**Natural Gemstones**

USGS - <https://pubs.usgs.gov/gip/gemstones/mineral.html>

[USGS logo](https://www.usgs.gov/)

[[USGS: Science for a Changing World - USGS visual identity mark and link to main Web site at http://www.usgs.gov/](https://www.usgs.gov/)](https://www.usgs.gov/)  
  
  
**Natural  
Gemstones**

[Version 1.1](https://pubs.usgs.gov/gip/gemstones/revision.html)

[Key Terminology](https://pubs.usgs.gov/gip/gemstones/terms.html)  
[Geologic Environment](https://pubs.usgs.gov/gip/gemstones/environment.html)  
[Mineral Gemstones](https://pubs.usgs.gov/gip/gemstones/mineral.html)  
[Birthstones](https://pubs.usgs.gov/gip/gemstones/birthstones.html)  
[Organic Gemstones](https://pubs.usgs.gov/gip/gemstones/organic.html)  
[Buyer Beware](https://pubs.usgs.gov/gip/gemstones/buyer.html)  
[U.S. Production](https://pubs.usgs.gov/gip/gemstones/production.html)  
[Chemical Formulas](https://pubs.usgs.gov/gip/gemstones/formulas.html)  
[Contacts](https://pubs.usgs.gov/gip/gemstones/contacts.html)  
[References](https://pubs.usgs.gov/gip/gemstones/references.html)  
[End Notes](https://pubs.usgs.gov/gip/gemstones/notes.html)   
  
  Quartz, Rhode Island  
  Photograph courtesy of The Smithsonian Institution   
  
**Related links:**[**Information on Rock and Mineral Collecting**](https://pubs.usgs.gov/gip/collect1/collectgip.html)  
[Education and Outreach](http://education.usgs.gov/)  
[Gemstones](http://minerals.er.usgs.gov/minerals/pubs/commodity/gemstones/) -- [Minerals Information](http://minerals.er.usgs.gov/minerals/)  
[Geologic Information](http://geology.usgs.gov/)

This page is URL:https://pubs.usgs.gov/gip/gemstones/  
Maintained by [Science Publishing Network](mailto:jmwatson@usgs.gov)  
Last modified 12-02-10 (jmw)

## Mineral Gemstones

Hardness and specific gravity are two of the major characteristics of gemstones.

Hardness of a gemstone is its resistance to scratching and may be described relative to a standard scale of 10 minerals known as the Mohs scale. F. Mohs, an Austrian mineralogist, developed this scale in 1822.

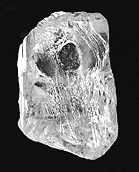
According to Mohs' scale, the hardness of--  
Talc is 1  
Gypsum is 2  
Calcite is 3  
Fluorite is 4  
Apatite is 5  
Feldspar is 6  
Quartz is 7  
Topaz is 8  
Sapphire is 9  
Diamond is 10

Specific gravity is the number of times heavier a gemstone of any volume is than an equal volume of water; in other words, it is the ratio of the density of the gemstone to the density of water.

*The 16 mineral gemstone groups listed below are highly prized for their beauty, durability, and rarity:*

**Beryl** (hardness: 7.5-8 Mohs)   
Beryllium aluminum silicate   
Specific gravity: 2.63-2.91  
  
  
*Emerald:* Intense green or bluish green   
*Aquamarine:* Greenish blue or light blue   
*Morganite:* Pink, purple pink, or peach   
*Heliodore:* Golden yellow to golden green   
*Red beryl:* Raspberry red   
*Goshenite:* Colorless, greenish yellow, yellow green, brownish

Aquamarine, Brazil  
Photograph courtesty of  
The Smithsonian Institution

**Chrysoberyl** (hardness: 8.5 Mohs)   
Beryllium aluminum oxide   
Specific gravity: 3.68-3.78  
  
*Chrysoberyl:* transparent yellowish green to greenish yellow and pale brown   
*Alexandrite:* red in incandescent light and green in daylight   
*Cat's eye:* usually yellowish or greenish  
  
**Corundum** (hardness: 9 Mohs)   
Aluminum oxide  
Specific gravity: 3.96-4.05  
  
*Ruby:* Intense red  
*Sapphire:* Blue  
  
**Diamond** (hardness: 10 Mohs)   
Carbon  
Specific gravity: 3.51  
  
Colorless to faint yellowish tinge, also variable

Diamond Star of Sierra Leone  
Photograph courtesty of  
The Smithsonian Institution

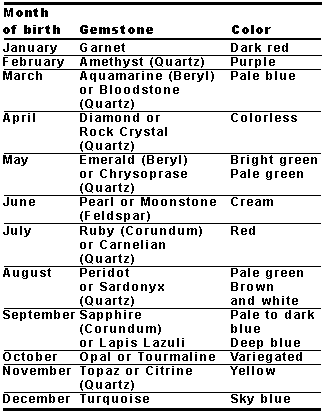
**Feldspar** (hardness: 6-6.5 Mohs)   
Two distinctly different alkali alumino silicates: the Plagioclase and the Alkali Feldspar Series   
Specific gravity: 2.55-2.76  
  
Plagioclase Series-  
*Labradorite:* Colorful, iridescent, also transparent stones in yellow, orange, red, and green   
*Sunstone:* Gold spangles from inclusions of hematite   
*Peristerite:* Blue white iridescence  
  
Alkali Feldspar Group- *Orthoclase:* Pale yellow, flesh red   
*Amazonite:* Yellow green to greenish blue   
*Moonstone:* Colorless; also white to yellowish, and reddish to bluish gray  
  
**Garnet** (hardness: 6.5-7.5 Mohs)   
A group of silicate minerals  
Specific gravity: 3.5-4.3  
  
*Almandine:* Orangy red to purplish red   
*Almandine-spessartine:* Reddish orange   
*Andradite:* Yellowish green to orangy yellow to black   
*Demantoid:* Green to yellow green andradite   
*Topazolite:* Yellow to orangy yellow   
*Grossular:* Colorless; also orange, pink, yellow, and brown  
*Tsavorite:* Green to yellowish green   
*Hessonite:* Yellow orange to red   
*Pyrope:* Colorless; also pink to red   
*Chrome pyrope:* Orange red  
*Pyrope-Almadine:* Reddish orange to red purple   
*Pyrope-Spessartine:* Greenish yellow to purple   
*Malaia:* Yellowish to reddish orange to brown   
*Color-change garnet:* Blue green in daylight to purple red in incandescent light   
*Rhodolite:* Purplish red to red purple   
*Spessartine:* Yellowish orange   
*Uvarovite:* Emerald green  
  
**Jade** (hardness: 6 Mohs)   
  
*Nephrite*   
Calcium magnesium silicate   
Specific gravity: 2.9-3.1  
  
White, deep green, creamy brown  
  
*Jadeite*   
Sodium aluminum silicate   
Specific gravity: 3.1-3.5  
  
White, leafy and blue green, emerald green, lavender, dark blue green and greenish black, deep emerald-green   
  
**Lapis lazuli** (hardness: 5-5.5 Mohs)   
A rock composed mainly of the mineral lazurite with variable amounts of pyrite (brassy flecks) and white calcite   
Specific gravity: 2.7-2.9  
  
Deep blue, azure blue, greenish blue (bluish color with flecks of white and gold)   
  
**Opal** (hardness: 5.5-6.5 Mohs)   
Hydrated silica   
Specific gravity: 1.98-2.25  
  
*White opal:* Opaque, porcelain-like white material; colors resemble flashes or speckles   
*Black opal:* Flashes and speckles appear against black background   
*Water opal:* A transparent, colorless opal is the background for brilliant flashes of color   
*Fire opal:* Reddish or orange opal  
  
**Peridot [Olivine]** (hardness: 7 Mohs)   
Magnesium iron silicate   
Specific gravity: 3.22-3.45  
  
Olive to lime green  
  
**Quartz** (hardness: 7 Mohs)   
Silicon dioxide or silica   
Specific gravity: 2.65  
  
Coarsely crystalline varieties of silica-  
*Rock crystal:* Colorless   
*Amethyst:* Purple   
*Citrine:* Yellow to amber   
*Morion:* Black  
*Smoky quartz or cairngorm:* smoky gray to brown   
*Rose quartz:* Translucent pink  
*Green quartz or praziolite:* Green

Candelabra: white quartz, blue-capped red elbaite, and tan albite, California  
Photograph courtesty of  
The Smithsonian Institution

Cryptocrystalline varieties of silica-  
*Chalcedony and Jasper (variable)*   
*Agate:* Bull's eye agate, Iris or fire agate, Onyx, Sardonyx. *Bloodstone or heliotrope. Carnelian. Chrysoprase. Moss agate. Plasma. Prase. Sard. Jasper.*   
  
**Spinel** (hardness: 8 Mohs)   
Magnesium aluminum oxide   
Specific gravity: 3.58-4.06  
  
*Balas ruby:* Red  
*Almandine spinel:* Purple red  
*Rubicelle:* Orange  
*Sapphire spinel and ghanospinel:* Blue  
*Chlorspinel:* Green  
  
**Topaz** (hardness: 8 Mohs)   
Aluminum silicate fluoride hydroxide  
Specific gravity: 3.5-3.6  
  
Wine yellow, pale blue, green, violet, or red   
  
**Tourmaline** (hardness: 7-7.5 Mohs)   
Complex aluminum borosilicate  
(Elbaite, Dravite, Uvite)   
Specific gravity: 3.03-3.25  
  
*Achorite:* Colorless  
*Brazilian emerald:* Green  
*Dravite:* Brown  
*Indicolite:* Dark blue  
*Rubellite:* Pink to red  
*Siberite:* Violet  
*Verdilite:* Green  
  
**Turquoise** (hardness: 5-6 Mohs)   
Hydrous copper aluminum phosphate  
Specific gravity: 2.6-2.8  
  
Sky blue; greenish blue  
  
**Zircon** (hardness: 7.5 Mohs)   
Zirconium silicate  
Specific gravity: 4.6-4.7  
  
*Jargon:* Variable  
*Matura diamond:* Colorless  
*Hyacinth:* Yellow, orange, red, brown

[USGS logo](https://www.usgs.gov/)

## Birthstones



**Organic Gemstones**

The four organic gemstone groups listed below are highly prized for their beauty and rarity. However, they are not as durable as gemstones from minerals:

**Amber** (hardness: 2-2.5 Mohs)   
A mixture of hydrocarbons   
Specific gravity: 1.05-1.096  
  
Hard fossil resin or sap of ancient pine trees. Usually amorphous (lacks crystalline structure). Sometimes mined, sometimes gathered on seashores.

Varies from transparent to semitransparent and generally from light yellow to dark brown, but can be orange, red, whitish, greenish-brown, blue, or violet. Can be dyed in any color.

Takes a fine polish. Used mainly in making beads or other ornaments.

**Coral** (hardness: 3.5-4 Mohs)   
Formed mainly of calcite (calcium carbonate) or conchiolin, a horny organic substance   
Specific gravity: 2.60-2.70

Each coral polyp, a tiny marine animal that lives in enormous colonies, extracts calcium carbonate from the sea and exudes it to build a protective home around and above itself. Each generation of polyps dies in its protective home and each succeeding generation builds on top of its predecessor.

Gem coral ranges from semitranslucent to opaque and occurs in white, pink, orange, red, blue, violet, golden, and black. The black and golden corals are largely horny organic substances, not calcium carbonate.

The finest coral is used to make figurines, cameos, carvings, and beads.

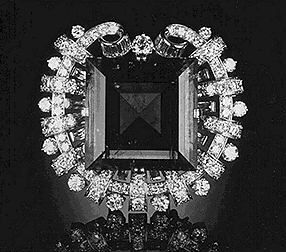
**Jet** (hardness: 2.5-4 Mohs)   
Carbon plus various hydrocarbon compounds   
Specific gravity: 1.30-1.32

This compact velvet-black coal takes a good polish and is often cut into beads, bracelets, and a wide range of decorative and useful objects.

**Pearl** (hardness: 2.5-4.5 Mohs)   
Formed within a mollusk, such as an oyster, that deposits a substance called *nacre* around an irritant that entered the organism   
Specific gravity: 2.71

Pearl-bearing mollusks are found in both salt and fresh water. Salt-water pearls of gem quality are usually preferred for jewelry; they are produced almost entirely by the mollusk *Pinctada*. Fresh-water pearls are produced by various clams and mussels.

Natural pearls come in various shapes: round, pear, drop, egg, and others. They also come in various colors, such as white, cream, light rose, cream rose, black, gray, bronze, blue, dark blue, blue green, red, purple, yellow, and violet.

  
  
The Hooker Emerald, Colombia  
Photograph courtesty of  
The Smithsonian Institution

**Buyer Beware**

Inexperienced buyers must take whatever steps are needed to ensure that gems they intend to purchase are exactly what the seller purports them to be and that they are being offered at a fair market price.

More and more synthetic gems--and inferior grades and cuts of natural gems--are being sold to unwary buyers by unscrupulous sellers.

**Since 1935, the mining of gemstones in the United States has been almost entirely a recreational activity of mineral collectors and hobbyists.**

In recent years, very few individuals have derived their entire income from gemstones mined by themselves.

This is not to say that the proprietors of roadside rock shops buy all of their stock from others. Rock shops are abundant in areas of the United States that are rich in gem materials, and the shops tend to specialize in the local gem commodities, most of which the proprietors gather.

Rather than doing the mining themselves, owners of land that has a deposit of gem-quality minerals sometimes charge hobbyists for the right to collect gemstones. For example, diamond in Arkansas, opal in Idaho, and agate in Oregon and Washington are mined by hobbyists under this "fee digging" arrangement.

However, the flow of money into the local economy by paying these small fees and by the purchase of gemstones is minor compared to the money the enthusiasts spend for lodging and other living expenses while visiting an area to dig for gemstones.

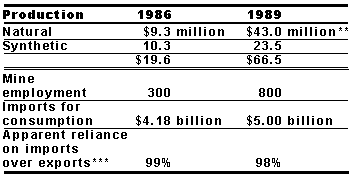
Several kinds of natural gemstones have been found in every State of the United States, but much larger deposits of the most precious kinds are found outside the United States.

**The 1990 U.S. output of natural gemstones was primarily from Tennessee, California, Arizona, Arkansas, Montana, Nevada, and Maine.**

An estimated 80,000 visitors found a total of 315 carats of diamonds in the Crater of Diamonds State Park in Arkansas. There were sizeable yields of freshwater pearls in Tennessee, turquoise in Arizona and Nevada, tourmaline in Maine, and tourmaline, kunzite, and garnet in California.

U.S. production of commercial gems includes agate, beryl, freshwater pearl, garnet, jade, jasper, mother-of-pearl, opal, peridot, quartz, sapphire, tourmaline, and turquoise.

**Gemstones: Value of U.S. production vs. imports, 1986 and 1989\***

  
\*Estimated.   
\*\*Including freshwater pearls, natural and cultured.   
\*\*\*Imports - exports + adjustments for Government and industry stock changes.  
Source: Mineral Commodity Summaries, 1991, U.S. Bureau of Mines.

**Except for the few gem diamonds found each year in Arkansas, U.S. diamond production is very low.**

Yet exploration for diamonds continues in Alaska, Colorado, Michigan, Minnesota, Wisconsin, and Wyoming. A diamond mining project at the Crater of Diamonds State Park in Arkansas is still being evaluated by the State.

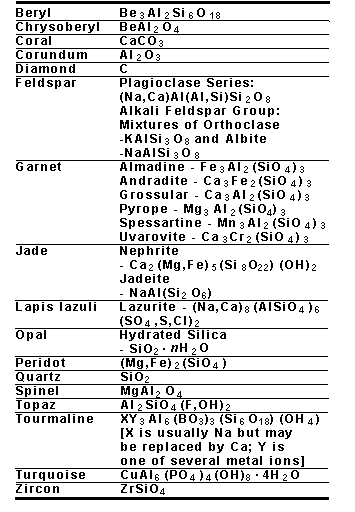
  
  
The Hope Diamond, India  
Photograph courtesty of  
The Smithsonian Institution

**World diamond reserves are estimated to be about 300 million carats, including near-gem materials but not diamonds of abrasive quality.**

Most of the reserves are in southern Africa, Siberia, and western Australia. It is difficult to estimate reserves because the value of a given deposit varies with the market for the gems.

[USGS logo](https://www.usgs.gov/)

## Chemical Formulas of Gemstones



  
  
Jade nephrite, China  
Photograph courtesty of  
The Smithsonian Institution

## Some Ways to Contact a Local Rock, Mineral, or Gem Club

Talk to a member of the geology or earth science department of your local college or university.

Talk to a member of the science department of your local high school.

Contact the [American Federation of Mineralogical Societies](http://www.amfed.org/).

Check the phone book for your nearest rock and mineral shop and talk to the owners.

## Role of the U.S. Geological Survey (USGS)

The USGS reports deposits that seem likely to contain gemstones. It is not a function of the USGS to exploit such resources.

USGS geologists perform continuing research on kimberlites, the initial source of diamonds. Not all kimberlites are diamond bearing, and some of the research is directed to learning what indications you look for during exploration to distinguish fertile from barren kimberlite.

## Lavender-hued rose quartz, BrazilSelected General References

A trip to your local library is the best first step toward understanding gemstones and toward planning a trip to gem and rock shops or to places where you may be able to collect gemstones.

Lavender-hued rose quartz, Brazil  
Photograph courtesty of  
The Smithsonian Institution

The references below focus mainly on natural gemstones and the gems made from them rather than on synthetic gemstones, rocks, or other nongem minerals.

[*Minerals Yearbook*](http://minerals.er.usgs.gov/minerals/pubs/commodity/myb/)

The relatively few pages on gemstones in the multivolume *Minerals Yearbook* provide data on sources, kinds, and volume of domestic production, domestic consumption, prices, and foreign trade. This U.S. Bureau of Mines yearbook is in the reference sections of many major libraries. It can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

*Books*

*Gemology,* Cornelius S. Hurlbut Jr. and Robert C. Kammerling: John Wiley & Sons, New York, 1991, 2nd ed.

*Gemstones and Their Origins,* Peter C. Keller: Van Nostrand Reinhold, 1990.

*Color Encyclopedia of Gemstones,* Joel Arem: Van Nostrand Reinhold, New York, 1987, 2nd ed., 68 p.

*Gemstones for Everyman,* B.W. Anderson: Van Nostrand Reinhold, 1976, 268 p.

*Gems and Precious Stones,* Curzio Cipriani and Alessandro Boreli; Valerie Palmer, translator: Kennie Lyman, U.S. editor: Simon and Schuster, New York,1986,384 p.

*Gem and Crystal Treasures,* Peter Bancroft: Mineralogical Record, Carson City, NV, 1984, 488 p.

*Planet Earth--Gemstones,* Paul O'Neil and the editors of Time-Life Books: Time-Life Books, Arlington, VA, 1983, 176 p.

*Gemstones of the World,* Walter Schumann (translated by Evelyne Stern): Sterling, New York, 1984, 256 p.

*Gems & Crystals from the American Museum of Natural History: An illustrated guide to the history, lore, and properties of the gems and minerals of one of the world's greatest collections,* Anna S. Sofiandes and George E. Harlow: Simon & Schuster, New York, 1990, 208 p.

*The Gem Collection* (Treasures in the Smithsonian Series No.1), P.E. Desautels: Smithsonian Institution, Washington, 1983, 77 p.

*Gemstones of North America,* John Sinkankas: D. Van Nostrand Company, Inc., Princeton, 1959, 675 p.

*Gems and Precious Stones of North America--A popular description of their occurrence, value, history, archeology, and of collections in which they exist,* G.F. Kunz: Dover Publishing, New York, 1968 (reprint of a classic work dated 1892), 367 p.

*Emerald and Other Beryls,* John Sinkankas: Chilton Way, Radnor, PA, 1981, 665 p.

*Handbook of Gem Identification,* R.T. Liddicoat Jr.: Gemological Institute of America, Santa Monica, CA, 1981 (11th ed.), 450 p.

*Field Collecting Gemstones and Minerals,* John Sinkankas: Geoscience Press, Prescott, AZ, 1988, 2nd ed., 397 p.

*Prospecting for Gemstones and Minerals* [Formerly *Gemstones and Minerals: How and Where to Find Them*], John Sinkankas: Van Nostrand Reinhold, New York, 1970, 2nd ed., 397 p.

*Mineral & Gem Trails of Delaware, Virginia, Maryland, North Carolina,* Ed and Bert Sloan: EDSCO, Box 79, Oneonta, NY 13820, 1978, 52 p.

*Gem Testing,* B.W. Anderson: Butterworth, Woburn, MA, 1980, 9th ed., 384 p.

*Gemology,* C.S. Hurlbut Jr. and G.S. Switzer: Wiley, New York, 1979, 596 p.

*Gems and Jewelry,* Joel Arem: Bantam Books, New York, 1975, 159 p.

*Gem Cutting: A Lapidary's Manual,* John Sinkankas: Van Nostrand Reinhold, New York, 1962, 2nd ed., 297 p.

*Journals*

*Gems and Gemology* (quarterly). Articles on gemstone localities, identification, and history. Includes annual index, lab notes, book reviews, and gemological abstracts. Published by the Gemological Institute of America, 1660 Stewart Street, Santa Monica, CA 90404.

*Lapidary Journal* (monthly). Articles on gemstones, locality information, expeditions to find sources of gemstones, gemcraft, club news, show news, product news, and book reviews. Published by the Lapidary Journal, Devon Office Center, Suite 201, 60 Chestnut Avenue, Devon, PA 19333-1312.

*Rocks & Minerals* (bimonthly). Features articles of interest to students of mineralogy, geology, and paleontology. Includes articles about gemstone localities. Regularly lists announcements of hundreds of mineral, rock, and gem shows (local, State, national, Canadian, and European). Includes media reviews, museum notes and announcements, and classified ads. Published by Heldref Publications, 4000 Albermarle Street, NW., Washington, DC 20016.

*Jewelers' Book Club - Catalog* (annual). Catalog of more than 550 jewelry-related publications from more than 250 publishers. Includes video- and audio-cassettes and book reviews. *Jewelers' Book Club - News* (quarterly) informs members of new titles and provides book reviews. Published by the Jewelers Book Club, Chilton Way, Radnor, PA 19089.

*Videocassettes*

*Gemstones of America* (60 minutes), Smithsonian Institution, 1991, can be ordered for $29.95 from the Museum Shop, Attention: Mail Order Clerk, National Museum of Natural History, 10th Street and Constitution Avenue, NW, Washington, DC 20560; (202) 357-1535.

*Splendid Stones.* This National Geographic Society special details the evolution from raw material to cut and polished gem, outlines many of the steps involved in marketing gemstones, and examines some of the world's most famous jewelry collections. It can be ordered for $95 from the National Geographic Society, 17th and M Streets NW., Washington, DC 20036.

[USGS logo](https://www.usgs.gov/)

**Acknowledgments**

The U.S. Geological Survey is grateful to the following individuals for their assistance:

Harvey E. Belkin, Geologist, Geological Survey, U.S. Department of the Interior, Reston, VA.

Gordon T. Austin, "Gemstones," *Mineral Commodity Summaries 1991,* Bureau of Mines, U.S. Department of the Interior, Washington, DC.

Robert E. Thaden, "Gem Stones," in *United States Mineral Resources,* Geological Survey Professional Paper 820, U.S. Government Printing Office, Washington, 1973, p. 247-250.

Jane Jenness, Minerals Information Office, U.S. Geological Survey, Washington, DC.

**Photographs**

All photographs are courtesy of The Smithsonian Institution.

**Text**

This online version of "Natural Gemstones" contains the text of the originally published book in its entirety. Some figures, however, have been changed for purposes of online presentation.

The original "Natural Gemstones" publication is one of a series of general interest publications prepared by the U.S. Geological Survey to provide information about the earth sciences, natural resources, and the environment. To obtain a catalog of additional titles in the series "General Interest Publications of the U.S. Geological Survey," write:

U.S. Geological Survey  
Information Services  
P.O. Box 25286  
Denver, CO 80225

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.