999). Nevertheless, further exploration for diamond continued in the Kelsey Lake area and in other parts of Colorado during 1998. The only other significant diamond-bearing area known in the United States is in Crater of Diamonds Park near Murfreesboro, AR, where a dig-for-fee operation for tourists is maintained by the State. An Arkansas law prohibiting commercial diamond mining in the park was debated in the State legislature during 1998 and was enacted early in 1999 (Diamond Registry Bulletin, 1999b).

In addition to natural gemstones, synthetic gems and gemstone simulants are produced in the United States. Synthetic gemstones have the same optical, physical, and chemical properties as the natural materials that they appear to be. Simulants have an appearance similar to that of a natural gem material but have different optical, physical, and chemical properties. Synthetic gemstones produced in the United States include alexandrite, emerald, ruby, sapphire, turquoise, and zirconia. The major simulants produced in the United States are colored and colorless varieties of cubic zirconia. Simulants of coral, lapis lazuli, malachite, and turquoise also are manufactured. In addition, certain colors of synthetic sapphire and spinel, used to represent other gemstones, are classified as simulants.

Synthetic gem production in the United States exceeded $24 million during 1998; simulant gemstone output was even greater—estimated to be well over $100 million. Six firms in five States, representing virtually all the U.S. synthetic gem industry, reported production to the USGS in 1998. In descending order of production value, the States with reported synthetic output were New York, California, North Carolina, Arizona, and Michigan. Some of the producers are attempting to produce synthetic gem-quality diamond (Tom Chatham, Chatham Created Gems, oral commun., 1998).

During 1998, a North Carolina firm began marketing moissanite, a gem-quality silicon carbide that it produces (C3 Inc., 1998). According to published reports, the moissanite is an excellent diamond simulant, but has been marketed for its other gem qualities as well.

Consumption

Although the United States accounts for less than 1% of total global gem production, it is the world's leading gemstone market. On the basis of indicators, such as trade data and income growth rates, U.S. gemstone markets—bolstered by strong demand among consumers with increasing personal wealth and growing discretionary income—apparently accounted for at least 35% of world gem demand in 1998. The U.S. market for unset gem diamonds during the year was estimated to have exceeded $8 billion, the largest in the world. Domestic markets for natural, unset nondiamond gemstones totaled more than $650 million.

In addition to jewelry, gemstones are used for collections, exhibits, and decorative art objects. According to a poll conducted by a U.S. jewelry retailers association in the mid-1990's, about two-thirds of domestic consumers who were surveyed preferred diamond as their favorite gemstone; most others chose, in descending order, emeralds, sapphires, and rubies (ICA Gazette, 1996).

Prices

Gemstone prices are governed by many factors and qualitative characteristics, including beauty, clarity, defects, demand, and rarity. Diamond pricing in particular is complex; values can vary significantly depending on time, place, and the subjective evaluations of buyers and sellers. There are more than 14,000 categories used to assess rough diamond and perhaps 100,000 price points for polished diamond alone (Pearson, 1998).

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 shown in tables 3 through 5. In addition, customs values for diamonds and other gemstones imported and exported/reexported are shown in tables 6 through 10.

DeBeers Consolidated Mines Limited in South Africa is a significant force affecting gem diamond prices worldwide because it mines about one-half the diamonds produced each year and controls at least three-quarters of global raw diamond supply through its Central Selling Organization (CSO), which has marketing agreements with other producers. Estimates based on the reported output of major diamond mines in 1998 indicate that the average value of all diamond produced during the year was about $55 per carat; by country, the average value per carat ranged from about $10 in Australia to more than $270 in Namibia (Rombout, 1999).

Foreign Trade

Several export and import measures demonstrate the significance of the United States in world gemstone trade. During 1998, total U.S. gemstones trade with all countries and territories exceeded $11.6 billion; diamonds accounted for 96% of the total. In 1998, U.S. exports/reexports of diamond were shipped to 63 countries/territories, and imports of all gemstones were received from 98 countries/territories (tables 6-10).

During 1998, U.S. trade in cut diamonds reached unprecedented levels; the country continued to be the world's leading diamond importer and set export records as well. Record high imports were attributed to a strong U.S. economy that boosted domestic demand for diamond jewelry among consumers with increasing personal wealth and more discretionary income.

The United States is a significant international diamond transit center as well as the world's largest gem diamond market. The large volume of reexports (table 6) shipped to other centers reveals the significance that the United States has in the world's diamond supply network.

Synthetic gemstones became more prominent trade issues for the United States in 1998. Imports of synthetic gems

(particularly from China, Russia, and Taiwan) reportedly increased during the year. Prices of certain synthetic gem imports, such as amethyst, were very competitive (Mike Romanella, Commercial Mineral Company, oral commun., 1999). The marketing of synthetic imports as natural gemstones has become a serious problem for some domestic producers (Tom Chatham, Chatham Created Gems, Inc., oral commun., 1998).

During 1998, the Office of the United States Trade Representative, assisted by the USGS, continued negotiations with 17 Asian and Pacific Rim Governments to reduce barriers in gemstone trade (AJM, 1998). The negotiations, still underway at yearend, focused on tariffs and other barriers to international trade.

World Review

The gemstone industry worldwide is comprised of two distinctly different sectors: (1) diamond mining and marketing, and (2) the production and sale of colored gemstones. Most diamond supplies are controlled by a few major mining companies; prices are supported by managing the quantity and quality of the gems relative to demand, a function performed by DeBeers through its CSO. Unlike diamonds, colored gemstones are primarily produced at relatively small, low-cost operations with few dominant producers; prices are influenced by consumer demand in addition to supply availability.

In 1998, world diamond production totaled at least 115 million carats with an estimated value of more than $7 billion (table 11). Some estimates of worldwide diamond mine output (including industrial-quality diamonds) in 1998 ranged up to 126 million carats (Mining Journal, 1999). Most production was concentrated in a few regions—Africa (Angola, Botswana, Namibia, South Africa, and Zaire); Asia (northeastern Siberia and Yakutia in Russia); Australia; and South America (Brazil and Venezuela). In 1998, Botswana was the world's leading diamond producer in terms of output value; Australia, which increased its output significantly during the year, led in quantity of production (Diamond Registry Bulletin, 1998a).

Sales of rough diamond by the CSO in 1998 were only $3.3 billion, 28% below sales during 1997 and almost one-third less than the record high sales of 1996 (Diamond Registry Bulletin, 1999a). The sales loss reflected reduced demand in the markets of Japan and several Southeast Asian countries, which experienced severe declines in their national economies. In order to stabilize and support prices, the CSO reduced its supply of diamonds for worldwide markets to its lowest level in 6 years (Jewellery News Asia, 1999c). Strong market demand in the United States helped the CSO and other suppliers compensate for the Asian decline; domestic diamond jewelry sales alone grew by 9% and reached a record high in 1998, the seventh consecutive year sales have risen (Jewelers' Circular Keystone, 1999b; Rapaport Diamond Report, 1999). Demand in the United States for rough diamond equated to almost one-fifth of CSO sales during the year.

Additional events in 1998 significant to diamond mining and marketing worldwide include the following:

- Russia extended its diamond supply contract (covering 8% to 15% of world production) with DeBeers for three more years (Diamond Registry Bulletin, 1998c).
- Canada's first commercial diamond mine opened amid expectations that it would make Canada a major diamond producer (Diamond Registry Bulletin, 1998b). The new mine is expected to account for about 6% of world diamond output value when it reaches full production levels in 1999 (Diamond Registry Bulletin, 1998b). One-third of the mine's output will be marketed by DeBeers through the CSO (Jewellery News Asia, 1999a).
- Civil wars afflicting several nations in central Africa continued to threaten the viability of significant diamond-producing areas in the region. In 1998, the USGS helped the U.S. Department of State assess issues concerning diamond mining and the hostilities in central Africa.
- China, with a potential market of more than 1 billion consumers, began to establish its first international diamond exchange and a free trade zone for diamonds (Jewellery News Asia, 1998c and 1999b).
- Some governments (e.g., Belgium's parliament) considered stronger regulatory regimes for their diamond industries (Diamond International, 1998).

Worldwide production of natural gemstones other than diamond was estimated to have exceeded $2 billion per year in the late 1990's. 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 (beryl, 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, and Japan are key producers.

Like the diamond industry, colored gemstone producers attempted to recover from the weakened markets created by the Asian economic crisis of 1997-98. Mining and sales reportedly were disrupted in many nations, particularly in southeast Asia. Prices of high-quality colored gemstones, however, did not decline dramatically (Cavey, 1998).

Additional noteworthy events in the colored gemstone industry during 1998 included the following:

- Proposals to establish the world's first emerald exchange were considered at a Government-sponsored conference in Colombia (Mining Journal, 1998).
- Like diamonds, the introduction and proliferation of new synthetic gem-quality materials and simulants—as well as treatment processes to enhance gemstone attributes artificially—continued to raise issues and controversies regarding standards for disclosure to consumers.
- As the Japanese pearl industry continued to suffer losses, a potentially significant cultured pearl industry that emerged in China during the 1990's was able to maintain its 10% annual growth rate (Jewelers' Circular Keystone, 1998a; Jewellery News Asia, 1998a).

Outlook

The collapse of several important diamond markets in recent years reminds gemstone industry forecasters that market strength ultimately is sustained by consumer demand, not supply constraints. Because gemstone markets are concerned with luxury merchandise, they must rely on the growth of personal wealth and discretionary income levels among consumers who make choices among nonessential goods in the marketplace.[1] Fortunately for producers of precious gems, long-term economic forecasts predict continued growth of discretionary income in the industrialized world, and anticipate even higher growth rates in developing countries, such as China and other Asian nations.

The recovery of diamond markets in the next few years, however, may be slow. Buoyed by U.S. demand, CSO sales are expected to rebound and reach $3.8 billion in 1999 (Paribas Group, 1998). Nevertheless, this achievement is well below the successes enjoyed by DeBeers in recent years. Diversification of markets, with less reliance on U.S. consumption, will be the key to long-term, steady growth in world demand.

The ability of the CSO to manage the flow of diamonds to world markets also will be a greater challenge for DeBeers in the coming decade. Independent producers, such as Argyle Diamond Mines in Australia and new mines in Canada, will bring a greater measure of competition to global markets. More competition presumably will bring more supplies and lower prices; at present, however, the actual impact of such competition is uncertain.

Demand for gemstones other than diamond will depend on how successfully jewelers promote their alternatives. As the jewelry industry consolidates toward fewer, larger companies and turns more to mass merchandizing, smaller dealers will need to focus on niche markets and target specific demographic groups to remain competitive. Numerous synthetics, simulants, and treated gems will enter the marketplace and necessitate more transparent trade industry standards to maintain customer confidence. Russia is expected to become a major source of synthetic gems for U.S. markets within a few years. Much greater volumes of gem jewelry will be sold via telemarketing programs and new electronic media, such as the internet.

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[1]Other important factors that will drive market demand include consumer confidence and interest rates.

[2]Prior to January 1996, published by the U.S. Bureau of Mines.

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 characters
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	Fossil resin, soft.
Benitoite	Barium titanium silicate	Blue, purple, pink, colorless	Small to medium	High	6.0-6.5	3.64-3.68	Double	1.76-1.80	Sapphire, tanzanite, blue diamond, blue tourmaline	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.	do.	Small	Very high	7.5-8.0	2.63-2.80	do.	1.58	Pressed plastics, tourmaline	Refractive index.
Emerald	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	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.	do.	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.
Chrysoberyl:										
Alexandrite	Beryllium aluminate	Green by day, red by artificial light	Small (Former U.S.S.R.) Medium (Sri Lanka)	High	8.5	3.50-3.84	Double	1.75	Synthetic	Dichroism, inclusions in synthetic sapphire.
Cats-eye	do.	Greenish to brownish	Small to large	do.	8.5	3.50-3.84	do.	1.75	Synthetic, shell	Gravity and translucence.
Chrysolite	do.	Yellow, green, and/or brown	Medium	Medium	8.5	3.50-3.84	do.	1.75	Tourmaline, peridot	Refractive index, silky.
Coral	Calcium carbonate	Orange, red, white, black, or green	Branching, medium	Low	3.5-4.0	2.6-2.7	do.	1.49-1.66	False coral	Dull translucent.

See footnotes at end of table.

TABLE 1--Continued
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Corundum:										
Ruby	Aluminum oxide	Rose to deep purplish red	Small	Very high	9.0	3.95-4.10	Double	1.78	Synthetics, including spinel	Inclusions, fluorescence.
Sapphire	do.	Blue	Medium	High	9.0	3.95-4.10	do.	1.78	do.	Inclusions, double refraction, dichroism.
Sapphire, fancy	do.	Yellow, pink, white, orange, green, or violet	Medium to large	Medium	9.0	3.95-4.10	do.	1.78	Synthetics, glass and doublets	Inclusions, double refraction, refractive index.
Sapphire and 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, or blue	Up to 20 carats	Low	9.0	3.95-4.10	do.	1.78	Synthetic spinel, glass	Curved striae, bubble inclusions.
Diamond	Carbon	White, blue-white, yellow, brown, green, pink, blue	Any	Very high	10.0	3.516-3.525	Single	2.42	Zircon, titania, cubic zirconia	High index, dispersion, hardness, luster.
Feldspar:										
Amazonite	Alkali aluminum silicate	Green	Large	Low	6.0-6.5	2.56	--	1.52	Jade	Cleavage, sheen, vitreous to pearly, opaque, grid.
Labradorite	do.	Gray with blue and bronze sheen color play	do.	do.	6.0-6.5	2.56	--	1.56	do.	Do.
Moonstone	do.	Colorless or yellow	do.	do.	6.0-6.5	2.77	--	1.52-1.54	Glass	Pale sheen, opalescent.
Garnet	Complex silicate	Brown, black, yellow, green, ruby 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.
Jade:										
Jadeite	do.	Green, yellow, black, white, or mauve	Large	Low to very high	6.5-7.0	3.3-3.5	Cryptocrystalline	1.65-1.68	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	do.	Do.
Opal	Hydrous silica	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	Play of color.
Pearl	Calcium carbonate	White, pink, or black	Small	do.	2.5-4.0	2.6-2.85	--	--	Cultured and imitation	Luster, structure, X-ray.
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.

See footnotes at end of table.

TABLE 1--Continued
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Name	Composition	Color	Practical size 1/	Cost 2/	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characters
Quartz:										
Agate	Silica	Any color	Large	Low	7.0	2.58-2.64	--	--	Glass, plastic, Mexican onyx	Cryptocrystalline, irregularly banded, dendritic inclusions.
Amethyst	do.	Purple	do.	Medium	7.0	2.65-2.66	Double	1.55	do.	Refractive index, double refraction, transparent.
Cairngorm	do.	Smoky	do.	Low	7.0	2.65-2.66	do.	1.55	do.	Do.
Citrine	do.	Yellow	do.	do.	7.0	2.65-2.66	do.	1.55	do.	Do.
Crystal, rock	do.	Colorless	do.	do.	7.0	2.65-2.66	do.	1.55	do.	Do.
Jasper	do.	Uniform or spotted red, yellow, or green	do.	do.	7.0	2.58-2.66	--	--	do.	Opaque, vitreous.
Onyx	do.	Many colors	do.	do.	7.0	2.58-2.64	--	--	do.	Uniformly banded.
Rose	do.	Pink, rose red	do.	do.	7.0	2.65-2.66	Double	1.55	do.	Refractive index, double refraction, translucent.
Spinel	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.
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	Small	High	6.0-7.0	3.30	do.	1.69	Sapphire, synthetics	Strong trichroism.
Topaz	do.	White, blue, green	Medium	Low to medium	8.0	3.4-3.6	do.	1.62	Beryl, quartz	Refractive index.
Tourmaline	do.	All, including mixed	do.	do.	7.0-7.5	2.98-3.20	do.	1.63	Peridot, beryl, corundum, glass	Double refraction, refractive index.
Turquoise	Copper aluminum phosphate	Blue to green	Large	Low	6.0	2.60-2.83	do.	1.63	Glass, plastics	Difficult if matrix not present, matrix usually limonitic.
Zircon	Zirconium silicate	White, blue, or 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.

1/ Small, up to 5 carats; medium, up 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
SYNTHETIC GEMSTONE PRODUCTION METHODS

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

TABLE 3
VALUE OF U.S. GEMSTONE PRODUCTION, BY GEMSTONE 1/

(Thousand dollars)

Gem materials	1997	1998
Agate	218	128
Beryl	901	1,060
Coral (all types)	65	76
Diamond	W	(2/)
Garnet	35	66
Gem feldspar	579	378
Geode/nodules	100	46
Opal	341	769
Quartz	1,130	768
Sapphire/ruby	964	369
Shell	11,700	1,150
Topaz	8	8
Tourmaline	16	49
Turquoise	976	837
Other	7,990	8,610
Total	25,000	14,300

W Withheld to avoid disclosing company proprietary data.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Included in "Other."

TABLE 4
PRICES OF U.S. CUT DIAMONDS, BY SIZE AND QUALITY 1/

Carat weight	Description, color 3/	Clarity 2/ (GIA terms)	Representative prices January 1998 4/	June 1998 5/	December 1998 6/
0.25	G	VS1	$1,500	$1,500	$1,500
.25	G	VS2	1,380	1,380	1,380
.25	G	SI1	1,130	1,130	1,130
.25	H	VS1	1,400	1,400	1,400
.25	H	VS2	1,250	1,250	1,250
.25	H	SI1	1,050	1,050	1,050
.50	G	VS1	3,300	3,400	3,400
.50	G	VS2	2,900	3,000	3,000
.50	G	SI1	2,500	2,500	2,500
.50	H	VS1	2,900	3,000	3,000
.50	H	VS2	2,600	2,700	2,700
.50	H	SI1	2,400	2,400	2,400
.75	G	VS1	3,800	3,800	3,800
.75	G	VS2	3,600	3,600	3,600
.75	G	SI1	3,300	3,300	3,300
.75	H	VS1	3,650	3,650	3,650
.75	H	VS2	3,450	3,450	3,450
.75	H	SI1	3,100	3,100	3,100
1.00	G	VS1	5,500	5,500	5,700
1.00	G	VS2	5,200	5,200	5,300
1.00	G	SI1	4,700	4,700	4,800
1.00	H	VS1	5,100	5,100	5,200
1.00	H	VS2	4,900	4,900	4,900
1.00	H	SI1	4,500	4,500	4,500

1/ Data are rounded to three significant digits.
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/ Gemological Institute of America (GIA) color grades: D, colorless; E, rare white; G - H - I , traces of color.
4/ Jewelers' Circular Keystone, v. 169, no. 2, February 1998, p. 196.
5/ Jewelers' Circular Keystone, v. 169, no. 7, July 1998, p. 74.
6/ Jewelers' Circular Keystone, v. 170, no. 1, January 1999, p. 42.

TABLE 5
PRICES PER CARAT OF U.S. CUT COLORED GEMSTONES

Gemstone	Price range per carat 1/ January 1998	December 1998
Amethyst	$7-$16	$7-$16
Aquamarine	75-190	75-190
Emerald	750-1,900	900-2,000
Ruby	1,800-2,900	1,800-2,800
Sapphire	800-1,800	800-1,800
Tanzanite	130-200	180-300

1/ Jewelers' Circular Keystone, v. 169, no. 2, February 1998, p. 196 and v. 170, no. 1, January 1999, p. 42. These figures represent a sampling of net prices that wholesale colored stone dealers in various U.S. cities charged their cash customers during the month for fine-quality stones.

TABLE 6
U.S. EXPORTS AND REEXPORTS OF DIAMOND (EXCLUSIVE OF INDUSTRIAL DIAMOND), BY COUNTRY 1/

Country	1997 Quantity (carats)	1997 Value 2/ (millions)	1998 Quantity (carats)	1998 Value 2/ (millions)
Exports:				
Belgium	20,500	$2	14,800	$6
Canada	77,500	29	67,100	25
France	586	2	180	10
Hong Kong	7,670	20	22,300	5
India	1,080	1	29,000	2
Israel	7,890	2	2,770	7
Japan	5,540	15	7,750	17
Singapore	1,940	2	409	(3/)
Switzerland	9,860	26	5,480	28
Thailand	616	(3/)	200	(3/)
United Arab Emirates	2,440	(3/)	--	--
United Kingdom	2,860	(3/)	6,590	6
Other	13,900	7	52,500	15
Total	152,000	108	209,000	123
Reexports:				
Bahrain	40	(3/)	--	--
Belgium	822,000	612	852,000	676
Canada	73,900	32	81,300	39
France	25,600	30	16,600	27
Hong Kong	570,000	380	567,000	272
India	187,000	23	401,000	42
Israel	768,000	732	846,000	960
Japan	74,000	55	76,800	58
Singapore	16,000	42	14,600	27
Switzerland	52,400	159	56,000	164
Thailand	101,000	24	137,000	22
United Arab Emirates	57,300	13	22,700	12
United Kingdom	24,400	86	79,100	97
Other	28,100	26	52,800	39
Total	2,800,000	2,210	3,200,000	2,430
Grand total	2,950,000	2,320	3,410,000	2,560

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Customs value.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF DIAMOND, BY KIND, WEIGHT, AND COUNTRY 1/

Kind, range, and country of origin	1997 Quantity (carat)	1997 Value 2/ (millions)	1998 Quantity (carat)	1998 Value 2/ (millions)
Rough or uncut, natural: 3/				
Australia	1,320	(4/)	13,000	(4/)
Belgium	585,000	$110	306,000	$111
Brazil	26,000	11	8,990	1
Congo (Brazzaville)	11,600	13	1,820	2
Congo (Kinshasa) 5/	87,100	88	66,300	72
Ghana	195,000	97	59,900	61
Guinea	8,170	10	16,800	11
India	110,000	4	5,320	(4/)
Israel	60,500	47	30,500	34
Russia	29,800	1	112,000	(4/)
Sierra Leone	13,900	16	7,450	10
South Africa	120,000	40	109,000	61
Switzerland	7,360	12	1,030	3
United Kingdom	652,000	186	609,000	206
Venezuela	13,300	3	13,800	2
Other	17,300	9	79,600	14
Total	1,940,000	646	1,440,000	588
Cut but unset, not more than 0.5 carat:				
Belgium	779,000	213	1,110,000	261
Brazil	2,960	2	14,100	2
Canada	5,050	1	676	(4/)
Germany	5,370	4	11,400	4
Hong Kong	419,000	77	378,000	61
India	7,790,000	1,320	9,820,000	1,560
Israel	1,010,000	568	1,010,000	521
Japan	7,000	4	7,190	2
South Africa	4,480	4	8,600	5
Switzerland	23,600	6	7,330	2
Thailand	57,100	11	70,400	10
United Kingdom	1,200	1	1,150	1
Other	51,100	12	73,200	24
Total	10,200,000	2,230	12,500,000	2,450
Cut but unset, more than 0.5 carat:				
Belgium	989,000	1,470	1,050,000	1,490
Botswana	15,200	9	1,690	1
Canada	2,660	7	880	3
France	1,760	8	1,780	16
Hong Kong	62,900	83	92,200	105
India	375,000	260	556,000	306
Israel	1,690,000	2,390	2,040,000	2,990
Japan	5,800	17	3,920	8
Russia	44,100	41	20,000	57
Singapore	575	4	3,860	15
South Africa	25,200	106	21,200	92
Switzerland	30,400	235	24,900	239
Thailand	11,000	11	10,700	14
United Kingdom	12,300	32	5,670	77
Other	22,300	37	25,400	39
Total	3,280,000	4,720	3,860,000	5,440

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Customs value.
3/ Includes some natural advanced diamond.
4/ Less than 1/2 unit.
5/ Formerly Zaire.

Source: Bureau of the Census.

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

Kind and country	1997 Quantity (carats)	1997 Value 2/ (millions)	1998 Quantity (carats)	1998 Value 2/ (millions)
Emerald:				
Belgium	10,500	$3	20,700	$2
Brazil	493,000	6	499,000	5
Canada	1,950	(3/)	5,750	1
China	32	(3/)	5,120	(3/)
Colombia	1,430,000	80	1,500,000	68
France	4,380	1	588	(3/)
Germany	30,500	3	33,500	4
Hong Kong	356,000	18	350,000	10
India	2,830,000	45	2,730,000	50
Israel	162,000	23	243,000	24
Japan	4,590	(3/)	399	(3/)
South Africa	17,700	(3/)	7,790	(3/)
Switzerland	71,300	25	67,800	21
Taiwan	247	(3/)	377	(3/)
Thailand	448,000	7	434,000	6
United Kingdom	3,600	2	3,090	1
Other	96,900	3	31,100	4
Total	5,960,000	217	5,930,000	195
Ruby:				
Belgium	2,100	1	2,610	(3/)
Brazil	5,550	(3/)	4,520	(3/)
Burma	29,700	3	1,090	7
Canada	1,010	(3/)	24	(3/)
China	14,200	(3/)	3,080	(3/)
Colombia	613	(3/)	4,300	(3/)
France	366	(3/)	2,440	1
Germany	71,000	2	15,700	1
Hong Kong	404,000	11	287,000	15
India	1,480,000	8	970,000	10
Israel	218,000	1	21,400	1
Japan	1,140	(3/)	3,730	(3/)
Switzerland	69,400	30	66,300	29
Thailand	2,830,000	48	2,370,000	47
United Kingdom	5,780	4	8,440	4
Other	233,000	2	50,800	3
Total	5,360,000	111	3,810,000	119
Sapphire:				
Australia	103,000	2	37,000	(3/)
Belgium	3,480	(3/)	29,000	1
Brazil	5,470	(3/)	5,770	(3/)
Burma	331	1	824	1
Canada	1,680	(3/)	283	(3/)
China	64,100	(3/)	6,700	(3/)
Colombia	3,690	(3/)	2,400	(3/)
France	337	(3/)	250	(3/)
Germany	101,000	2	59,900	2
Hong Kong	246,000	7	244,000	6
India	354,000	3	757,000	4
Israel	99,600	2	96,300	2
Japan	6,220	(3/)	3,550	(3/)
Singapore	36	(3/)	2,270	(3/)
Sri Lanka (Ceylon)	616,000	12	346,000	17
Switzerland	349,000	20	137,000	16
Tanzania	--	--	7,030	(3/)
Thailand	4,450,000	64	4,900,000	66
United Kingdom	8,990	$6	23,400	$5
Other	243,000	3	16,800	3
Total	6,660,000	124	6,670,000	123

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	1997 Quantity (carats)	1997 Value 2/ (millions)	1998 Quantity (carats)	1998 Value 2/ (millions)
Other:				
Rough, uncut:				
Australia	NA	3	NA	3
Brazil	NA	23	NA	19
China	NA	8	NA	1
Colombia	NA	1	NA	1
Fiji	NA	1	NA	2
Hong Kong	NA	1	NA	1
India	NA	1	NA	2
Kenya	NA	1	NA	(3/)
Nigeria	NA	(3/)	NA	(3/)
Pakistan	NA	1	NA	1
Philippines	NA	1	NA	1
Russia	NA	(3/)	NA	(3/)
South Africa	NA	1	NA	1
Switzerland	NA	1	NA	(3/)
Taiwan	NA	12	NA	(3/)
Tanzania	NA	2	NA	1
Thailand	NA	1	NA	1
United Kingdom	NA	1	NA	1
Zambia	NA	3	NA	1
Other	NA	8	NA	9
Total	NA	70	NA	45
Cut, set and unset:				
Australia	NA	8	NA	8
Brazil	NA	10	NA	10
Canada	NA	(3/)	NA	1
China	NA	7	NA	8
French Polynesia	NA	5	NA	7
Germany	NA	9	NA	9
Hong Kong	NA	31	NA	35
India	NA	26	NA	37
Israel	NA	5	NA	4
Japan	NA	10	NA	14
Kenya	NA	2	NA	1
Sri Lanka (Ceylon)	NA	3	NA	4
Switzerland	NA	2	NA	2
Taiwan	NA	2	NA	2
Tanzania	NA	3	NA	5
Thailand	NA	28	NA	24
United Kingdom	NA	2	NA	3
Other	NA	4	NA	4
Total	NA	155	NA	178

NA Not available.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Customs value.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 9
VALUE OF U.S. IMPORTS OF SYNTHETIC AND IMITATION GEMSTONES, BY COUNTRY 1/

(Thousand dollars) 2/

Country	1997	1998
Synthetic, cut but unset:		
Australia	386	187
Austria	6,250	6,770
Brazil	176	205
China	10,100	11,300
France	1,120	720
Germany	11,500	10,800
Hong Kong	2,010	2,240
India	1,130	1,640
Italy	123	32
Japan	138	25
Korea, Republic of	1,710	1,990
Spain	123	47
Sri Lanka (Ceylon)	674	444
Switzerland	4,930	3,670
Taiwan	519	926
Thailand	6,100	4,280
Other	475	560
Total	47,400	45,900
Imitation: 3/		
Austria	40,000	37,100
China	609	1,320
Czech Republic	10,500	7,880
Germany	2,430	1,880
Japan	1,190	765
Spain	317	212
Taiwan	304	284
Other	1,240	908
Total	56,600	50,400

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Customs value.
3/ Includes pearls.

Source: Bureau of the Census.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES 1/

(Thousand carats and thousand dollars)

Stones	1997		1998	
	Quantity	Value 2/	Quantity	Value 2/
Diamonds:				
Rough or uncut	1,940	646,000	1,440	588,000
Cut but unset	13,400	6,950,000	16,400	7,900,000
Emeralds, cut but unset	5,960	217,000	5,930	195,000
Coral and similar materials, unworked	NA	6,080	NA	7,640
Rubies and sapphires, cut but unset	12,000	235,000	10,500	242,000
Pearls:				
Natural	NA	785	NA	1,090
Cultured	NA	34,000	NA	36,900
Imitation	NA	2,210	NA	1,530
Other precious and semiprecious stones:				
Rough, uncut	1,180,000	57,900	883,000	31,100
Cut, set and unset	NA	120,000	NA	140,000
Other	NA	5,640	NA	6,330
Synthetic:				
Cut but unset	230,000	47,400	275,000	45,900
Other	NA	6,040	NA	7,770
Imitation gemstone 3/	NA	54,400	NA	48,800
Total	XX	8,380,000	XX	9,250,000

NA Not available. XX Not applicable.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Customs value.

3/ Does not include pearls.

Source: Bureau of the Census.

TABLE 11
NATURAL DIAMOND: ESTIMATED WORLD PRODUCTION, BY TYPE AND COUNTRY 1/ 2/

(Thousand carats)

Country	1994	1995	1996	1997	1998
Gemstones: 3/					
Angola	270	2,600	2,250	1,110	2,400
Australia	19,500	18,300	18,897 4/	18,100	18,400
Botswana	10,550 4/	11,500	12,400 r/	15,100 r/	13,500
Brazil	300	676 4/	200	300	300
Canada	--	--	--	--	278
Central African Republic	401	400	350	400	330
China	230	230	230	230	230
Congo (Kinshasa) 5/	4,000	4,000	3,600	3,300 r/	2,000
Cote d' Ivoire	80	53	202	207	207
Ghana	118 4/	126	142	664 r/	640
Guinea	306	274	165	165 r/	165
Liberia	40	60	60	60	60
Namibia	1,312 4/	1,382 4/	1,400 r/	1,420 r/	1,600
Russia	10,000 r/	10,500 r/	10,500 r/	10,500 r/	10,500
Sierra Leone	155	113	162 4/	64 r/	50
South Africa	5,050	5,070	4,280	4,380	4,100
Venezuela	380	125	99 r/	158 r/	100
Zimbabwe	104	114	300	321 r/	40
Other	99 r/	119 r/	165 r/	121 r/	126
Total	52,900 r/	55,700 r/	55,400 r/	56,600 r/	55,000
Industrial:					
Angola	30	300	250	124	364
Australia	23,800	22,400	23,096 4/	22,100	22,500
Botswana	5,000	5,300	5,000	5,000	5,000
Brazil	600	600	600	600	600
Central African Republic	131	130	120	100	200
China	850	900	900	900	900
Congo (Kinshasa) 5/	13,000	13,000	17,000	18,900 r/	13,000
Cote d' Ivoire	4	22	100	100	100
Ghana	473 4/	505	573	166 r/	160
Guinea	75	91	40	40	40
Liberia	60	90	90	90	90
Russia	10,000 r/	10,500 r/	10,500 r/	10,500 r/	10,500
Sierra Leone	100	101	108	40 r/	30
South Africa	5,800	5,880	5,670	5,790	6,200
Venezuela	203	66	73 r/	90 r/	150
Zimbabwe	69	90	137	100	30
Other	92 r/	101 r/	120 r/	105 r/	106
Total	60,300 r/	60,100 r/	64,400 r/	64,700 r/	59,900
Grand total	113,000 r/	116,000 r/	120,000 r/	121,000 r/	115,000

r/ Revised.

1/ World totals and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through May 27, 1999.

3/ Includes near- and cheap-gem qualities.

4/ Reported figure.

5/ Formerly Zaire.