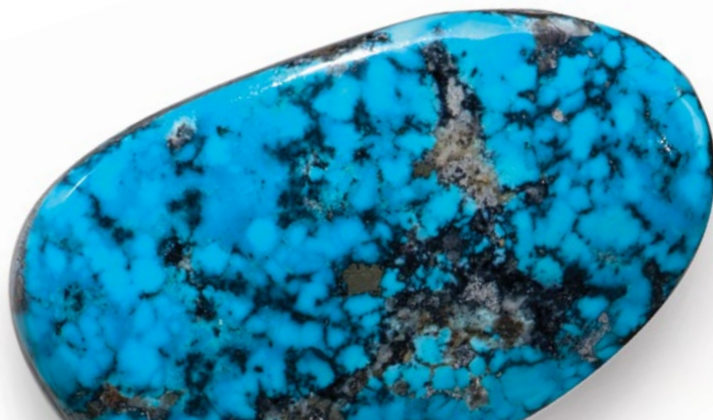




Gemstones

Retailers' Reference Guide



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Images for this section are courtesy of GIA. The majority of faceted gems shown are courtesy of the Dr. Eduard J. Gübelin Gem Collection, now part of the GIA Gem Collection



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Alexandrite and chrysoberyl



A twinned chrysoberyl crystal.

History, lore and appreciation

Of all of the mineral species, chrysoberyl has the most notable phenomenal varieties – in the sense that it possesses unique optical characteristics known as phenomena. Alexandrite, a rare variety of chrysoberyl, exhibits a chameleon-like colour change. On rare occasions, these colour-change gems exhibit a second phenomenon, called cat's eye or chatoyancy, seen as a narrow bright line on the surface that appears to move as the gem is turned. This phenomenon is caused by reflections of light from parallel needle-like inclusions.

Alexandrite shows a colour-change effect and exhibits reddish hues under incandescent light and bluish-green hues in daylight (or daylight equivalent). Alexandrite was discovered in Russia's Ural Mountains in early 1830, and the deposit along the Takovaya River began to be worked by 1833. At the time, the colour-change gem was named after Tsarevich Alexander Nikolaevich, the future Czar Alexander II.

Among the most cherished gems that exhibit chatoyancy is cat's eye chrysoberyl sometimes, though rarely, referred to as cymophane. This phenomenon is caused by inclusions; minute fibres of the mineral rutile that are oriented parallel to one another throughout the chrysoberyl. In gems that are properly oriented and cut en cabochon, this silvery, floating line appears when a strong or pinpointed light is directed perpendicular to the gem's surface. Cat's eye stones are best viewed in direct light such as sunlight.

An indistinct cat's eye effect, observed as a broad sheen along the gem's surface, is caused by a multitude of randomly oriented included needles. Yellow to greenish chrysoberyl is the standard bearer for the name of the species. *Chrysos* is a Greek word meaning "golden," and *berilos* (also Greek), form the root for the chrysoberyl name. It is worth noting that chrysoberyl is not a form of beryl, which is an entirely different mineral species.

Birthstones and anniversaries

Alexandrite is one of the birthstones used for the month of June, along with pearl. Alexandrite is also the gemstone for a 55th wedding anniversary.

Alexandrite and chrysoberyl

Description and properties

Chrysoberyl is a beryllium and aluminium oxide, with the chemical formula: BeAl_2O_4 , and it forms in the orthorhombic crystal system. Non-phenomenal chrysoberyl is transparent to semi-transparent, comprising a range of colours. Chrysoberyl can be yellow, greenish-yellow to yellow-green, green and a rare vanadium-rich chrysoberyl that is a pale bluish green. The phenomenal varieties include alexandrite and cat's eye chrysoberyl. The alexandrite variety contains gems that vary from transparent to semi-transparent, and whose colour appears different depending on the light it is viewed in. Cat's eye chrysoberyl is opaque to semi-transparent, containing minute parallel inclusions that cause chatoyancy when the gems are fashioned as cabochons.

Among natural gems, non-phenomenal chrysoberyl may be confused with yellow or greenish sapphire, grossular garnet and some spinel, due to their colour overlap.

Trained gemmologists may easily identify and separate these gems based on their optical and physical characteristics.

Alexandrite may be confused with colour-change garnet and colour-change sapphire, which often exhibit overlapping colours and colour-change phenomena. Cat's eye chrysoberyl tends to be straightforward to identify based on its optical characteristics, however some very convincing look-alikes do exist: cat's eye opal, scapolite, kornerupine, tourmaline and quartz – may look similar. Here again, in the case of alexandrite and cat's eye, a trained gemmologist may easily separate them from other visually similar gemstones.

Colours:

- Chrysoberyl: Light to medium yellow to yellowish green, greyish green, bluish green, brown to yellow-brown to light blue.
- Alexandrite (daylight): Yellowish, brownish, greyish or bluish green
- Alexandrite (incandescent light): Orangey or brownish red to purplish red.

Refractive Index: 1.746 to 1.755

Birefringence: 0.004 to 0.006

Specific Gravity: 3.73 (± 0.02)

Cause(s) of colour: Predominantly iron and chromium in chrysoberyl, chromium in alexandrite and iron (and sometimes chromium in rare, cat's eye alexandrite). Vanadium is the cause of colour in bluish green chrysoberyl.

Mohs Hardness: 8.5.

Internal identifying characteristics:

Multi-phase inclusions, hollow tubes, mica platelets, calcite, and metal sulphide inclusions in chrysoberyl and alexandrite. Silk-like bands of minute needles are found in cat's eyes, and are the cause of chatoyancy.

Treatments

Chrysoberyl generally is not treated, to enhance colour or diminish the appearance of inclusions. Although, treatments such as neutron irradiation have been used in the past to obtain brown-coloured cat's eye.

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Alexandrite and other chrysoberyls

Collector quality

Alexandrite and cat's eye chrysoberyl are quite rare to begin with and as such highly collectible due to their exotic, phenomenal qualities. A premium is placed on gems with a strong colour change, since with alexandrite a predominantly "muddy" mix of greens, browns and reds tends to be the norm, resulting in a vague colour change.

With cat's eyes, a strong, sharp and unwavering silvery line that is visible from girdle-to-girdle is highly desirable, accompanied by rich green, yellow or brown colours. Cat's eye alexandrite is especially collectible since they exhibit two phenomena. An additional and easy confirmation of quality for cat's-eyes is to shine a direct light towards the gem at an oblique angle. In fine, semi-translucent gems, a "milk and honey" effect can be observed. This shows strong brownish to saturated yellow "honey" colours on one side of the gem, and a milky translucence on the other. In all collector varieties, size matters since alexandrite as well as cat's eyes tend to be found mostly in small sizes, generally under a carat.

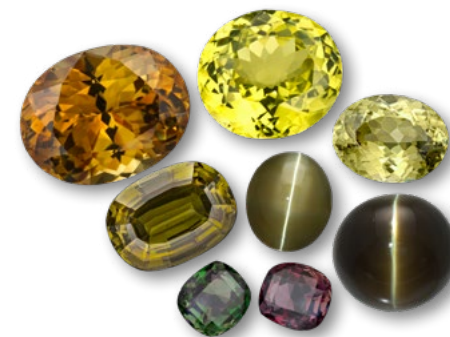
Finally, collectors have become much more discriminating about the quality of cut – symmetry, orientation, crisp facets and facet junctions and appealing outlines – since such aspects tend to show phenomena at its very best and because the overall effect is more pleasing to the eye.

Localities

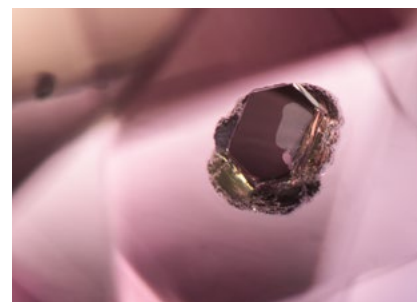
Chrysoberyl, while rare as an occurrence, is found on several continents – Africa, South America and Asia. Sources for chrysoberyl and alexandrite include Sri Lanka, Myanmar, Brazil, Kenya, Tanzania, Madagascar, India, Australia and Russia.

Cutting, care and cleaning

With a hardness of 8½ and excellent toughness, chrysoberyl is extremely resilient for use in jewellery. It is never a good idea to wear gems during any type of arduous work or exercise. However, chrysoberyl may be worn daily under normal conditions. Most chrysoberyl jewellery may be cleaned in an ultrasonic cleaner unless there are preconditions, such as a fractured gem. Otherwise, a damp cloth and warm soapy water are generally enough to clean chrysoberyl gems and jewellery.



This group of fashioned chrysoberyl exhibits a range of colour. Included here are the phenomenal varieties: alexandrite, which exhibits colour change (in this case red to green) and cat's eye chrysoberyl (cut as cabochons)



This inclusion in an alexandrite from Brazil is a metal sulphide. Field of view: 1.99 mm

Amethyst



This amethyst crystal from Brazil is doubly terminated

History, lore and appreciation

Enthusiasts who appreciate quartz's diverse family of gems often single out amethyst as the most significant variety of the quartz mineral. Amethyst has been used in personal adornment for millennia, often sought out by royalty or important members of the clergy.

In Medieval Europe particularly, the colour purple was worn in rare dyed textiles that could only be afforded by the very wealthy. Amethyst's bold purple colour, and rare reddish flashes, coupled with the fact that only a few mines for it existed in ancient times, further contributed to its selection as a "royal" or "bishop's gem". Important amethysts feature prominently in British regalia. The name amethyst has a peculiar derivation. It comes from the Greek word *amethystos*, which translates to "not intoxicated." A belief based in Classical mythology says that amethyst protected its wearer from inebriation (even following copious consumption of alcohol) consequently made the gem highly desirable by those so inclined.

Birthstones and anniversaries

Amethyst is the birthstone for February. It is also considered to be a 6th wedding anniversary gem.

Description and properties

Amethyst is a variety of quartz that crystallises in the trigonal system and is composed of silica, with the chemical composition: SiO_2 .

Colour(s): Transparent to translucent lilac to purple through bluish purple, with a reddish purple colour-shift that is sometimes visible in incandescent light. Ametrine is an unusual form of quartz mined from southeastern Bolivia, principally at the Anahí mine. The colours are both yellow and purple in areas of crystal growth-related zoning. Such gems are sometimes cut or carved in a way that mixes the colours, and at other times to show the division of colours.

Refractive Index: 1.544 to 1.553

Birefringence: 0.009

Specific Gravity: 2.66 (+0.03, -0.02)

Cause(s) of colour: Iron-related colour centres, natural irradiation of geological origin.

Mohs Hardness: 7

Internal identifying characteristics:

Amethyst often contains areas of colour next to areas that have no colour – called colour zoning. Amethyst, which has a hydrothermal geologic formation, often has liquid inclusions containing solids and gases, so-called two – and three-phase inclusions. Inclusions of other minerals such as rutile and hematite sometimes can be found in amethyst as well. Amethyst might show a bull's eye effect viewed with crossed polarizing filters.

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Amethyst

Treatments

Amethyst is sometimes subject to heat treatment, which in a controlled environment may cause overly dark amethyst to be lightened. Heating amethyst from some sources may turn them yellow, known as citrine. Some amethyst can be heated to turn green, a colour referred to in the trade as “oro verde”.

Collector quality

Collectors of amethyst look for depth of the purple colour with red flashes if the gem is cut conventionally. Many famous lapidaries (cutters) work with amethyst to make unusual carvings or cuts, which are also highly prized. Because commercial quantities of ametrine come from only one region in the world, it is sometimes collected if the depth of colour and the division of colour is strong, or if it has been skilfully or cleverly carved.

Amethyst localities

The Ural Mountains in Russia is considered the “classic” source for amethyst because that it is a known historical source. “Uralian” amethyst, often called “Siberian” in the trade (a curious trade name because there are no known deposits in Siberia) at their best, exhibit deep reddish purple, to purple red colours. Other important sources include Brazil and Uruguay, Bolivia, the United States (Arizona), Morocco, DR Congo, Rwanda, Myanmar and Zambia.

Cutting, care and cleaning

Amethyst – once considered rare – today has thankfully become one of the world’s most plentiful gems. It is available in many sizes, different cutting styles and carvings. Amethyst is fairly resilient and can be worn extensively. Care should be taken not to knock the gem during use, as small fissures or cracks may develop, especially along facet junctions. It can be cleaned with warm, sudsy water or a dampened cloth. Some amethyst may lighten in tone over time after prolonged exposure to bright light.



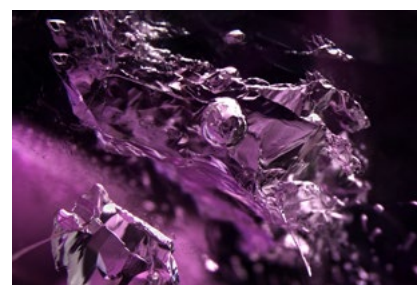
This rough shows both the amethyst and citrine colours mixing together



Pictured here are a group of faceted amethyst, exhibiting varied tonality and cutting shapes



Ametrine can be cut to show the division of colour (left), or faceted to mix the colours, resulting in reds and russets



Amethyst often shows 2-phase inclusions, such as these large ones. Field of view: 7.19 mm

Aquamarine



Aquamarine crystals may form as a cluster of crystals in a range of tones that are blue green to greenish blue

History, lore and appreciation

Aquamarine reminds us of the sea; its watery greenish blue colours have elicited such comparisons for centuries. In 1609, Flemish mineralogist and scholar Anselmus Boetius de Boodt first drew this association and his description became universal. The Latin root names, aqua and marina, literally translate to "water of the sea." Aquamarine is a gem of subtlety with its light and clear pastel hue, tones they are best associated with. However, some deposits have yielded deeply saturated blue colours, and they are considered rare. It is often worn for evening events when the gems can gleam enticingly, even in low lighting conditions. Despite the understanding that subtlety is part of an aquamarine's character, depth of colour remains an important characteristic as well.

Aquamarine differs greatly from emerald, despite being varieties of the same mineral. Unlike emerald, for instance, aquamarine frequently forms as large crystals – sometimes weighing hundreds of carats. Additionally, it frequently possesses a vitreous clarity not found

in emerald. For this reason, aquamarine may be fashioned as exceptional clean gems and carvings. That said, some aquamarine is sufficiently included to impart a slightly milky appearance. In other rare cases, the inclusions are miniscule, hollow growth tubes that form parallel to one another, causing chatoyancy (cat's eye effect) in the gem.

Birthstones and anniversaries

Aquamarine is the birthstone for March. It is also considered to be a 19th wedding anniversary gemstone.

Description and properties

Aquamarine is an important member of the beryl family of gems, and forms in the hexagonal crystal system. It has the following composition: $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$.

Colour(s): Generally transparent and greenish blue, to blue green and generally light in tone. Deeper blues are less common; some highly included aquamarine has a milky, translucent quality.

Refractive Index: 1.577 to 1.583 (± 0.017)

Birefringence: 0.005 to 0.009

Specific Gravity: 2.72

Cause(s) of colour: iron

Mohs Hardness: 7.5 to 8.0

Internal identifying characteristics:

Inclusions in fine aquamarine are sometimes hard to find. However, fluid inclusions including two and three-phase inclusions (containing a liquid, a solid and a gas), sometimes referred to as "fingerprint" inclusions, are sometimes seen. Parallel hollow growth tubes may be present and if in sufficient quantity may cause a chatoyant effect in cat's eye aquamarine.

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Aquamarine

Treatments

More often than not, slightly greenish blue aquamarine is heat-treated, causing it to mitigate a secondary yellowish colour component (that causes some aquamarines to look very slightly greenish blue). The treatment results in a purer blue colour. Most aquamarine in today's market is considered to be heat-treated, although it is generally impossible to determine that fact gemologically.

Collector quality

Aquamarine with a saturated blue colour is especially desirable, though a few beryl collectors prefer a slight greenish tinge since such gems follow the "classic" description of aquamarine. Unusually cut gems are also popular, especially in gems that have been fashioned by an important lapidary artist. Aquamarine and other beryls often lend themselves to sculptures because of their size. Locality plays a role in collecting as well. Aquamarine from desirable localities, such as Santa Maria in Itabira or Marambaia, in the state of Minas Gerais, Brazil, are collectible due to

its legendary depth-of-colour. Ukrainian green beryl and aquamarine also became sought after as mineral specimens thanks to their startling sizes, peculiar growth etching and deep colours.

Localities

Aquamarine forms in pegmatites on almost every continent. Brazil is perhaps one of the best-known localities for aquamarine – as well as various other beryls.

The gem-rich state of Minas Gerais is Brazil's strongest producer, though important finds first occurred in Rio de Janeiro, and later as exploration into the interior continued, in Ceará, Espírito Santo and Bahia.

Other strong producers include Pakistan's Skardu district and Ukraine. Other Asian localities include Tajikistan, Afghanistan, India and China. China, particularly, is emerging as an important producer. Aquamarine is also mined at several localities in the United States, but perhaps the most significant is Mt. Antero in Colorado. African aquamarine

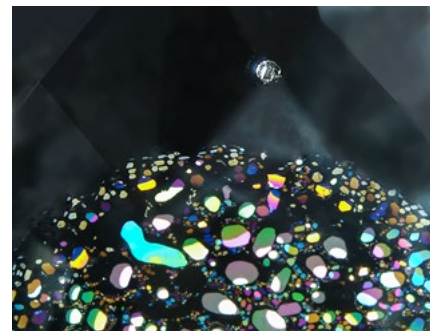
has been found at deposits in the Zambézia province of Mozambique (where deep-coloured "Santa Maria Africana" aquamarines are found), Kenya, Malawi, Tanzania, Namibia, Nigeria and Madagascar.

Cutting, care and cleaning

Aquamarine's hardness of 7½ to 8, combined with being relatively inclusion-free, gives it good toughness as a gemstone if it is worn under normal use. Large aquamarines should be worn with care, especially in settings such as rings that can be easily knocked. It is best when prongs are placed in corners of square-shaped gems, because they can protect the gems from chipping at sharp angles and facet junctions. Aquamarine may be cleaned in an ultrasonic cleaner if it does not have inclusions that might expand or endanger the integrity of the gem. Sudsy water followed by wiping with a damp cloth is a good and safe way to clean an aquamarine.



Some aquamarines form as single crystals



Thin, reflective oriented fluid inclusions are common features observed in aquamarine. Field of view 2.88 mm

Other beryls



As with all beryl, the very rare red beryl forms hexagonally

History, lore and appreciation

Aficionados often praise the many pastel colours available in the beryl mineral species – notably the subtle blues observed in aquamarine. But a handful of other colour varieties grace it as well. Pink to peach colours, yellow, colourless, light green, deep blue and very rare – red colours are also part of this family. It is worth pausing for a moment to remember that emerald is also a beryl variety. Emerald's importance as the deep green gem par excellence is well established throughout history. Aquamarine is a significant beryl too, and for that reason individual chapters for these two gems have been written. (See Emerald p. 18 or Aquamarine p. 7).

Pink beryl was first discovered in Pala, California (together with other gems including kunzite and tourmaline) in the early 20th century. The new gem was soon named morganite in honour of U.S. financial mogul, John Pierpont Morgan, who was an avid collector, particularly of North American gems. Morgan was reputed to have had the largest collection of gems and minerals in the United

States during the late 1800s. In 1889, his collection was shown at the World's Fair in Paris, France (at the time the Eiffel Tower was built). Despite this prominent link, morganite is in shorter supply than aquamarine, and consequently is less well known. However, morganite occasionally forms as large crystals, suitable for oversized gems or carvings.

This is also true for heliodor, the bright yellow beryl whose name is derived from the Greek word helios, meaning sun. Occasionally, if the yellow colour of the gem is deep enough, or contains some orange colour, the gem is also referred to as golden beryl. Goshenite, named after Goshen, Massachusetts where it was found, describes a beryl crystal or cut gemstone that is essentially colourless. All of the varieties of beryl owe their colour to trace impurities of another element; goshenite is the purest form of the species, and thus colourless.

The colour of green beryl does not have sufficient tone or saturation to be called an emerald, which is why this gem classified separately. It is no surprise that borderline emerald/green beryl gems

sometimes pose a challenge to determine. There is also a rare, red colour of beryl. This rare variety is sometimes called bixbite in the trade, after its discoverer, Maynard Bixby. (That nomenclature is discouraged because the name may be confused with bixbyite, a completely different, opaque, black mineral). Red beryl is not pastel coloured like other varieties but a strong, red colour, and generally very small – under one carat. Red beryl was discovered in Utah, USA, as rare, non-commercial crystals in the early 1900s, but it was only in the late 1950s that larger quantities were found. Red beryl remains unique to North America, and production is sporadic at best. It is a gem for collectors and connoisseurs.

Maxixe beryl, primarily found at the Piauí valley in the State of Minas Gerais, Brazil, are a medium to dark blue when mined and extracted from the earth, but the colours fade quickly upon exposure to light or heat. It is worth noting that some beryl materials can be treated by irradiation to resemble their natural colour Maxixe beryls; these stones, referred to as Maxixe-type also lose their rich

Other beryls

colour upon exposure to light. Much like red beryl has its followers, so too does Maxixe. Collectors take great pride in their collections of the deep blue beryl. But they only take them out of their dark containers every once in a while, to remind themselves of the beautiful, if ephemeral, deep blue colour.

Birthstones and anniversaries

Only emerald and aquamarine are considered to be birthstones and anniversary gems. Please consult the specific chapters for these gems for additional details.

Description and properties

Beryl forms in the hexagonal crystal system and has the following chemical composition: $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$.

Regarding colour ranges, green beryl (other than emerald) may be strongly bluish green to green to yellowish green (generally in lighter tones and saturations). Morganite may be reddish orange through slightly purplish red (generally in lighter tones and saturations). Yellow beryl may

be greenish yellow through orangey yellow (generally in lighter tones and saturations). Red beryl is far more saturated than morganite and Maxixe, and Maxixe-type, should be more saturated than aquamarine.

Refractive Index: 1.577 to 1.583 (± 0.017)

Birefringence: 0.005 to 0.009

Specific Gravity: 2.72 (+0.18, -0.05)

Cause(s) of colour: pink and red are caused by manganese; yellow is caused by iron; green is caused by chromium, vanadium and iron. Maxixe's colour is caused by unstable colour centres. Note: In Maxixe as well as Maxixe-type beryls, colour and optical behaviour can be restored through irradiation treatment, though the colour is also not stable.

Mohs Hardness: 7.5 to 8

Internal identifying characteristics:

The pastel coloured gems tend to have fewer inclusions than saturated varieties. Liquid fingerprints, two-phase inclusions and hollow growth tubes are possible in all varieties, sometimes causing chatoyancy (cat's eye effect).

Treatments:

Heating – Morganite responds to some heat treatment, by removing a yellow colour component and thereby rendering a deeper pink colour. The colour is considered stable.

Irradiation – Sometimes colourless beryl (goshenite) is irradiated to produce yellow beryl (heliodor). This colour is considered stable. Maxixe and Maxixe-type beryl is always irradiated, either naturally or in a laboratory, and its fading colour may be restored through irradiation. However, the colour fades anew with re-exposure to light and heat. Some colourless and light pink beryl from Minas Gerais is irradiated to produce Maxixe-type beryl.

Oil impregnation – While oils and polymer resins are rarely used with pastel colour beryl, colourless oil and resins are sometimes used to hide fissures in red beryl.

Collector quality

Large gems that exhibit a high degree of saturation are always in demand. Collectors often like to have all the varieties in a species. Other collectors prefer to specialize in rare gems, such as red beryl. Borderline gems (Is it emerald or green beryl?) also have admirers. Cat's eye beryl is rare and therefore collected.

Localities

Brazil produces much of the world's pastel coloured beryl – and Maxixe. Afghanistan, Pakistan, Russia, Ukraine, Madagascar, Nigeria, Namibia, Zimbabwe, United States also produce various kinds of beryl. Only the United States commercially produces red beryl.

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Other beryls

Cutting, care and cleaning

Beryl may be cut several different ways, though emerald cut and oval cut gems tend to predominate. Beryl is generally quite hardy unless heavily included. Red beryl tends to be more like emerald in this respect and may be fragile if the gem has many surface reaching fissures. For safety's sake, ultrasonic cleaners and steamers should be avoided. A dampened, non-abrasive cloth is best used to clean beryl jewellery.



Aside from emerald and red beryl, most other beryls are a pleasing array of pastel hues



This image displays the natural etched surface of beryl. Field of view: 0.72 mm



Rare, maxixe beryl fades to almost colourless upon exposure to light. Kept in the dark, it remains deep blue

Chalcedony



Cryptocrystalline quartzes, or chalcedony, can assume a wide range of appearances. Sometimes chalcedony and drusy quartz can be found in the same gemstone

History, lore and appreciation

Chalcedony is a significant form of microcrystalline (or cryptocrystalline) quartz, which has dozens of varieties and colours. Chalcedony has been enjoyed and used in jewellery for thousands of years. Some estimates gauge the use of chalcedony (in carvings such as seals) and other ornaments as far back as the Bronze Age, circa 1800 BCE. Though subject to interpretation, a more recent record for chalcedony dates back to the Israelites' exodus from Egypt (ca. 5-6th century BCE) where at least three varieties of chalcedony are described in the High Priest's Breastplate jasper, chrysoprase and sardonyx. Other agates were possibly also used.

Here is some of the principal chalcedony trade names used in jewellery today:

- **Agate** – The word "chalcedony" is sometimes used interchangeably with the word agate, though agate generally describes curved or angular-banded varieties of chalcedony.
- **Amethystine** – Semi-translucent to opaque purple colour.
- **Bloodstone** – A dark green semi-translucent to opaque cryptocrystalline quartz containing dark green body colour (coloured by actinolite) with deep red spots. It has also been referred to as heliotrope.
- **Carnelian** – Semi-transparent to translucent yellow orange to orangey red or brownish orange material.
- **Chrysocolla-in-chalcedony** – Translucent to semi-translucent intense light blue or blue green, owing its colour to chrysocolla, a copper silicate.
- **Chrysoprase** – Translucent to semi-translucent, light to medium yellowish green caused by nickel-related impurities.
- **Dendritic Agate** – Chalcedony containing dark, branch-like or tree-like inclusions.
- **Fire agate** – Semi-translucent to opaque botryoidal chalcedony with iridescent phenomena against a brown body colour.
- **Landscape agate** – A chalcedony, often with a layered structure, containing trace elements that add colour and inclusions (such as dendrites). Properly oriented during the cutting process, these agates resemble landscapes.
- **Iris agate** – A rare, semi-transparent to translucent agate, exhibiting phenomenal iridescent colours when light, especially pinpoint lighting, is transmitted through a slice of this material.
- **Jasper** – Translucent to opaque microcrystalline material, that may be any colour or combination of colours – except black.
- **Onyx** – Generally opaque, banded chalcedony. The parallel layers of chalcedony are black and white.

Chalcedony

- **Prase** – Semi-transparent to translucent green colour caused by mineral inclusions (e.g. actinolite, chlorite).
- **Sard** – Semi-transparent to translucent dark brownish red to brown or dark orange, but less saturated in colour than carnelian.
- **Sardonyx** – Semi-transparent to translucent dark brownish red to brown or dark orange, but less saturated in colour than carnelian, containing concentric white and reddish banded parallel layers.

Birthstones and anniversaries

Bloodstone is an alternate birthstone for the month of March. Onyx is suggested as a 7th wedding anniversary gemstone.

Description and properties

Chalcedony has a chemical composition of SiO_2 and forms as an aggregate material. Some chalcedony grows in a botryoidal formation.

Refractive Index: 1.535 to 1.539

Birefringence: usually not detectable.

Specific Gravity: 2.60 (+0.10, -0.50)

Cause(s) of colour:

Carnelian: Body colour due to iron impurities. Chromium may be present in redder colours.

Chrysocolla chalcedony: Colouration normally due to impurities of copper minerals.

Chrysoprase: Colouration normally due to nickel-related impurities.

Fire agate: Body colour due to iron impurities.

Sard: Body colour due to iron impurities. Chromium may be present in redder colours.

Mohs Hardness: 6.5 to 7

Internal identifying characteristics:

Inclusions of other minerals. Thick bands of colour often characterize chalcedony. Dendritic inclusions are seen in chalcedony as well.

Treatments:

Dyeing – Chalcedony can be dyed in practically all colours, due to its porous nature. Bleaching may be combined in the treatment process to remove colour. Much of the black chalcedony sold on the market is treated black. In banded material, some more porous bands may be dyed while others retain their natural colour.

Heating – Some yellow to brown material may be heat-treated to result in deeper red colours.

Collector quality

Chalcedony exhibiting unusual banding or landscape scenes is particularly prized, as are agates containing dramatic dendritic inclusions. Slabs of iris agates and cabochons or free form fashioning of fire agate exhibiting strong iridescent colours are also collected. Finally, carved chalcedony, such as intaglios or cameos, may be collectible if they have provenance that can be identified as typical of a certain era. Signed gems from a known lapidary artist are also collectible.

Localities

Germany (historical source), Brazil, India, Russia, Australia, Austria, Scotland, Italy, Mexico, USA.

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Chalcedony

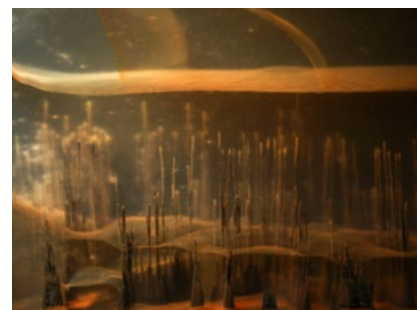
Cutting, care and cleaning

Chalcedony is a gem composed of cryptocrystalline and microcrystalline (microscopic) quartz crystals that form in tightly interlocking, fibrous masses. This provides chalcedony with extraordinary toughness, allowing it to be carved in cabochons, intaglios, cameos, tablets or even plates or bowls. Idar-Oberstein, twin cities in Germany, have been known for developing the cutting and carving industry for this gem since the 15th century. Artists there carved local chalcedony but began to import agate from Brazil in the 19th century as supplies dwindled in Germany.

Chalcedony is very durable in general, but special care should be taken not to subject it to temperature extremes. It may be cleaned in an ultrasonic cleaner, if it is clear and there are no fissures that could endanger the durability of the stone.

Chalcedony may be porous, so care must be taken not to immerse the gem in substances that could change its appearance. As with most gems, using a damp, soft cloth, or gently scrubbing with a soft-bristle toothbrush, is the best way to clean chalcedony.

Chalcedony often takes on the colour of the minerals contained in it and can sometimes be identified by its inclusions



Etch tubes were visible in this example of landscape agate (chalcedony). Field of view: 19 mm



Citrine



Citrine crystal with faceted citrines

History, lore and appreciation

The description for citrine is contained in its name. Citrine, from the French word citron literally means “lemon,” in deference to a multitude of rich yellow hues. There are several sources for the gem, and consequently the gem is readily available.

Citrine actually covers a much wider range of yellows than do most lemons, including rich, orangey yellow colours and deep orange. Some citrines may be reminiscent of a gem from a different species called topaz. There is no relation between topaz and citrine whatsoever, despite misnomers such as “smoky topaz”, “quartz-topaz” or “Madeira topaz” which are sometimes incorrectly used to describe a particular hue of citrine quartz. In fact, citrine has significant attributes of its own to stand upon: aside from its rich and optimistic colours, it is found in an impressive range of sizes and quantities, making it a favourite for gem carvers.

While citrine is found in nature, the majority of the gems used in jewellery began as amethyst, which has been heat-treated to change its colour. Citrine is greatly esteemed for its warm, earthy colours and vivacious sparkle, especially among lighter toned gems.

Birthstones and anniversaries

Citrine is one of the birthstones for November, along with topaz. It is also considered a 13th wedding anniversary gem.

Description and properties

Citrine is a variety of quartz that grows in the trigonal crystal system and has the following chemical composition: SiO_2 .

Colour(s): Citrine is transparent to translucent pale yellow to deep orange and/or brownish orange.

Refractive Index: 1.544 to 1.553

Birefringence: 0.009

Specific Gravity: 2.66 (+0.03, -0.02)

Cause(s) of colour: Traces of iron are the principal cause of yellow. Heat treatment of some amethyst under controlled conditions also causes yellow to brownish yellow colours.

Mohs Hardness: 7

Internal identifying characteristics:

Citrine is often devoid of eye-visible inclusions though some material may show colour zoning. In some cases, fluid inclusions and negative crystals may be seen. Inclusions of other minerals such as goethite or rutile can also be found in citrine.

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Citrine

Treatments

Most citrine starts out as amethyst that has been heat treated to turn it yellow to yellowish brown. Heat treatment of amethyst requires considerable experience, and not all amethyst responds in a manner that is expected. However, altered colour is considered stable.

Collector quality

Collectors of citrine look for a pure yellow or orange colour to begin with. Lapidaries (gem cutters) often work with citrine to make unusual carvings or cuts, which are also highly prized. Because ametrine – a form of quartz that combines the colours of amethyst and citrine – comes essentially from only one region in the world, it is collectible if the depth of colour and the division of colour is strong, or if it has been cleverly carved and fashioned.

Localities

Brazil is one of the main sources of citrine; particularly from the gem rich states of Minas Gerais and Rio Grande do Sul. Bolivia's Anahí mine has also become a leading producer of citrine. It is also found in Uruguay, as well as in African countries such as Tanzania, Madagascar, Namibia and Zambia.

Cutting, care and cleaning

Citrine is one of the most plentiful gems in the market. It can be found in many sizes. Citrine is often cut as large gems or in carvings. Citrine is also fairly resilient and may be worn extensively, though wearing citrine during any type of manual labour or strenuous activity should be avoided. Care should be taken not to knock the gem during use, as small fissures or cracks may develop, especially along facet junctions. It is best cleaned with warm, sudsy water or a damp cleaning cloth.



Citrine is available in a multitude of yellow tones from pale yellow to deep orange

Emerald



A perfectly hexagonal emerald crystal in calcite with pyrite



Emeralds, such as this one, are formed in a mica matrix

History, lore and appreciation

Emerald's appearance and colour make this gemstone instantly and universally recognized. The rich, green hue has also been the primary reason for the gemstone's tremendous popularity throughout history. In many instances, the word "emerald" is used to define saturated variations of green, such as the lush vegetation of the "emerald isle," or an "emerald green ocean." Marbode, the medieval poet and Bishop of Rennes, France, loved emerald's colour, causing him in 1120 CE to have observed the following:

"Of all green things, which the bounteous earth supplies, Nothing in greenness with the emerald vies."

Hundreds of years earlier, the naturalist Pliny the Elder (23 CE to 79 CE) declared his sentiments as well:

"We delight in feasting our eyes on the pleasant green grasses and leaves, but the enjoyment of beholding an emerald is incomparably greater, for its green is most soothing."

Pliny was one of the first to classify gemstones, including emerald. But appreciation for emerald was evident long before him. It is thought that emerald was first used as a gemstone circa 3500 BCE, and later during the first dynastic reigns in Egypt and so, conceivably for thousands of years, Egypt was the world's main emerald source. Actress Elizabeth Taylor, who played Queen Cleopatra on film, was equally enamoured with emerald as the Egyptian she portrayed. Aside from wearing magnificent emerald jewellery throughout her life, Taylor used the colour and popularity of emerald to once launch a perfume.

Emerald represents rebirth and eternal spring. Its colour denotes honesty, and integrity; finally, emerald has long been thought to be capable of soothing one's eyes. The Roman Emperor Nero is said to have watched gladiator fights through emerald slices for that very reason! However, that reference from Pliny the Elder's observations remains the subject of some debate today.

Birthstones and anniversaries

Emerald is the birthstone for the month of May. It is also considered a 20th wedding anniversary gem.

Description and properties

Emerald is a variety of the beryl species of minerals and has the following chemical formula: $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$

Beryl also includes the following gemstone varieties: aquamarine, morganite, red beryl, green beryl, heliodor and goshenite (Note: more about the beryl gem varieties in the chapters, Aquamarine and Other Beryls). Emerald (and other beryls) typically grows as hexagonal (six-sided) crystals.

Colour: Vibrant, deep green colour that is often described as very strongly bluish green through green.

Refractive Index: 1.577 to 1.583 (± 0.017)

Birefringence: 0.005 to 0.009

Specific Gravity: 2.72 (+0.18, -0.05)

Cause of colour: Chromium generally, sometimes vanadium and sometimes a combination of chromium and vanadium.

Emerald

Mohs Hardness: 7.5

Internal identifying characteristics: multi-phase inclusions, mica platelets, calcite, actinolite, and pyrite inclusions. In Colombian emeralds, jagged or blocky multi-phase inclusions are sometimes seen. A roiled appearance from columnar growth, called *gota de aceite*, which translates drop of oil, is a desirable trait some rare emeralds may exhibit. Inclusions in emerald are considered customary and expected. While gems with no eyevisible inclusions do exist, they are extraordinarily rare. Some inclusions in emerald are informally referred to as *jardin*, (meaning garden in both French and Spanish) and may consist of networks of tiny liquid filled inclusions and minute fissures that permeate the gem, lending it the appearance of a lush garden – hence the term. These inclusions also impart the emerald with a distinctive, somewhat hazy appearance because they diffuse and spread light through the gemstone. Included crystals, such as pyrite, are fascinating to examine through a microscope, and provide positive proof

of the gemstone's natural origin. Buyers should check for occasional larger fissures (especially those located at corners where a prong might be placed). Because of potential durability issues, such stones should be avoided.

Emerald is durable enough to bring joy to successive generations if handled with appropriate care. Conversely, lighter beryls, such as aquamarine and morganite, are very often eye-clean (viewed without magnification) even in sizes larger than 5 carats.

Treatments

The minute fissures that are often found in emerald lend themselves to a form of treatment aimed at diminishing or masking their appearance. These fissures often reach the surface and may be filled with substances including oils, resins and polymers. The manipulation of an emerald's appearance (other than cutting or fashioning) was first described by Pliny and as such has probably been practiced to varying degrees for centuries. Because introducing substances into emeralds may substantially change their appearance (and

perceived value) the presence of these kinds of treatments must be disclosed from the seller to the buyer along the supply chain. Special care considerations need to be explained as well because oils and some resins may seep out of the fissures, especially when subjected to heat or pressure. Others may oxidize over time so it becomes important for sellers to be able to offer services to clean and re-treat an emerald if so required.

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Collector quality

Deeply coloured, large, relatively clean and non-treated emeralds are rare and collectible. There are also two rare kinds of unusual collector emeralds that are rarely seen commercially:

Cat's eye – Green beryl that is saturated enough to be classified as emerald, and has microscopic hollow growth tubes that formed in a parallel fashion to one another throughout the gem. When cut en cabochon, the domed surface of these gems exhibits a rare cat's eye phenomenon in direct (non-diffused) lighting.

Trapiche – These Colombian emeralds display a unique six-fold structure, (similar to spokes on a bicycle wheel) usually composed of a dark hexagonal central prism surrounded by six crystallographically-controlled prisms separated by a mixture of albite and beryl containing either black carbonaceous shale (the host in which these emeralds form), or white albite (a form of feldspar) spokes. These gems are cut as slices or as cabochons to show the spokes radiating

Emerald

out from the centre. The name comes from the spokes in wheel-like sugar cane crushers, called trapiches, found in Colombia and other South American countries.

Localities

South America has been the world's primary source for emerald since the discovery of the New World. The Incas traded emerald throughout their Andean empire until the arrival of Spanish Conquistadors. But the Spanish discovery of emerald in Colombia in the 1500s dramatically changed appreciation for the gem. Egypt's and Austria's emerald sources were quickly forgotten as European and Indian nobility demanded Colombia's superb gems. This South American source quickly became the world's most significant producer of fine emerald, and remains significant today. However, many other sources are gaining importance, including Brazil, Zambia, Zimbabwe, Ethiopia, India, Nigeria, Madagascar, Pakistan, Afghanistan, Russia and China. Emerald has been found on the North American continent as well; Hidden, North

Carolina, is the U.S. historic emerald source, and some emerald material has also been discovered in the Yukon Territories, Canada. Neither location is commercially active, though rare collector gems are found from time to time.

Cutting, care and cleaning

Emerald is one of the few gemstones to have a specific cut named after it. The "emerald cut" is a square or rectangular outline step-cut with cut corners. Many emeralds are cut this way because it orients the gem to show its strongest colour and the tapered corners prevent damage during setting. These cuts contain large table facets through which an admirer can best view the emerald's rich colour and its fascinating inclusion panorama. Emerald is increasingly cut in other shapes, including round, oval, free form, pear and marquise. It is important to closely examine all pointed corners for durability issues. It might be recommended for such gems to be mounted in earrings, pins or pendants (rather than rings) to minimize potential damage to sharp points. Emerald

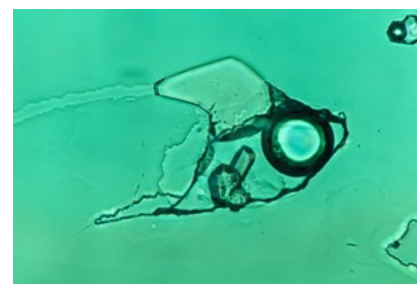
jewellery should not be cleaned in ultrasonic cleaning machines because the heat and vibration may damage or remove fillers. Emerald should not be immersed in detergents for similar reasons, and are best cleaned with a water-dampened, soft cloth. Common sense indicates it is not a good idea to wear an emerald ring during gardening or other intense physical activity.



While understood to be generally included, emeralds such as these can be quite clean



Trapiche emeralds are characterized by six spokes. Seen here are the front and back of the cabochon



Typical of many emerald formations are multiphase inclusions, such as this liquid, solid and gas inclusion in an Ethiopian emerald. Field of view: 0.288 mm

Feldspar group



One of the most complex yet plentiful minerals on earth, feldspar produces some rare gems such as moonstone and labradorite

History, lore and appreciation

Feldspar is an extremely diverse group of minerals that includes several species and varieties. Some varieties of feldspar possess unique optical phenomena. Feldspar is a common rock-forming mineral that is found on every continent. (It is estimated that feldspar makes up well over half of the earth's crust). However, feldspar also has gem varieties that have been sought after and revered for centuries. In India, for example, moonstone (a variety of adularic orthoclase feldspar, also referred to as adularia) has long been thought to be sacred. George Frederick Kunz, a famous gemmologist and consultant to Tiffany & Co. in the late 1800s, notes in his book, *The Curious Lore of Precious Stones*, that "As a gift for lovers the moonstone takes high rank, for it is believed to arouse the tender passion."

Under direct (and sometimes subdued) lighting conditions, moonstone exhibits adularescence, which is described as a "billowy" light effect observed along the gems' surface. In moonstone with a white body colour, "billowy blue" colour may

be seen. In other moonstones, asterism (4 rayed star), or cat's eye phenomena can sometimes be observed. Moonstone may have orangey, brownish, greyish or greenish body colour.

Not to be outdone in moonstone's celestial designation, another feldspar variety is called plagioclase sunstone. This gem often exhibits warm red to brown and yellow body colours, an allusion to the name. Its phenomenal nature, however, is equally captivating. When interacting with light, similarly oriented, miniscule inclusions of copper or hematite platelets exhibit glittering, spangled reflections, shimmering through different depths within the gem. This phenomenon is known in the trade as aventurescence.

Labradorite, named after the first place it was discovered – the Labrador Peninsula in Canada, is another plagioclase feldspar that has a phenomenal effect. In certain light conditions, a broad, multicoloured sheen appears to float along the gem's surface, particularly visible as the gem, or the light source, is moved. This iridescent effect is called labradorescence. In

recent years, andesine – a rare, albite-rich plagioclase feldspar has gained recognition. It began entering the market in surprising quantities in 2002. The material has been found to come from at least two known localities: Inner Mongolia and Tibet.

Microcline feldspar has one gem variety called amazonite, which is bluish green to green in colour, and may be semi-translucent to opaque. Though named after the Amazon, it has not been found there as a commercial source, but is found in other states in Brazil as well as in North America, Africa and Russia. The beauty and intrigue of amazonite is revealed under direct lighting, when a fibrous interlacing between green and white streaks can clearly be seen along the gem's surface. On rare occasions, the gemstone may also have a directional glittery effect, or sheen, under direct lighting, also caused by inclusions.

Gem feldspar occurs in non-phenomenal, transparent varieties as well, particularly in plagioclase, and orthoclase species. In this case, the body colour is generally yellow – but greenish yellow and

Feldspar group

colourless varieties occur as well. The colour of feldspar has much to do with its chemical makeup, trace elements and inclusions.

Birthstones and anniversaries

Moonstone is the birthstone for June, together with pearl and alexandrite.

Description and properties

Microcline feldspar (amazonite) forms in the triclinic crystal system; orthoclase feldspar (most moonstones and transparent varieties) in the monoclinic crystal system; plagioclase feldspars (oligoclase, labradorite and sunstones and transparent varieties) in the triclinic crystal system. For specific properties of each species or variety, see below.

Treatments

Treatments in feldspar are not generally common, though wax impregnation of tiny fissures that reach the surface of some amazonite has been reported as well as some impregnation in moonstone. This gives the gem a more uniform look. However, such treatment is not permanent and can be affected by heat and pressure. It has also been reported that some white microcline varieties may be irradiated to achieve deep blue-greenish colours associated with amazonite. In some instances, moonstone and transparent labradorite may be backed with a black coating to better exhibit their phenomenal characteristics. In loose gems, this treatment is easily discernible. Some pale andesine is treated by a complex diffusion process to achieve rich red and yellow colours similar to those found in sunstone.

Collector quality

Feldspars that exhibit double phenomena, such as adularescence and cat's eye, are collector's gems because of their rarity. Large gems and richness of colour also make them collectible. Although feldspar has perfect cleavage (can separate along planes of atomic growth in the crystal), and can be damaged during the fashioning process, they are sometimes carved.

Cutting, care and cleaning

Feldspar, when properly cared for, is durable enough to wear in jewellery, despite being somewhat brittle at times. Cutters, who properly understand the hardness and toughness of feldspar, often cut them as cabochons, which (unlike faceted gems) are less subject to abrasion. Additionally, cabochons are more likely to exhibit the phenomenal aspects of these gems. Some lapidary artists choose to carve these gems. Feldspar is somewhat delicate and care must be taken in setting.

Feldspar should never be placed in an ultrasonic cleaner. A clean, water dampened cloth, containing no soap or other cleaning agent, is the best way to clean this gem.

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Feldspar group

Microcline

Chemical Formula: KAlSi_3O_8

Colours: Amazonite is light green to greenish blue, white and rarely light orange or pink.

Refractive Index: 1.522 to 1.530 (± 0.004)

Birefringence: 0.008

Specific Gravity: 2.56 (± 0.02)

Cause(s) of colour: Amazonite – colour centres involving lead and water.

Mohs Hardness: 6 to 6.5

Localities: Amazonite is found in the United States, mainly in Colorado, but also in Madagascar, Myanmar (Burma), Brazil, Germany and Russia.

Orthoclase

Chemical Formula: KAlSi_3O_8

Colours: (Moonstone) is colourless to white, green, yellow brown or grey and rarely black

Refractive Index: 1.518 to 1.526 ($+0.010$)

Birefringence: 0.05 to 0.008

Specific Gravity: 2.58 (± 0.03)

Cause(s) of colour: Yellow is due to iron; adularescent colours due to scattering of light.

Mohs Hardness: 6 to 6.5

Internal identifying characteristics:

In moonstone, interesting inclusions with a "centipede" appearance may sometimes be seen. Such inclusions are considered identifying features for the gem.

Localities: Sri Lanka, India and Myanmar (Burma) are the major sources of moonstones. Canada, Mexico, Madagascar and the United States are major sources of transparent orthoclase.



Most sunstone contains inclusions, sometimes resulting in phenomena. These inclusions add that adds to the gems' appeal, whereas others like orthoclase yellow feldspar, are traditionally very clean



Orthoclase feldspar results in the very popular gemstone called moonstone, with soft "billowy" colours

Feldspar group

Plagioclase

Chemical Formula: $(\text{Na,Ca})\text{Al}_{1-2}\text{Si}_{2-3}\text{O}_8$

Colours: (Labradorite) grey to black bodycolour, colourless, green, yellow orange to brown or brownish red; (oligoclase) yellow to green as well as transparent.

Refractive Index: 1.559 to 1.568 (± 0.005) (labradorite), 1.537 to 1.547 ($+0.004$, -0.006) (oligoclase).

Birefringence: 0.007 to 0.10

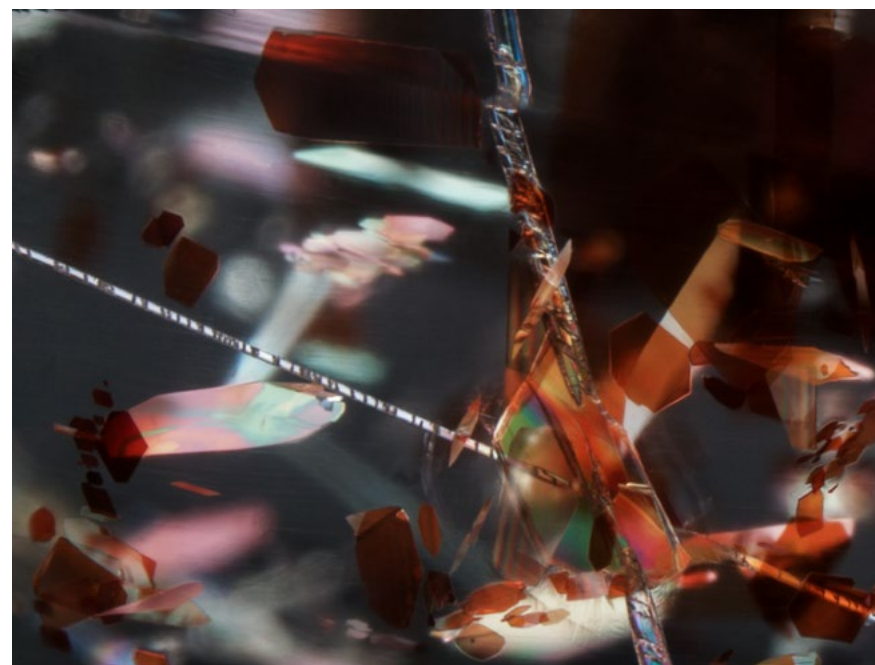
Specific Gravity: 2.70 (± 0.05) (labradorite), 2.65 ($+0.02$, -0.03) (oligoclase).

Cause(s) of colour: Sunstone: sheen colours, sometimes referred to as "aventurescence," are due to metallic-looking inclusions such as copper or hematite. Labradorescent colours are due to interference of light reflecting off finely layered structure.

Mohs Hardness: 6 to 6.5

Internal identifying characteristics:

The most important thing to remember is that the inclusions in feldspar are what provide some of them with their phenomenal characteristics. In sunstone from Oregon, colour is largely influenced by the copper content of the gems, and the spangled inclusions are themselves extremely small copper platelets. Sunstone from Africa contains different inclusions composed mainly of hematite and mica platelets, which also cause the aventurescent effect.



Hematite platelets like these can occur in oligoclase sunstone. Field of view: 2.88 mm

Garnet group



Spessartine garnet crystal cluster

History, lore and appreciation

Several colourful gemstone species and varieties are members of the garnet group. The diversity of garnet – principally in colour and appearance – places it among gemmology's most alluring subjects. These gems are found in variations of almost every hue, and are linked to one another by their common crystal growth structure and basic chemical composition. However, the optical, physical and chemical properties of some garnet species and varieties overlap, making it difficult even for gemmologists to pinpoint the distinct member of the garnet group.

Garnet has been appreciated for millennia. Historically, garnet was called "carbuncle," a reference to hot, glowing coals, to describe its blazing red colour. Most people think of garnet as red, and in fact the Latin derivation of the name reflects that. The phrase *malum granatum* refers to the striking resemblance some red garnet has to pomegranate seeds – especially rough garnet. Red garnet species include pyrope (from the Greek *pyropos*, meaning fiery) and almandine. Actually, most red garnet falls between pyrope and almandine in

composition. For example, a violetish red variation is known in the trade as rhodolite.

Garnet occurs in deep yellow and fiery orange colours as well. Spessartine garnet (sometimes called spessartite in the trade) is named after the region of Spessart, Germany where it was first found. A spessartine garnet locality in Namibia produced a glowing orangey gem in the early 1990s that has come to be known as a "mandarin" garnet in the trade.

Demantoid, a variety of andradite garnet, is bright green, though andradite garnet can also be yellowish or brown in colour. Demantoid derives its name from diamond, an allusion to the diamond-like lustre of this garnet. Rich red chrome-pyrope garnets are often found in association with diamonds during the mining process. Consequently, diamond miners think of garnets as "indicator minerals" in their search for diamonds.

Grossular garnet is principally known through the brilliant green tsavorite garnet. Green grossular garnet was first found in the 1960's in Tanzania, and later in Kenya not far from Tsavo National Park, after

which it acquired its trade name. An orange grossular variety, hessonite, sometimes with a characteristic roiled internal appearance, was widely used in the past and often known in the trade as cinnamon stone, alluding to its colour. Africa is the principal source of many garnets that are challenging to classify. Malaya garnet, is the trade name for a pinkish yellow, vivid orangey red variety of a mixture of pyrope-spessartine also found in the 1960's in Tanzania, and later in Kenya and Madagascar.

Garnet also has interesting phenomenal varieties, namely four, six and twelve-rayed star garnets. In New Mexico (and in Mexico) a form of andradite garnet displays incredible iridescent colours in bright light, known in the trade as rainbow andradite. Some East African garnets display remarkable alexandrite-like, colour-change characteristics. Similarly, some pyrope-spessartines change from grey or violetish blue in daylight, to deep, purplish red in incandescent light.

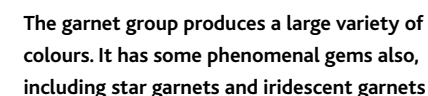
Garnet is the birthstone for January. While consumers sometimes believe they are limited to only red garnet, it is clear they can choose many different colours. Garnet is the gem of choice for a 2nd wedding anniversary.

Garnet belongs to a group of related silicate minerals that crystallize in the cubic crystal system. For specific properties of each species or variety, see garnet name below.

Garnet is one of the few gems that is rarely treated to enhance its colour or clarity. In rare instances, Russian demantoid (green andradite garnet) may be heated to enhance its colour. This treatment involves low heat so as not to damage the collectible "horsetail" inclusions.

Garnet has been used in jewellery since antiquity, especially as engraved gemstones, which are highly collectible. In red garnet, the size and pureness of colour is highly desirable. Green garnet is almost always small – gems over 3 carats are considered rare and are therefore collectible. Demantoid often has signature “horsetail” inclusions composed of chrysotile fibres. Clever cutters will attempt to leave such inclusions in the centre of the gem to exhibit a classic, collectible gem.

Garnet is generally somewhat susceptible to heat (and to some acids) so it is recommended that it be cleaned with a soft, non-abrasive, damp cloth. Garnet may abrade along facet junctions if scraped.



Garnet group

Almandine

Chemical Formula: $\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$

Colour(s): Reddish orange to red, slightly purplish red to reddish purple; typically dark in tone

Refractive Index: 1.790 (± 0.030)

Birefringence: None (singly refractive)

Specific Gravity: 4.05

Mohs Hardness: 7 to 7.5

Internal identifying characteristics:

In almandine, tiny, oriented rutile needles may be seen in clusters. These sometimes are prevalent enough throughout the gem to cause a star effect (asterism). Other types of included crystals are also found.

Cause(s) of Colour: Iron

Localities: India, Sri Lanka, Madagascar, Brazil, Greenland, Kenya, Pakistan, Tanzania, and the United States.

Andradite

Chemical Formula: $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$

Colour(s): Yellow, green, brown, black

Refractive Index: 1.888 ($+0.007$, -0.033)

Birefringence: None (singly refractive)

Specific Gravity: 3.84

Mohs Hardness: 6.5 to 7

Cause(s) of Colour: Iron and titanium (black); chromium (green), and in the case of demantoids from Namibia and Madagascar, lower concentrations of chromium and vanadium.

Localities: Italy, Korea, Russia (the classic source for demantoid), Iran, Madagascar, Pakistan, Namibia, Mexico and the United States (especially for the phenomenal iridescent variety).

Grossular

Chemical Formula: $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$

Colour(s): Light to dark green, light to dark yellow to reddish orange, colourless (rare); occasionally translucent to opaque pink (rosolite).

Refractive Index: 1.740 ($+0.020$, -0.010)

Birefringence: None (singly refractive)

Specific Gravity: 3.61 ($+0.12$, -0.04)

Mohs Hardness: 7 to 7.5

Cause(s) of Colour: Iron or vanadium with a trace of chromium. In tsavorite, a mix of chromium, and vanadium (green).

Localities: Sri Lanka, Kenya, Tanzania, Ethiopia, Mali, Namibia, Myanmar, Brazil, Canada, India and the United States.

Tsavorite garnet is known for its bright green colour, such as in this rare crystal. A relatively new stone, tsavorite was discovered in East Africa in the mid 1960s

Hydrogrossular

Chemical Formula: $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_{3-x}(\text{OH})_{4x}$

Colour(s): green to bluish green, pink, white, grey.

Refractive Index: 1.720 ($+0.010$, 0.050)

Birefringence: None (singly refractive)

Specific Gravity: 3.47 ($+0.08$, -0.032)

Mohs Hardness: 7.00

Cause(s) of Colour: Chromium and possibly iron, manganese.

Localities: South Africa, New Zealand, Canada, the United States, Myanmar (Burma) and China.



Garnet group

Malaya

Chemical Formula: $(\text{Mg,Mn})_3\text{Al}_2(\text{SiO}_4)_3$

Colour(s): Light to dark, slightly pinkish orange, reddish orange, yellowish orange.

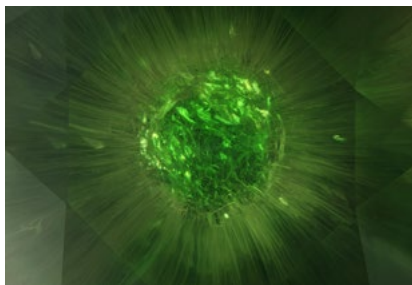
Refractive Index: 1.760 (+0.020, -0.018)

Birefringence: None (singly refractive)

Specific Gravity: 3.78 to 3.85

Mohs Hardness: 7 to 7.5

Localities: Tanzania, Kenya and Madagascar.



In this demantoid garnet from Russia, a characteristic radiating fibrous chrysotile inclusion is visible just under the table. Field of view: 14.52 mm

Pyrope

Chemical Formula: $\text{MgAl}_2(\text{SiO}_4)_3$

Colour(s): Medium to dark reddish orange, red through slightly purplish red, colourless (rare).

Refractive Index: 1.714 to over 1.742, 1.74 is normal

Birefringence: None (singly refractive)

Specific Gravity: 3.78 (+0.09, -0.16)

Mohs Hardness: 7 to 7.5

Internal identifying characteristics: In pyrope, tiny, oriented rutile needles may be seen in clusters. These sometimes are prevalent enough throughout the gem to cause a star effect (asterism). Other types of included crystals are also found.

Cause(s) of Colour: Iron, chromium.

Localities: Australia, Czech Republic (the classic source in the 1700-1800s), South Africa, Brazil, Mozambique, Madagascar, and the United States.

Rhodolite

Chemical Formula: $(\text{Mg,Fe})_3\text{Al}_2(\text{SiO}_4)_3$

Colour(s): Light to dark purplish red through reddish purple.

Refractive Index: 1.760 (+0.010, -0.020)

Birefringence: None (singly refractive)

Specific Gravity: 3.84 (± 0.10)

Mohs Hardness: 7 to 7.5

Internal identifying characteristics: In rhodolite, tiny, oriented rutile needles may be seen in clusters. These sometimes are prevalent enough throughout the gem to cause a star effect (asterism). Other types of included crystals are also found.

Cause(s) of Colour: Iron.

Localities: Sri Lanka, Tanzania, Kenya, Madagascar, Mozambique, Ethiopia, India and the United States.

Spessartine

Chemical Formula: $(\text{Mn}_3\text{Al}_2)(\text{SiO}_4)_3$

Colour(s): yellowish orange to reddish orange.

Refractive Index: 1.810 (+.004, -0.020)

Birefringence: None (singly refractive)

Specific Gravity: 4.15 (+ 0.05, -0.03)

Mohs Hardness: 7 to 7.5

Cause(s) of Colour: Manganese and iron.

Localities: Brazil, Sri Lanka, Nigeria, Kenya, Tanzania, Australia, India, Madagascar, and the United States.



Occasionally, colour change garnet is found, such as this rare pyrope/spessartine sample from Tanzania (shown in incandescent and daylight)

Jade and nephrite



A collection of jadeite jade

History, lore and appreciation

Jade is a blanket term essentially used to describe two types of gem-quality metamorphic rocks: jadeite jade and nephrite jade. (Henceforth, simply described as jadeite and nephrite). The name for jade (as it is known in the West) comes from the Spanish *piedra de hijada*, referring to the stones' shape as they were found, resembling kidneys. In China, appreciation and knowledge about both forms of jade far surpasses that of the West. Since approximately 5000 BCE, the word for jade-like materials, especially nephrite jade, is *yu*. It is often said that in China, the value and appreciation for jade surpasses that of gold and other gemstones. What the Chinese valued in nephrite was its incredible toughness; as such the gem was often carved into statues, sculptures, hollowed beads, bowls and weapons. The Chinese philosopher Confucius, who was born in 551 BCE, appreciated jade as well, and is widely quoted in regards to the gem:

"The wise liken jade to virtue. Its polish and brilliancy represents purity. Its extreme hardness is intelligence. Its angles, which do not cut, although they seem sharp, are justice. The pure and prolonged sound, which it sings when one strikes it, are music. Its colour is loyalty. Its iridescent brightness represents heaven."

When jadeite from Myanmar (Burma) became regularly traded with China in the 18th Century, it was an immediate success. China maintains an unparalleled affinity for jadeite, as well as for nephrite jades. Appreciation for jades in the Far East is, in fact, widespread. In Japan, jadeite was already known since the Jomon era, in 3500 BCE.

Enthusiasts of jadeite appreciate its vivid variety of colours including red, orange yellow, green, violet (lavender) and black. (Note: while blue jade is not found in Myanmar (Burma), very small quantities of blue Guatemalan jadeite have been found.) In Central America, one of the other historic sources of jadeite jade, the Mayas and Aztecs appreciated the gem for its hardness and colours as well since before 400 BCE. Today, deep colour and

relative transparency are the yardsticks by which both types of jade are measured. Translucent jadeite with a deep uniform green colour sometimes referred to as "Imperial jade," is especially coveted and collectively known in China as "fei cui".

Birthstones and anniversaries

Jade is considered a 12th wedding anniversary gemstone.

Jade and nephrite

Jadeite Jade

Description and properties

Chemical Composition: Polycrystalline aggregate composed mostly of jadeite that is a sodium aluminium silicate and member of the pyroxene mineral group. $\text{NaAlSi}_2\text{O}_6$

Colour(s): Appearance is semi-transparent to opaque often with mottled colours in white, green, yellow to reddish orange, brown, grey, black, light purple.

Refractive Index: 1.666 to 1.680 (± 0.008)

Birefringence: Usually not detectable

Specific Gravity: 3.34 (+0.06, -0.09)

Cause(s) of colour: In green jadeite: chromium (and /or iron). Iron is the main cause of colour in lavender, orange and brown jadeite.

Mohs Hardness: 6.5 to 7; toughness is exceptional.

Internal identifying characteristics: mottled colours, a granular (sugary) appearance in cracked or unfinished areas of a gemstone.

Treatments

Surface Waxing: Jadeite is sometimes cleaned in acids and neutralizing solutions, followed by boiling in water to clean off any residue. Next, it is dipped in wax as part of the polishing process. The wax enters tiny fissures and pits on the surface of the jadeite, giving the gem a more uniform appearance. Purely natural jadeite (or slightly waxed during polishing) is referred to as "A jade" in the trade.

Acid Bleaching / polymer impregnation: Jadeite with surface stains is submerged in acid to bleach the stains. The treatment causes jade to become more porous; a subsequent polymer resin impregnation renders the jadeite more evenly coloured and translucent. Treatment with acid followed by polymer resin impregnation is referred to as "B jade" in the trade.

Dyeing: Some jadeite is dyed after bleaching, using various colours. Some colours may fade over time, especially when exposed to strong light sources. As a final step, some jade is then polymer impregnated to make the surface appear homogenous. Such treatments result in jadeite that is referred to as "C jade" in the trade.

Heating: Some jadeite is heated in an effort to change their colour. Heating may lighten some overly dark greens or cause yellow staining to turn a deeper reddish colour.

Localities

The classic and most important source of jadeite is Myanmar (Burma), and it remains the principal producer of the gem today. Guatemala is another commercial source, though production is not as sustained as the Asian source. Japan, Russia and Uzbekistan are also sporadic sources of jadeite. Significantly, Burmese jade remains the classic standard by which other jadeite is compared.

Collector quality

Deep natural colour and the homogeneity of the colour plays a large role in the appreciation of jadeite jade. Deep green, translucent jadeite is revered and known in China as "fei cui", but apple green jade is also highly appreciated. Lavender jade is also popular and rare, while yellow, orange and greyish jade may contain unique symbolic meaning that is linked to their colour. While solid colours in a gem are always appreciated, mottled jadeite jade, where two or more colours can be seen, might be perceived as symbolic and highly coveted. Mottled jade is often used in carvings and they are frequently Chinese in origin because China has a long history of appreciation for jade.

Jade and nephrite

Cutting, care and cleaning

Jadeite is extremely durable – even though it doesn't rank as high as some other gems on the Mohs hardness scale. This is because of its extremely compact, fibrous and granular structure. Jadeite is vulnerable to strong acids and heat. However, assuming the colour is natural and untreated, it is safe for steaming and immersion in an ultrasonic cleaner. If it is not known whether the gem was treated, a soft bristle toothbrush or damp, non-abrasive cloth should be used for cleaning.

Nephrite Jade

Description and properties

Chemical Composition: Nephrite jade (henceforth simply nephrite) is an amphibole aggregate rock essentially composed by actinolite-tremolite (nephrite) $\text{Ca}_2(\text{Mg,Fe}_5\text{Si}_8\text{O}_{22}\text{OH})_2$

Colour(s): Nephrite can be transparent to opaque, creamy, often with mottled colours in light to dark green, yellow to brown, white, grey, black.

Refractive Index: 1.606 to 1.632 (+0.009, 0.006)

Birefringence: Usually not detectable

Specific Gravity: 2.95 (+0.15, -0.05)

Cause(s) of colour: iron is the cause of many colours.

Mohs Hardness: 6 to 6.5 hardness; toughness is exceptional, exceeding that of jadeite jade.

Treatments

Dyeing: Some nephrite is impregnated with dye to improve its colour, though the treatment is considered rare.

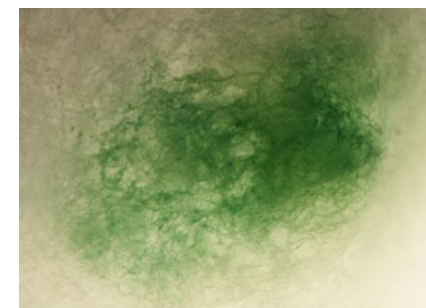
Surface waxing: Some nephrite may be treated with paraffin to conceal surface irregularities (such as cracks or fissures) in the gem.

Heating: Sometimes heating can lighten overly dark colours of nephrite.

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Localities

China is the classic source for nephrite, but it is found on almost all continents. Other important sources include Canada, New Zealand, South Korea, the United States, Russia and Australia.



Since colour is critical in judging the value of jadeite, it is important to examine samples carefully. Here, a green colour concentration (dye) is seen inside the structure of treated jadeite

Jade and nephrite

Collector quality

Nephrite with strong natural colours as well as materials that are carved into symbols are meaningful to collectors. So, too, are sophisticated carvings. Because of its durability, clever carvings that exhibit a three-dimensional object (such as a hollow bead in which jade material had to be carved out) are also objects of desire. China has a long history of appreciation for jade. The pure white varieties, known in the trade as “mutton fat jade”, are highly appreciated, particularly in historically relevant artefacts.

Cutting, care and cleaning

Nephrite is extremely durable – even though it doesn’t rank as high as some other gems on the Mohs hardness scale. This is because of its extremely compact, fibrous and sometimes granular structure. Nephrite is vulnerable to strong acids and heat. However, assuming the colour is natural and untreated, it is safe for steaming and immersion in an ultrasonic cleaner. If it is not known whether the gem was treated, a soft bristle toothbrush or damp, non-abrasive cloth should be used for cleaning.

Nephrite is extremely tough and durable. Aside from fashioning it into gems for traditional use in jewellery, it can also be fashioned into extremely intricate, pierced carvings. Nephrite has a long history of appreciation in Asia where it was once considered more valuable than precious metals.



A collection of nephrite jade

Kunzite



Kunzite typically has an etched morphology along its crystal faces

History, lore and appreciation

Delicacy and subtlety of colour are this gem's most notable attributes, making it an excellent choice for eveningwear, where its understated pink to lilac colour flashes can be divined and admired even at a distance. Rarity also lends this gem an added sense of exclusivity. It is not widespread enough to be known by all gem aficionados, but those who have developed a passion for it are quick to extol its virtues. Kunzite, while rare, may still be found as large crystals that are excellent candidates for jewellery designs that feature large and impressive centre stones.

This gemstone was first discovered near Pala, in California's San Diego County, in 1902. Crystals were sent for identification to America's top gem expert, George Frederick Kunz, a notable jeweller, author and gemmologist based at Tiffany & Co. at the time. In a report about the new gem, Kunz wrote: "As this is an entirely new gem of a peculiar beauty, a name will be given to it as soon as its characteristics are definitely determined." As it happened, the gem variety was soon

named after him. It was also determined that the gem was a variety of the mineral spodumene, a source for lithium which was often used for industrial purposes. Certainly spodumene, as it had been found till then, hardly qualified for use as a gemstone. But the delicate pinks, lilacs, and deep purples, were greatly appreciated for those hues, definitely classifying kunzite as a gem. Kunzite has since been found in several other localities around the world. A very rare green spodumene comprises a different variety of the species. It is a chromium-bearing variety, called hiddenite, named after its locality in Hidden, North Carolina, USA. Brazil, and India produce some of this green material also.

Birthstones and anniversaries

Kunzite is not used as birthstone, though Kunz at one time suggested kunzite as an alternate American birthstone for the month of September, in his book *The Curious Lore of Precious Stones* (1913).

Description and properties

Kunzite is a variety of the mineral spodumene that forms in the monoclinic crystal system.

Chemical composition: $\text{LiAlSi}_2\text{O}_6$

Colour(s): Light in tone, pink to bluish purple.

Refractive Index: 1.660 to 1.676 (± 0.005)

Birefringence: 0.014 to 0.016

Specific Gravity: 3.18 (± 0.03)

Cause(s) of colour: Manganese.

Mohs Hardness: 6.5 to 7

Internal identifying characteristics:

Kunzite rarely has inclusions, but being of pegmatitic origin, sometimes has a few fluid inclusions. However, kunzite has perfect cleavage, meaning it has a tendency to break or split in certain directions due to its crystal structure.

Kunzite

Treatments

Irradiation may produce pink or deeper pink colours from colourless to pink varieties of spodumene. Kunzite's colour, including irradiated colour, is susceptible to fading upon prolonged exposure to light.

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Collector quality

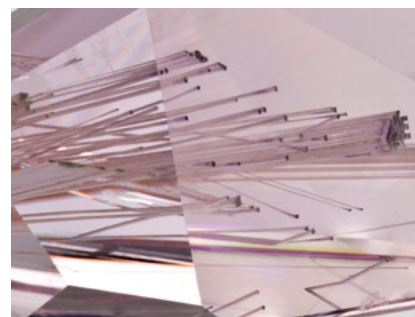
Because kunzite is often thought of as a uniquely American gemstone (though they are also mined elsewhere), gems from the Pala district possess a unique provenance, especially since they were named after a famous American. Depth of colour, especially in rich magenta coloured gems, is appreciated.

Localities

The United States (the classic source), Afghanistan, Myanmar (Burma), Brazil and Madagascar.

Cutting, care and cleaning

Kunzite is often fashioned into large, step cut gems and rarely carved because of its directional cleavage. Care must be taken, especially with gems set in rings, because they tend to absorb the most physical impact. Kunzite should not be cleaned in an ultrasonic cleaner. It is best to use a damp, non-abrasive cloth to clean them. Because of its susceptibility to fade upon prolonged exposure to bright light, kunzite should be kept in a dark storage container when not in use.



Occasionally needles of a different mineral, such as gypsum, are visible in kunzite



This selection of kunzite shows a variety of tones in the gems

Lapis lazuli



Lapis lazuli exhibits its three principal components that are eye-visible; lazurite, calcite and pyrite

History, lore and appreciation

Technically, lapis lazuli is a rock since several minerals combine to form it, with lazurite being its principal component, and giving the material its deep blue colour. It is, in fact lapis lazuli's intense blue colour, at times flecked with white calcite and golden coloured pyrite crystals that has captivated people's attention for thousands of years. The Assyrians and Babylonians prized lapis lazuli for use as carved seals. It was used throughout many of Egypt's dynasties, and was referred to by them as "heaven's stone." Pharaoh Cleopatra VII had a particular affinity for it; aside from using it in jewellery and as an inlay for artefacts, she had it (or lazurite crystals from the same source) ground into a powder, which could then be emulsified for use as eye shadow makeup. Further, it was used as a blue pigment (called ultramarine) for many centuries. It is thought that lapis lazuli was one of twelve gems that comprised the High Priest's Breastplate – mentioned in the Book of Exodus – an account of when the Israelites left Egypt. Lapis Lazuli, which has long been mined in Afghanistan in an area travelled by merchants along the ancient

Silk Road, spread appreciation for the blue gem in the Far East as well. Interestingly, the material was long described as *sapphirus*, meaning that what was known as such in ancient times was lapis lazuli – and not sapphire. An example is Pliny the Elder who used the word *sapphirus* in describing a blue gemstone with golden spots. Actually, lapis lazuli is thought to come from the Latin lapis, stone, and Persian *lajevard*, blue stone, literally meaning "stone blue stone". It was first used with this meaning in the 17th century. It is important to bear in mind that, as far as blue gems were concerned, lapis lazuli was the blue gem to covet and cherish, long before blue sapphire came to be appreciated in the West. Today, lapis lazuli is valued as a bold ornamental gem that can be beaded, fashioned into cabochons, polished for inlays and carved.

Birthstones and anniversaries

While lapis lazuli is not mentioned as a birthstone in modern lists, it was once suggested as an alternate gem for the month of December, together with turquoise. It is considered a 9th wedding anniversary gemstone.

Description and properties

A rock composed primarily of lazurite, calcite and pyrite. It may also contain haüynite, sodalite, and diopside.

Colour(s): Medium to dark, slightly greenish blue to purplish blue, often containing metallic looking pyrite crystals and/or white to grey flecks of calcite.

Refractive Index: 1.50 or 1.67 (with lots of calcite); it can be challenging to obtain a refractive index reading for lapis lazuli.

Birefringence: None

Specific Gravity: 2.75 (± 0.25) (This may vary due to mineral content).

Cause(s) of colour: In lazurite, sulphur-related colour centres.

Mohs Hardness: 5 to 6 (variations due to composition).

Internal identifying characteristics: randomly scattered pyrite crystals (that appear as yellow metallic flecks) and mottled white calcite crystals.

Lapis lazuli

Treatments

Dyeing: Lapis lazuli, which is naturally porous, is easily dyed to deepen the colour and give the stone a more uniform appearance.

Coating or impregnation: This treatment using colourless paraffin, wax or resins sometimes follows dyeing in an attempt to seal the gem surface, continue to deepen the colour and help improve its polish.

Oiling: Some lapis lazuli may be treated with oil in an attempt to deepen its colour.

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Collector quality

Lapis lazuli that is naturally deep and uniformly blue in colour, is the most collectible form of the gem material. Care must be taken to determine it has been dyed. If so, it is not considered collectible quality. Some collectors appreciate a discreet spray of pyrite crystals, which serve as further proof of the gem's natural origin, though calcite's mottled white flecks are not as well appreciated. Because of lapis lazuli's ancient past, jewels with known provenance are considered collectible. Carvings, seals, inlays and intaglios that have been fashioned by known artists are also collectible.

Localities

Afghanistan's mountainous North-eastern area of Badakhshan, notably in Sar-e-Sang, is the world's most famous locality. It still produces the standard qualities by which other sources are compared. Deposits in Iran, Chile and Russia produce lighter, less saturated varieties of lapis lazuli.

Cutting, care and cleaning

Lapis lazuli is generally cut in the form of cabochons or tablets, and these cuts wear well since they have no sharp edges to abrade. Beads also wear well for the same reason. Free form cuts and carvings of lapis lazuli are also popular. A soft damp cloth is ideal for cleaning the gem and because it is naturally porous, lapis lazuli should be kept away from substances that could permeate the gem's surface. Nail polish remover (acetone) and other chemicals may damage dyed material.

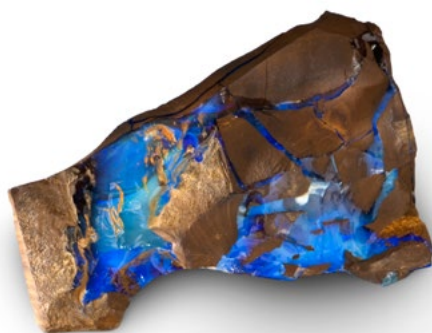


Lapis lazuli is sometimes used ornamentally

Lapis lazuli is often fashioned as cabochon material for use in jewellery

This photo-micrograph clearly shows the lazurite, pyrite and calcite that make up this gem material

Opal



Opal seams are clearly visible in this ironstone matrix from Australia

History, lore and appreciation

The name opal likely derives from the Latin word *opalus*, and was mentioned in Pliny the Elder's *Natural History*, though some scholars point to ancient Sanskrit descriptions, and the root word, *upala*. Human fascination for the gemstone is due to some of its principal features: its phenomenal nature and extraordinary range of hues. In the numerous varieties of opal, many spectral colours can be enjoyed within a single gem. It is this colourful complexity about opal that caused naturalist Pliny the Elder – in the first century CE, to write following:

"There is in them a softer fire than the ruby, there is the brilliant purple of the amethyst, and the sea green of the emerald, all shining together in incredible union. Some by their splendour rival the colours of the painters, others the flame of burning sulphur or of fire quickened by oil."

In 1550, Italy's brilliant mathematician and naturalist, Girolamo Cardano, noted in his monograph, *De Subtilitate Rerum*, (The Subtlety of Things), a study of natural phenomena, that he had once bought [an opal] for fifteen gold crowns. His enthusiastic observation was that, compared to a diamond costing him thirty-three times as much, the opal had brought him much greater pleasure. Part of his enchantment may have been that one opal never looks like another because play-of-colour patterns change from gem to gem. Like the people who wear them, each opal is unique.

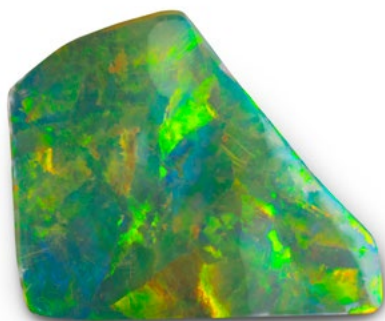
Other writers have invoked opal as well. Shakespeare alludes to the changeable nature of opal in his play, *Twelfth Night*, when he contrasts the versatile personality of one of its characters to the gem. He also described opal as "the queen of gems."

Opal's phenomenal nature has clearly brought enjoyment to many, but it has also evoked unwarranted superstitions. Because of a work of fiction by Sir Walter Scott, "Anne of Geierstein" written in 1829, attributing "enchanted powers" to an opal, some readers mistakenly began to think of opal as an unlucky gem. In the century elapsed since then, opal has regained its rightful reputation as an adaptable gem of beauty. In Australia, where the vast majority of the world's opal is mined, the gem – especially black opal – is in fact perceived as lucky. Australian aborigines, for example, attributed opal's discovery with the simultaneous, and fortuitous discovery of how fire can be tamed and utilised.

There are two broad classes of opal: precious and common. While fiery colours – and play-of-colour has always been precious opal's principal asset, common opals can be colourless, composed of a single body colour, or be opaque, translucent or transparent with no play-of-colour.

Opal

During opal formation, silica may substitute or replace an organic host, taking on some of its physical characteristics. As such, opal may form as fossils by replacing clam shells, snails, bones, trees or branches, and in the hollow inside joints of bamboo stalks. Here, the opal takes on the outward appearance of the item it replaced. However, most opal forms in seams or cracks within harder rocks such as sandstone, basalt, ironstone, quartzite or rhyolite.



A large, free-form carving of opal

It is not surprising that there are several dozen types or varieties of opal, not all of which can be described here. The main commercial varieties are:

White opal: Translucent to semi-translucent opal, with play-of-colour against a white or light body colour.

Black opal: Translucent to opaque opal, with play-of-colour against black, grey, blue, green or brown body colour.

Crystal opal: Transparent to semi-transparent gem opal that has an essentially colourless body colour, but often shows play of colour.

Fire opal: Transparent to semi-transparent opal with a range of light yellow to deep orange body colour. These gems may have play-of-colour or none at all.

Jelly opal: Transparent to semi-transparent light to orangey-coloured opal and exhibits no play-of-colour.

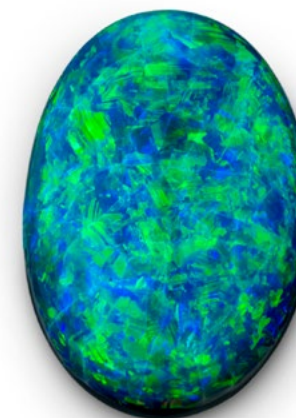
Contra-luz opal: Transparent opal that shows play-of-colour when light is transmitted through it. Mexican opal often shows this characteristic. The Spanish words *contra luz* literally translate to “against light.”

Boulder opal: An opal seam in the matrix host rock where it formed, namely ironstone. These can be very thin but still exhibit extraordinary play-of-colour.

Moss opal: Translucent to opaque opal with no play-of-colour that contains dendrite inclusions of another mineral or of oxides that cause a moss or fern-like appearance within the gem.

Oolitic opal: Opal that contains very small dark black or brown spherical areas that looks like fish roe in appearance. This material has play-of-colour.

Hydrophane: An absorbent variety of opal that may have play-of-colour. Some material may appear as common opal when dry, but which develops play-of-colour phenomena when immersed in liquid.



This is a black opal cabochon from Australia



Some opal are devoid of phenomena but are desirable for their strong body color, such as in these opals from Peru

Opal

Birthstones and anniversaries

Opal is one of the birthstones for the month of October, along with tourmaline. Opal is also considered an appropriate gift to commemorate a 14th wedding anniversary.

Description and properties

Opal is an amorphous or poorly crystallized material, essentially composed of hydrated silica with the following composition: $\text{SiO}_2 \cdot n\text{H}_2\text{O}$. Tightly packed and arranged, microscopic spheres of silica, of which opal is composed, cause play-of-colour. Light reflecting off of, and passing through these packed spheres, frequently causes interference and diffraction of light, which we are able to perceive as play-of-colour. This phenomenon may be compared to rainbows, which form as light passes through water droplets in air. While opal may be essentially colourless to light orange, it can still have play-of-colour that is revealed as the gem catches the light.

Colour(s): Many colours are seen in opal. Body colours can vary from white to dark blue and to black, with brown, red orange in between. In recent years, translucent, vivid greenish blue, as well as pink common opal varieties have been discovered in Peru, Mexico and France. A milky, green opal found in Tanzania is called prase opal due to its similarity to the chalcedony variety of prase. Because these gems have no play-of-colour, but are attractive for the body colour they exhibit, they are often faceted or cut as cabochon gems or beads. Opal may be transparent to opaque; most opal is translucent.

Refractive Index: 1.450 (+0.020, -0.080) Mexican opal may have lower readings, (1.37 to 1.43).

Birefringence: None

Specific Gravity: 2.15 (+0.08, -0.90).

Cause(s) of colour: Diffraction-grating related interference colours, as seen as play-of-colour, caused by the arrangement of tiny spheres of silica. In green opal, it is caused by nickel impurities, in blue opal by copper and chrysocolla and in pink opal by organic substances.

Mohs Hardness: 5 to 6.5

Internal identifying characteristics: Occasionally, small amounts of matrix, brown ironstone, can be seen through thin seams in boulder opal. Consequently, opal often contains elements of the environment in which they formed. Pyrite, hematite and other minerals may occur as stain plumes or tiny, included crystals. Two and three phase inclusions are rare but may occur. Cristobalite inclusions are common in Mexican opal.

Treatments

There are several opal treatments. Most are designed to stabilize the gem, deepen the colour, or cause the play-of-colour to stand out against a darker body colour.

Impregnation with oils, wax or polymers: may be used to improve play-of-colour and mask the effects of crazing.

Dyeing: Causes lighter opal to look like darker, more-valuable black opal.

Sugar impregnation and smoke treatment: Creates the appearance of black opal.

Black paint backing: darkens the gem improving the appearance of play-of-colour.

Opal doublet or triplet: While not within the classic definition of treatments, doublets constitute an artificial product, a composite stone, taken to make thin seams of opal usable in jewellery. A doublet is a thin, natural opal slice that is glued to a strong black substrate, such as dyed black chalcedony. Some glued slices are then capped with transparent quartz cabochons in an effort to protect the thin seam of opal. Two separate materials glued together are called doublets. If a third cap is also used, it is considered a triplet. These assembled stones may also exhibit strong displays of play-of-colour.

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Opal

Collector quality

Collectors prize solid opal (without matrix or backing of the host rock) that displays strong play-of-colour, especially in dark body colours. Collectors look for patterns such as "harlequin", which shows large areas of different colours with straight boundaries when the gem or light source is moved; "pinfire," which exhibits tiny flashes of multi-colour patches. Many other terms apply to different colour patterns (e.g. block, Chinese writing, flagstone, jigsaw, peacock tail, ribbon, straw and stripes, are but a few). White precious opal can also show the above-mentioned characteristics. Contraluz opals are also collected because of their relative rarity, and because of their dramatic reactions to light. There are collectors of ironstone-opal nodules from Yowah, an Australian locality. "Yowah nuts" are highly contrasting, large roundish opals, which formed within dark ironstone matrix. In fact, there is a growing appreciation for boulder opals, due to their strongly contrasting hues and play-of-colour. Pink, blue and green opal is rare and therefore collectible as well.

Localities

Australia produces most of the world's opal, and some of the finest come from a locality called Lightning Ridge. In the 1950s L. Hudson, a postmaster for the region, wrote a poem describing the area, part of which follows:

There's a sleepy little township, out beyond the western plains,

Lightning Ridge, the town of opal, where there's heat and scanty rains. The location is not scenic, just rough ridges all around

Nature sired her scenes of beauty, in black opal, underground.

Several other Australian localities: Opal is mined in Coober Pedy, Andamooka, Mintabie and many occurrences in Queensland, especially for boulder opal, notably in Yowah and Koroit. Opals have been found since early Roman times in today's Slovakia. Today it is found also in the United States, Mexico, Brazil, Peru, Honduras, Tanzania, Kenya, Ethiopia (especially hydrophane opal) and Indonesia.

Cutting, care and cleaning

Because of its water content, opal is sensitive to heat and temperature changes. Opal may develop a network of tiny fissures over time, or if subjected to heat or pressure. These fissures are referred to as "crazing" in the trade. Because opal is delicate, they require gentle, loving care. Opal is rarely faceted because the facet edges and junctions are prone to abrasion.

Most are cut en cabochon, which avoids abrasion along sharp edges. Although some Mexican, Peruvian and crystal opal is faceted and tends to exhibit a sleepy, milky appearance on colourless or coloured body colour. Cabochons are the main canvas upon which to best exhibit opal's play-of-colour. Dampened soft fabrics with no abrasive or chemical additives, or a soft bristle toothbrush doused with water are the best ways to clean opal jewellery. Gemmologists advise against storing opal in a dry environment to avoid crazing.



Opal comes from all over the world and manifests in a multitude of body colours with varying degrees of play-of-colour

Organic and biogenic gem materials



Pearl remains among the most important biogenic gem products in jewellery

History, lore and appreciation

People have adorned themselves with gem materials long before recorded history began. Prehistoric people probably did so with organic and biogenic materials to begin with – because they were likely a side product of hunting, fishing and gathering during human evolution. CIBJO recognizes a general collective name for all gem materials of biological origin: biogenic gem materials; and there distinguishes one group of materials essentially composed by organic matter or organic molecules: organic gem materials (e.g. ivory, tortoiseshell, bone, copal). Pearls, cultured pearls, mother-of-pearl and precious coral because are essentially composed of biomineralized calcium carbonate, are better described simply as biogenic gems. Others, like amber and jet, are better described as fossils.

There is great appreciation for these gem materials, even today, because of this tie to life, and also because of their inherent beauty. As an example, amber's heritage as a fossilised tree resin, results in the golden coloured gems we love today. It is also treasured because it typically formed between 10 and 90 million years ago, depending on the geological deposit where it is found. Some amber can date back 345 and 146 million years. Ancient Greeks believed that amber gems were tears shed by the gods, while others believed amber to be fragments of the setting sun. Entrapped insects and other animals occasionally found in amber dispelled those notions. Today, such fossil inclusions are sought after and prized because they offer a fascinating glimpse into a vanished world. Another form of hardened tree resin is called copal. Copal formed much more recently, and is sometimes referred to as immature, or pre-fossilized amber. Determinations between amber and copal are often made based upon their geologic settings. Copal is more susceptible to certain solvents than older ambers as it contains much more volatiles in its composition.

Humans are equally linked to the oceans through pearls, shell, precious coral and tortoiseshell. As jewellery products of the early 20th century, cultured pearls come in many shapes, sizes, textures and colours, and are easily put to use in design concepts. In recent years, the explosion of technology in freshwater cultured pearl growth, mainly in China, has added greatly to the choices that jewellers have. High quality natural pearls, at one time valued over diamonds, remain a very rare biogenic gem material.

Since 1975, CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), also known as The Washington Convention, regulates the trade in materials of biological origin in the wild. There are three levels of protection, or Appendixes (I, II and III). Some species that give rise to gem materials are listed in CITES with different levels of protection, including elephants, rhinoceros, hippopotamus, narwhals, sperm whales, walrus, sea turtles, blue coral and black coral. This information is updated every three years by CITES.

Organic and biogenic gem materials

Finally, it should be noted that several other – though rarely used – organic materials are sometimes used in jewellery, though they will not be discussed in this Guide. These include rhinoceros horn, hippopotamus tooth, hornbill ivory, wild boar ivory, narwhal tusk, bone and deer antlers. Ivory nut palms (also called tagua nuts) are sometimes used as a substitute for animal ivory.

During the 17th and 18th centuries, and through the Victorian era, a black material called jet was used. It is a fossilized wood found principally in Whitby, England. It is considered a fossil rather than an organic gem material. Queen Victoria famously used jet in mourning jewellery. Human hair, another organic substance, was also woven and used in jewellery during the Victorian Era.

Cutting, care and cleaning

Most organic and biogenic gem materials are fashioned as cabochons, carvings, cameos or rounded or free-form beads, and are rarely faceted. Ivory may be carved into very delicate, intricate, detailed carvings, and objects of art, particularly in Eastern Asia. While rings using organic materials are used, the user must take special care.

Avoid rough handling, heat and chemicals for all organic and biogenic materials. They are soft, occasionally brittle, and porous enough to be damaged easily. Cleaning may be performed using a dampened cloth or a moistened soft bristle toothbrush. Beads strung on silk should not be soaked in water, as this will cause the cord to stretch.

Description and properties

Straightforwardly defined, an organic or biogenic gem is a gem material produced by, or derived from, a living organism from either the plant or animal kingdoms. For specific properties of each organic and biogenic gem, see below.



Due to protections for the species, tortoiseshell is generally only found in antique jewellery, combs or objects of art

Organic and biogenic gem materials

Amber

Description and properties

Refractive Index: 1.540 (+0.005, -0.001)

Birefringence: none

Specific Gravity: 1.08 (+0.02, -0.08)

Cause(s) of colour: Impurities and organic substances cause colours (yellow, orange and brown). Green and blue colours in amber are perceived due to strong fluorescence in some amber from the Dominican Republic.

Mohs Hardness: 2 to 2.5

Identifying characteristics: Two-phase inclusions containing gas and liquid, flow lines, inorganic inclusions, insects and other arthropods, and small animals such as lizards. Heating amber may alter their appearance.

Treatments

Heating in low temperature is used to modify clarity, alter colour and may cause some inclusions to expand, creating spangled, disc-like inclusions, known in the trade as sun spangles or sun sparks. Amber is sometimes dyed to add a darker tone to lighter materials.

Collector quality

Strong colours in amber are considered collector items, as is any amber containing unusual insects. Entomologists seeking to understand a bygone world often collect these amber samples for further study. Size is a factor in evaluating amber, especially in combination with fine colours. Gems containing interesting inclusions are highly collectible.

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Localities

Dominican Republic, Baltic Sea (bordering Germany, Poland and Russia), Ukraine, Mexico, Myanmar, Italy and Ethiopia.



Small insects, such as this millipede and an ant were captured during the formation of this Colombian copal. Field of view: 52 mm



Amber and copal sometimes contain insects or other small creatures that are highly collectible

Organic and biogenic gem materials

Precious Coral

Description and properties

CIBJO describes as precious corals those that are used in jewellery and decoration, specifically red, pink and white varieties with porcelaneous lustre after polishing. They are limited to a few species belonging to the Corallidae family, consisting of the three following groups: *Corallium rubrum* (Mediterranean, Sardinian), *Pleurocorallium secundum* (Midway, Rosato or White/Pink), *Pleurocorallium elatius* (salmon to red-coloured: Cerasuolo, Momo, Satsuma; flesh pink-coloured: Angel's Skin, Boké, Magai, Pelle d'Angello), *Hemicorallium regale* ("garnet" coral), *Hemicorallium laauense* (Deep Sea or Shinkai), *Hemicorallium sulcatum* (Missu) and *Corallium japonicum* (oxblood coral, Aka, Moro). They live in deeper waters and are harvested below 50 metres.

CIBJO distinguishes with other coral species not considered precious, such as the reef building species that live in shallow waters and that face threats from climate change and ocean acidification, and the so-called common corals, that are mostly of calcareous type, usually found in the coral reef, and some of with soft skeletons e.g., sponge coral, bamboo coral, black coral, golden cora and blue coral. After treatment, some species may be used in jewellery and ornaments.

Currently, four species of precious coral are listed on CITES Appendix III for monitoring: *Corallium elatius*, *Corallium japonicum*, *Corallium konojoi* and *Corallium secundum*.

Refractive Index: 1.486 to 1.658

Birefringence: 0.172

Specific Gravity: 2.65 (± 0.05)

Cause(s) of colour: (Red, pink, orange, white, occasionally spotted or variegated). Organic molecules are the main cause of the colour in coral.

Mohs Hardness: 3 to 4

Identifying characteristics: tubular or fibrous structure, colour variegation.

Treatments

Precious coral is routinely surface waxed with a colourless substance, sometimes oiled, a practice that is considered a normal part of the lapidary process. Other treatments such as bleaching, heating, dying, coating, fracture or cavity filling are occasionally reported.



Coral has been used in human adornment for millennia, mainly because of its vibrant color and because, once fashioned, takes on an appealing polish

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Organic and biogenic gem materials

Collector quality

Depending on the species, there are different quality factors. Usually, size and uniform colour are important, especially in strands where matching is of primary relevance. Large, fine art coral carvings of rich pink to deep red colours are highly prized and very rare.

Localities

The Mediterranean Sea, and the Eastern Atlantic Ocean (harvested by countries bordering the Mediterranean Sea); the East China Sea, harvested by Taiwan; and the Pacific Ocean, with Japan Philippines, South China Sea, the United States (Hawaii, Midway), among the major producers.



Coral may be carved into a variety of decorative uses or for use in jewellery

Peridot



Peridot, a variety of olivine, forms in the orthorhombic crystal system

History, lore and appreciation

For anyone who loves hazy, yellowish green colours, peridot is sure to be appreciated. At its best, the gem exudes a soft, oily appearance; comparable to the deep greens you might see in olive oil. In ancient times, peridot was described as a gem “containing rays of sunshine.” It is easy to see why: in direct, brilliant sunshine, peridot often returns a warm, yellowish glow to the eyes. Additionally, peridot has very high double refraction causing an optical effect in which a doubling of pavilion facets often is observed when looking through the table of the gem; this feature accentuates peridot’s soft, velvety look.

Peridot is a variety of olivine and it has been treasured as a gem for thousands of years. Egyptian slaves are said to have discovered the first source for it at Zabargad, a desolate island in the Red Sea (today’s St. John Island). Zabargad is considered the classic source for the gem, though it no longer produces commercial quantities. Luckily, the mineral olivine occurs on every continent. As a transparent, bright green gem, peridot is much more elusive. Interestingly, Peridot has been found in a particular type of meteorites, a pallasite from Argentina, from which small (up to 1 carat) stones have been cut for collectors that prize them as an extra-terrestrial gem.

The origin of the name is thought to be Arabic, deriving from the word *faridat*, meaning gem. However, French and 13th Century English root words have also been suggested as the name derivation for this gemstone.

Birthstones and anniversaries

Peridot is one of the birthstones for August. It is also a 15th wedding anniversary gemstone.

Description and properties

Peridot is an olivine, a solid solution between the minerals forsterite and fayalite that crystallizes in the orthorhombic system and has the following chemical composition: $(\text{Mg,Fe})_2\text{SiO}_4$

Colours: yellowish green to greenish yellow to brownish green

Refractive Index: 1.65 to 1.69 (± 0.020)

Birefringence: 0.035 to 0.038

Specific Gravity: 3.34 (+0.14, -0.07)

Cause(s) of colour: traces of iron and magnesium, and in some gems chromium may be present.

Mohs Hardness: 6.5 to 7

Internal identifying characteristics:

Inclusions of biotite mica, chromite and biotite in the gem often cause internal stresses to occur. In turn, these stresses cause liquid filled discoid fractures known as lily pad inclusions.

Peridot

Treatments

None known.

Collector quality

With peridot, locality, colour and size are the significant aspects to consider. Gems that can be proven to come from Zabargad are rare since that classic deposit has been largely depleted. Myanmar (Burma) and, more recently, Pakistan are sources that continue to provide exceptional gems of significant size, and exceptional colour, often over ten carats.

Because peridot is plentiful, collectors often opt for size (ten carats or above) with saturated, slightly yellowish green colours. Cut has become an important factor: well-balanced gems that efficiently return colour and light, together with crisp facet junctions, are always appreciated. On extremely rare occasions, a star peridot (sporting 4 rays) is reported.

Localities

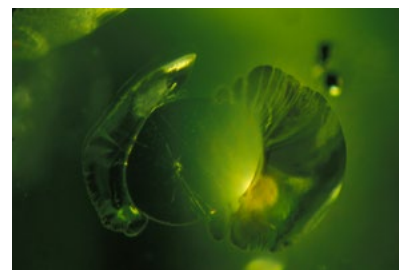
Egypt (St John's Island) is the classic source, though it is no longer a commercial producer of the gem. Myanmar (Burma) is considered a classic source too, if only because it has consistently produced large, clean peridots, which have become a global gauge to measure this gemstone's beauty. In recent years, Pakistan has also become a producer of very fine material. The United States consistently mines for the gem in Arizona, though they are generally smaller and sometimes slightly brownish in colour. Australia, Brazil, China, Kenya, Ethiopia, Norway, Sri Lanka, Finland, Tanzania, Vietnam, and the Antarctic have also produced it, though not in significant commercial quantities.

Cutting, care and cleaning

Because peridot is not an extremely hard gem, ultrasonic cleaners are not an ideal way to clean peridot jewellery. Peridot is also susceptible to extreme heat, so steamers should not be used. Certain acids used in jewellery manufacturing may etch peridot, so it is recommended they not be used around this gem. Finally, a soft, damp cloth, or a soft bristle toothbrush is probably best to use when cleaning peridot jewellery.



Peridot is available in a variety of shapes and sizes and may range in tone



A common inclusion scene in peridot is called a "lily pad" due to its similarity with the pond plant. In peridot the discoid appearance is caused by a microscopic stress fracture inside the stone

Quartz



Rock crystal quartz

History, lore and appreciation

Quartz can be colourless or richly coloured, transparent or opaque, highly included or not. It can exhibit chatoyancy, asterism, aventurescence or iridescence. Quartz can be as common as particles of sand on the beach, or deeply coveted gems in private collections and insured at high values. The noted Swiss gemmologist, Dr. Eduard Gübelin, aptly referred to quartz as the "jack of all trades." Yet it is found on every continent on Earth, standing in as one of the world's most plentiful minerals.

In ancient times, it was believed that transparent colourless quartz was a form of permanent ice, a suggestion first offered by the natural historian, Pliny the Elder. This belief evolved from what was once a major source for quartz, the snow and ice-covered Alps. The word "crystal" in fact derives from this mode of thinking. The Ancient Greek word for ice is *kristallos*. In 1646, Sir Thomas Browne proved crystal quartz to be a mineral, rather than permanent ice. His book, *Pseudodoxia Epidemica*, described this as one of his corrections to "vulgar errors."

Colourless quartz, or rock crystal, has long been cherished for its clarity – references to the clarity of crystal emanate from ancient writings, including the Bible. Some people have long believed that gazing into a large round crystal ball gave clairvoyants an ability to "see" the future.

Colourless quartz with bold and colourful inclusions of another mineral (such as tourmaline, hematite, goethite, mica or rutile) is increasingly used in jewellery. Generally, more colourful quartz varieties, such as amethyst and citrine, are predominantly used in jewellery. (For more about amethyst see page 6; for more about citrine, see page 13).

The transparent brown coloured variety of this mineral is called smoky quartz. It was found in the Cairngorm Mountains of Scotland and extensively used in Scottish jewellery in the late nineteenth century. Since then, the majority of brown quartz has been sourced in other localities around the world. The very dark varieties are known in the trade as *morion*. There is also a small amount of natural green quartz available, called prasiolite, located in the Faroe Islands. However, the majority of

the green quartz available on the market today is irradiation-treated quartz also along with some pale amethyst that is heat treated to turn it green.

Rose quartz is a semi-transparent to translucent variety of quartz whose devotees appreciate its soft, pink colour. It tends to be very lightly saturated and when cut as a cabochon, it occasionally exhibits asterism with a 6-rayed, sometimes 12-rayed star effect, in direct lighting. Asterism is caused by light reflecting from tiny, oriented, included rutile needles that align themselves in trigonal symmetry during the crystal's formation. Stars and cat's eyes occasionally form in smoky quartz and, rarely, in colourless quartz as well.

Quartz

Aventurine quartzite exhibits phenomena as a result of its inclusions. (Note: Quartzite is a form of quartz; a granular, interlocking mass of quartz crystals formed in different environments, rather than single crystal quartz). Curiously, the term "aventurescence" was so named after a 17th century Italian glassmaker who accidentally tipped copper filings into a batch of molten glass. The result of his fortuitous accident was a glittering form of man-made glass. It is recounted that his colleagues remarked he had made it "*per avventura*," or by adventure, or simply, chance. The name stuck. Aventurine glass, which is still manufactured and faceted in Italy, should not be confused with aventurine quartz. Aventurine quartz is green in appearance and its aventurescent effect is generally less pronounced than in glass. Aventurescence in quartzite is due to the granular interlocking of quartz crystals, combined with flat, disc-like inclusions of green mica (fuchsite) that produce glittering reflections in direct light. This optical effect is similar to the one seen in sunstone feldspar due to reflections in the metallic copper (Oregon, USA) or hematite (Tanzania, Africa) inclusions.

Rutilated and tourmalinated quartz (also called sagenitic quartz) contain large, highly visible inclusions that become a celebrated part of the gem itself. Rutile needles may be random, large and golden in colour, or may form in multi-rayed, 6-fold star-like inclusions surrounding a hematite crystal within the gem.

Drusy quartz is occasionally used in jewellery design. This is an overgrowth of minute quartz crystals over other larger specimens, or on chalcedony. The result is a glittering, rugged texture that is kept in its rough form and mounted in jewellery.

Birthstones and anniversaries

Rose quartz is sometimes regarded as an alternate birthstone for the month of January, along with garnet.

Description and properties

Quartz has a chemical composition of SiO_2 and crystallises in the trigonal crystal system.

Refractive Index: 1.544 to 1.553

Birefringence: 0.009

Specific Gravity: 2.66 (+0.03, -0.02)

Cause(s) of colour: (Rose Quartz) Debate about the identity of the nano-inclusions in quartz, which causes both cloudiness and apparent colour, remains. In any case, the orientation of the mineral inclusions often causes asterism in rose quartz from Madagascar.

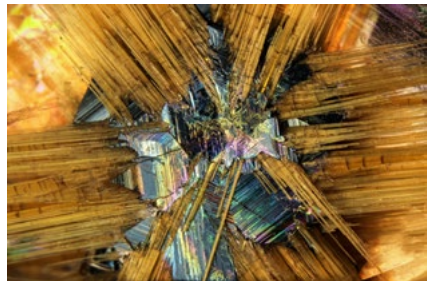
(Smoky quartz) Colour centres involving aluminium impurities.

Aventurine quartz: Colour is caused by inclusions of fuchsite mica platelets.

Mohs Hardness: 7

Internal identifying characteristics:

In transparent quartz varieties dendritic inclusions, and inclusions of many minerals may be present, including rutile, goethite, schorl (tourmaline), cristobalite, hematite and others. Fluid inclusions can be found in all varieties of transparent quartz.



Quartz may contain rutile inclusions. This sample from Brazil includes a rutile inclusion formed as a six ray star with another inclusion of hematite as its core. Field of view: 7.19 mm

Quartz

Treatments

Quench crackling: Heating, followed by immersion in water causes thermal shock and the gem develops cracks and fissures. This by itself is not attractive, but it is followed by dye impregnation to reach deep inside the quartz through the newly developed, surface-reaching fissures. The result, for example, can make a gem look surprisingly like emerald or ruby (depending on the dye used).

Irradiation: Colourless quartz can be irradiated to look smoky, green (prasiolite) or yellow; rose quartz's colour can sometimes be deepened through irradiation.

Heat treatment: Heating may lighten the colour of dark smoky quartz.

Coating or foil backing: Deepens the colour of some gems; may help with cat's eye or star phenomena.

Dyeing: (Generally after quench crackling) may cause the material to appear a totally different colour.

Collector quality

Rose quartz and other phenomenal varieties are often collected with emphasis placed on depth of colour and strength of phenomena. Smoky quartz is collected in antique jewellery – especially Scottish jewellery, due to its historical significance. Artistically carved rock crystal both modern and antique is quite desirable. Inclusions' connoisseurs collect cut rock crystal with its many mineral inclusions.

Localities

Quartz is found on all continents but some stand-out producing countries include: Germany, Hungary, India, Iran, Brazil, Bolivia, South Africa, Madagascar, Mexico, Sri Lanka, Scotland, Spain, Switzerland, and the United States

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Cutting, care and cleaning

Skilled lapidary artists often carve rock crystal quartz into objects of art, or in unusual shapes. Gems exhibiting phenomena are often cut en cabochon or tablet shapes.

While quartz is very durable in general, special care should be taken to not subject it to temperature extremes. Quartz may be cleaned in an ultrasonic cleaner if there are no fissures that could endanger the durability of the stone. As with most gems, using a damp, soft cloth, or gently scrubbing with a soft-bristle toothbrush, is the best way to clean quartz.

Quartz when used as a gemstone is extremely versatile, mainly due to the various kinds of beautiful inclusions it contains



Ruby



A series of ruby crystals have grown in matrix from Myanmar (Burma)

History, lore and appreciation

Throughout humanity, red has represented passion and romance. Ruby, the red gem variety of the mineral corundum, has been engaged for centuries to symbolize those sentiments. 17th Century English poet, Robert Herrick, alluded to both passion and the gems' colour when he wrote:

"Some asked me where the rubies grew,
and nothing I did say;
but with my finger pointed to
the lips of Julia."

Ruby is mentioned in the Bible – and its value is clearly understood. The remark in Job, "*The price of wisdom is above rubies*," is but one of six references.

The name ruby comes from the Latin, *ruber*, meaning red. While there are several red gemstones enjoyed by humankind, ruby is esteemed and regarded as the very definition of red. Descriptions of ruby's colour have wandered into passions as well, with the relatively old phrase "pigeon's blood", sometimes used still to describe a fine ruby. Aside from their red colour, ruby and spinel are often mined from the same sources, and interesting historical cases exist where large red spinels were called "balas" rubies. The famous Black Prince's Ruby, a 170 carat gem that graces the Imperial State Crown of the United Kingdom, nestled next to the famous Cullinan II diamond, is actually a spinel. Worn by successive Kings and Queens since the 1367 (and even in helmets going into battle) the spinel hails from present-day Tajikistan. Almost all large "rubies" reported in historical documents are, in fact, red spinels. The Persian scientist, Abu Rayhan al-Biruni did classify differences between spinel and ruby gemstones in the 11th century.

Portuguese travellers in the 1500s and the French traveller and merchant, Jean Baptiste Tavernier who traded in gemstones in the mid-1600s, identified Ceylon (Sri Lanka) and the Kingdom of Pegu, Myanmar (Burma) as the main sources of ruby. In describing the perils inherent in hunting for gems, he notes that a voyage to Kyatpyen, where ruby was traded, should not be attempted by land: "...on account of the jungles which abound with lions, tigers and elephants," he wrote. In 1904, traveller V.C. Scott O'Conner described Thabeit-Kyin as the port of Mogok, Burma's famous ruby and sapphire source: "Through this little postern gate the wealth of Capelan has passed for centuries on its way to the great world; to the treasures of kings, to the fingers of princes, to the necks of beautiful women; to the making of one, the undoing of another." And this is exactly how locality fits into appreciation. Because Myanmar (Burma) has produced a standard of quality by which ruby from other localities is often measured, the term "Burmese ruby" has also come to be understood by many in the trade as a quality designation. But designations

Ruby

of that kind require additional qualification, as Myanmar (Burma) produces both fine and commercial quality ruby.

Appreciation for red gems, especially ruby, has a historical genesis in India, especially during the rule of the Mughals in the 1600s, whose leaders, particularly Shah Jahan, had an affinity for ruby, spinel and other gemstones. These were often carved with verses from the Qur'an and worn in turbans, articles of clothing and jewellery. The features of ruby, which have always been appreciated, are those that help define the meaning of gemstone: ruby is beautiful, durable and rare.

Birthstones and anniversaries

Ruby is the birthstone for the month of July. The 15th and 40th wedding anniversaries are celebrated with ruby.

Description and properties

A variety of the mineral species corundum, forming in the trigonal crystal system with the chemical composition of Al_2O_3 .

Colours: orange red to strongly purplish red; also brownish red. The dominant colour must be red.

Refractive Index: 1.762 to 1.770 (+0.009, -0.005)

Birefringence: 0.008 to 0.010

Specific Gravity: 4.00 (± 0.05)

Cause(s) of colour: Chromium with possible modifications of colour with iron and titanium.

Mohs Hardness: 9

Internal identifying characteristics: Clouds of fine particles and networks of fine rutile needles (called silk), which may intersect at 60 degree angles, are commonly seen in natural ruby. Mineral inclusions and included crystals of zircon, and related stress fractures (called halos) are sometimes seen. Liquid-filled "fingerprint" inclusions are also common. Some of these identifying characteristics may disappear, change or be diminished as a result of heat treatment.

Treatments

Heating: This treatment dissolves or partially dissolves fine rutile needles thereby increasing the clarity and transparency of the gem. In certain cases, controlled heating helps redefine asterism in star rubies. It may also help remove purplish or brownish colour components in some gemstones, resulting in stronger red colours.

Diffusion: The diffusion of colour-causing elements through the crystal lattice at high temperature is sometimes performed with the intent of intensifying or altering the colour of some rubies.

Oil and dye: Some rubies with surface reaching fissures may be treated with oil or dyes, resulting in stronger colours. The treatments are not considered durable and require special care considerations.

Glass filling in cavities and fissures: High lead content glass is sometimes used to fill surface reaching fissures, pits or cracks in certain rubies/corundum. The treatment increases the transparency of low-grade ruby/ corundum. In some cases, the material is so prevalent that it may require special care considerations.



Star ruby results when intersecting rutile needles it contains form the phenomenon called asterism. This is best seen when the gems are cut as cabochons, and when a pinpointed light illuminates the gem

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Ruby

Collector quality

Location, or provenance, is particularly important with ruby. A fine ruby with a “Burmese” designation may be perceived by the trade to be more desirable than an equally fine ruby from a different locality, through the beauty of rubies from any locality can compete with gems from Myanmar. Much depends on the choice of the wearer. Colour is of extreme importance. The more purely red a ruby is, the more collectible it becomes.

Clarity and size of the gem is also important, though the presence of silk or other inclusions is often valued since it not only points to a gem’s natural origin; it also suggests the gem has not been treated at temperatures high enough to dissolve the silk. Cut or carved ruby with known provenance is also collectible.

Star ruby is rare and collectible especially if the legs of the star reach from girdle to girdle of the cabochon, and are unwavering and sharp. Star ruby often has a milky complexion due to inclusions of rutile, so depth of colour and transparency are additional important factors in valuing and collecting these gems.

Localities

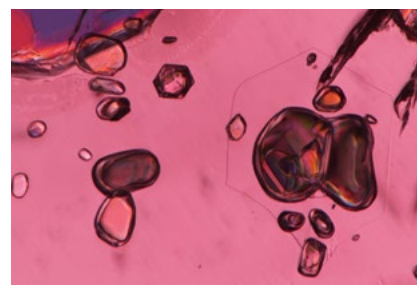
Thailand, Myanmar (Burma), Cambodia, Sri Lanka, Kenya, Afghanistan, India, Pakistan, Tanzania, Greenland, Tajikistan, Mozambique, Madagascar, Vietnam, Kenya, Malawi, and Nepal.

Cutting, care and cleaning

Ruby is mostly cut in traditional pear, round, oval, cushion and emerald cut outlines. Ruby is extremely durable due to its hardness and toughness – second after diamond on the Mohs hardness scale. Ruby jewellery may be cleaned in an ultrasonic cleaner, or it may be steamed. But this should follow close inspection to determine if there are any surface reaching fissures that could expand, or if oils, dyes or glass filling are present; cleaning could harm the filling material. As with most gemstones, a soft moistened cloth, or a soft bristle toothbrush may be used to clean the gem.



Faceted gems accompany this ruby in matrix from Myanmar



This ruby from Mozambique contains a series of amphibole inclusions. Field of view: 1.76 mm

Sapphire



A sapphire crystal and cabochon cut gem

History, lore and appreciation

If blue is the colour you think of when the word "sapphire" is said, you are very close to its root. It derives from Hebrew and Arabic terms *safir*, meaning blue, and *sapphiros*, meaning blue in Greek. In ancient times, such words referred to a blue gem material that was likely lapis lazuli. Conversely, the ancients called the today's sapphire "hyacinth," due to its colour similarity to blue hyacinths. Obviously, that term has changed with the passage of time, though a lovely poem about gems by Marbode, Bishop of Rennes, written approximately 1000 years ago speaks of the colours of hyacinth, as follows:

*Three various kinds the skilled as
Hyacinths name,
Varying in colour, and unlike in fame:
One, like pomegranate flowers
a fiery blaze
And one, the yellow citron's hue displays
One charms with paley blue the gazer's eye,
Like the mild tint that decks the
northern sky,
A strengthening power the several
kinds convey,*

*And grief and vain suspicions drive away.
The blue sort feels heaven's changes
as they play,
Bright on the sunny, dull when dark the day,
But best that gem which not too deep a hue,
O'erloads, nor yet degrades too light
a blue.*

Even then, a classification of hyacinth's beauty was tacitly underway. The reference to blue hyacinths, lovely flowers, remains an apt association, but the term began to fade. In the 15th Century, the naturalist Camillo Leonardo spoke and wrote about "sapphirini."

Modern day usage of sapphire includes almost all colours of the spectrum other than just blue – as Marbode's poem suggests. Sapphire, in fact, can be any colour but red. That's because red corundum (though essentially the same mineral as sapphire) is classified as a ruby. In short, the difference between ruby and sapphire is that only ruby can be red. So in separate colours of sapphire, descriptions are preceded by a colour designation, such as "yellow sapphire." Corundum, other than red or blue, may also be referred to as "fancy sapphire." Fine quality blue sapphire

has interesting colour descriptors that are often comparisons to a flower, as in ancient times. This includes the often-used "cornflower blue." Others may compare sapphire colours to other natural vibrant colours, such as a peacock's feathers.

The allusion to flowers does not end there. Colour variations are what make this variety of corundum so interesting, as are the "mixed colours." One important gem with a blend of colours, which captivates the imagination, is the *padparadscha* sapphire. The trade term, *Padparadscha* (which derives through the German language from the Sinhalese word *padmaraga*, meaning lotus colour) denotes an extraordinary and rare variety. The term is only applicable to sapphires with medium pinkish orange to orange-pink colours.

In recent years, there has been a growing appreciation for phenomenal gems – of which sapphire enjoys two principal varieties: Star sapphire in blue and various other colours with a six-rayed star, (and rarely a twelve-rayed star) cut as cabochons, as well as colour-change sapphires have both received increasing attention in recent years.

Sapphire

Birthstones and anniversaries

Sapphire is the birthstone for the month of September. It is used to celebrate 5th and 45th anniversaries.

Description and properties

A variety of the mineral species corundum, forming in the trigonal crystal system with the chemical composition of Al_2O_3

Colours: Blue sapphire: very light to very dark violetish blue to greenish blue. Fancy colours: All colours of the corundum species excepting blue and red (blue sapphire and ruby respectively). These colours include green, yellow, orange, pink, purple, violet, brown, black, and colourless. Sapphire may also contain two colours, mixed colours or other variations. In recent years, pale coloured sapphire has come to be known as “pastel sapphire” in the trade.

Refractive Index: 1.762 to 1.770 (+0.009, -0.005)

Birefringence: 0.008 to 0.010

Specific Gravity: 4.00 (+0.10, -0.05)

Cause(s) of colour: **Blue:** iron and titanium. **Green:** iron or iron and titanium. **Yellow:** iron and colour centres; **orange:** iron (and possibly chromium in *padparadscha* variety). **Purple:** varying traces of iron, titanium and chromium. **Pink:** chromium; possibly titanium. **Colour change:** combined presence of chromium, vanadium, iron and titanium.

Mohs Hardness: 9

Internal identifying characteristics: Inclusions in sapphire may be composed of fine rutile needles (called silk), which may intersect at 60-degree angles. In such cases, when the gem is cut as a cabochon, a star effect may occur. Included zircon crystals or crystals of different minerals, fluid inclusions, fingerprints or partially healed fractures, and negative crystals with liquid-gas (CO_2) may also occur and colour zoning, particularly seen in angular patterns.

Treatments

Heating: This treatment is undertaken to increase transparency by reducing the opacity of clouds of rutile inclusions. It has also been performed on low quality sapphire material from Sri Lanka, known as *geuda*, since the 1970s. This is a high temperature treatment that results in strong blue and yellow colours. Heating may also cause some overly dark blue or green sapphire to be lightened in tone, or to turn purplish sapphire into pink colours. Heating at high temperature in a moderate pressure environment has been recently reported to generate treated blue sapphire.

Diffusion: Heating some sapphire at very high temperatures with chemical additives causes lattice diffusion of those additives. Elements, such as beryllium or titanium, are diffused into the corundum crystal lattice, causing colours in the gem being treated to deepen or change.

Coating: On rare occasions, some sapphire is coated with a thin film to deepen or change its colour appearance.

Irradiation: Some colourless to near colourless sapphire can be turned orange or yellow though irradiation. Colour in irradiated sapphire fades over time.

Glass filling in cavities and fissures: While this treatment is less prevalent in sapphire than it is in ruby, it should be noted that any gem material with surface reaching fissures might be subjected to infilling of glass or other substances, with the goal of increasing the transparency of the gem.

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Sapphire

Collector quality

Several factors may be used to judge fineness in sapphire, though ultimately, the beauty of a gemstone remains in the eye of the beholder. Fine quality blue sapphire should possess the ability to be spotted from across the room because of its depth of colour and saturation. The transparency of sapphire also comes into play. Because inclusions can cause some gems to have milky colouration, this becomes a detriment if it also causes a perceived loss of blue. In one notable exception, haziness is not only expected – it is desired, and that is in the finest sapphire from Kashmir. The haziness (often referred to as sleepiness) acts to diffuse light and colour, resulting in magnificently even blue colouration.

The specific colour of blue sapphires, often described in the trade with descriptors such as “Royal Blue,” “Cornflower Blue” or “Peacock Blue,” also affects their desirability. Geographical provenance has been regarded as a value factor (e.g. Kashmir, Burma, Sri Lanka) in spite of the scientific recognition that it is more reliable to determine geological origin than

geographical origin. This is because there are well-documented situations of overlapping gemmological data.

In recent years, gemstones coming from various localities around the world, such as Madagascar, or the Umba River Valley in East Africa, have supplied a unique palette of colours that are desirable for collections, especially in suites showing an array of hues. East Africa and Madagascar have joined other sources such as Sri Lanka, in bringing to market rare colour change sapphire, many changing from a blue grey colour in daylight, to a violet or purple colour in incandescent light. Star sapphire with strong colour in which the “legs” of the star are girdle-to-girdle, straight and unwavering is desirable. Fine padparadscha is also considered collectible.



Sapphire forms in a variety of different colours that are then cut as fancy colour sapphires

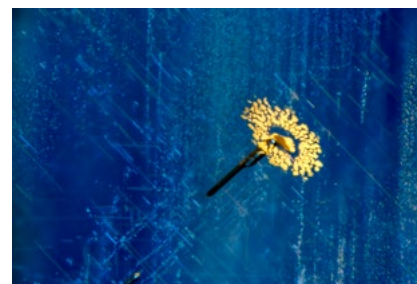
Sapphire

Localities

Sri Lanka and Myanmar (Burma) are historic sources for sapphire and produce some of the world's finest gems. In extremely high qualities, Kashmir has emerged as the preeminent source for blue sapphire, especially in the late 19th century. Sri Lanka is the classic source for padparadscha sapphire, though other sources also now produce mixes of pink and orange colours as well. Australia, Thailand, Cambodia, Kenya, India, Tanzania, Madagascar, Malawi, Greenland, Vietnam, Nigeria, Ethiopia, China, and the United States all produce blue sapphire, as well as many fancy coloured hues.

Cutting, care and cleaning

Sapphire is mostly cut in traditional pear, round, oval, cushion and emerald cut outlines. Sapphire is extremely durable due to its hardness and exceptional toughness, second after diamond on the Mohs hardness scale. Sapphire jewellery may be cleaned in an ultrasonic cleaner, or it may be steamed. But this should follow close inspection to determine if there is any surface-reaching fissure that could expand, possibly causing damage. As with most gemstones, a soft moistened cloth, or a soft bristle toothbrush may be used to clean the gem.



In this Sri Lankan sapphire, a reflective film and growth blockage tube resembles a flower. Field of view: 1.42 mm



Fancy colour sapphires can be any colour – except red and blue

Spinel



Red spinel octahedron with growth etching

History, lore and appreciation

Spinel has long been one of the most underestimated gems on Earth, but that is rapidly changing. With education, there is a greater understanding and appreciation for the gemstone's unique optical characteristics, its broad colour palette, its rarity, and versatility.

Red spinel has been known since ancient times, and for years it was referred to as "balas ruby" because the main historical source for the material was in present-day Tajikistan in a region called Badakhshan. In the chapter on ruby, it was noted that the Black Prince's Ruby, the centrepiece of the British Imperial State Crown is actually a spinel. Another famous gem spinel set in the crown of Queen Victoria is the so-called Timur Ruby, a 361 carat gemstone that is also a spinel. Many other historical red gems decorating the crowns of Europe and in Asia are, in fact, spinel. Spinel stands on their own as magnificent and long-celebrated gems.

Appreciation for spinel inevitably brings us to one of the world's greatest collectors of gemstones. Among the Iranian crown jewels is one named the Samarian Spinel. Weighing approximately 500 carats, it is thought to be the world's largest fashioned spinel. Its provenance dates back to the 18th Century Persian conquest of India. An inscription on the back of the spinel confirms that the great Indian Mughal gem collector, Jahangir, had once owned it. Interestingly, the Timur spinel in the British crown jewels bears an inscription indicating Jahangir had also owned it.

Much of the appreciation for spinel is due to its unique gemmology. There is a clarity and directness about spinel that many enthusiasts appreciate. Optically, spinel is singly refractive, meaning that light passing through it in any given direction is not split into two rays. Spinel has a high refractive index, and many transparent gems are relatively inclusion-free. Finally, spinel has moderate dispersion. This combination of optical characteristics renders spinel bright and reflective, and capable of breaking up white light into

spectral hues – what we call "fire." It may be this fire that first gave spinel its name: one derivation of the word comes from the Greek *spinter* – meaning "spark." Another theory suggests that the word comes from the Latin *spina*, alluding to the sharp points in the octahedral crystals.

Birthstones and anniversaries

Spinel is one of the birthstones for August and it is used to commemorate a 22nd wedding anniversary.



Red spinel crystal from Myanmar (Burma) often forms in calcite, alongside a cut red spinel

Spinel

Description and properties

Spinel is a mineral species, member of the spinel group, whose varieties are primarily distinguished by their colour. It forms in the cubic crystal system, and its basic chemical composition is: MgAl_2O_4 .

Colours: red, pink, orange, blue, violet, purple and grey are the most common colours. Other colours include brown and black, and rarely, yellow, green and near colourless. Colour-change spinel changes from greyish blue in daylight to purple in incandescent light. Vivid cobalt-blue spinel is coloured by cobalt.

Refractive Index: 1.718 (+0.017, -0.008)

Birefringence: None

Specific Gravity: 3.60 (+0.10, -0.03)

Cause(s) of colour: Blue: iron, cobalt.
Red to pink: chromium

Mohs Hardness: 8

Internal identifying characteristics:

Minute fingerprint inclusions may be seen in spinel. With sufficient magnification, tiny octahedral crystals or negative crystals may be seen. These

octahedral crystals, if large enough, may be accompanied by strain halos.

Treatments

Spinel is rarely treated, though occasional heating of pink-to-red spinel has been reported. Infrequently, surface reaching fissures are treated with oils or polymers.

Collector quality

Colour, carat weight, clarity and origin all play a role in how spinel is valued and collected. Gems whose provenance can be ascertained always have collectors. Spinel that is deep red, large and relatively free of inclusions is also highly desired. So too is rare, vivid blue spinel, particularly when a gemmological laboratory has determined that cobalt is the colouring agent. Locality plays an important role for collectors as well. Spinel from the Pamir Mountains in Central Asia is rare and collectible, as is spinel from Myanmar (Burma). New localities that produce desirable colour – anywhere from pink to deep red are collectible.



A grouping of spinel shows how diverse its colour range can be

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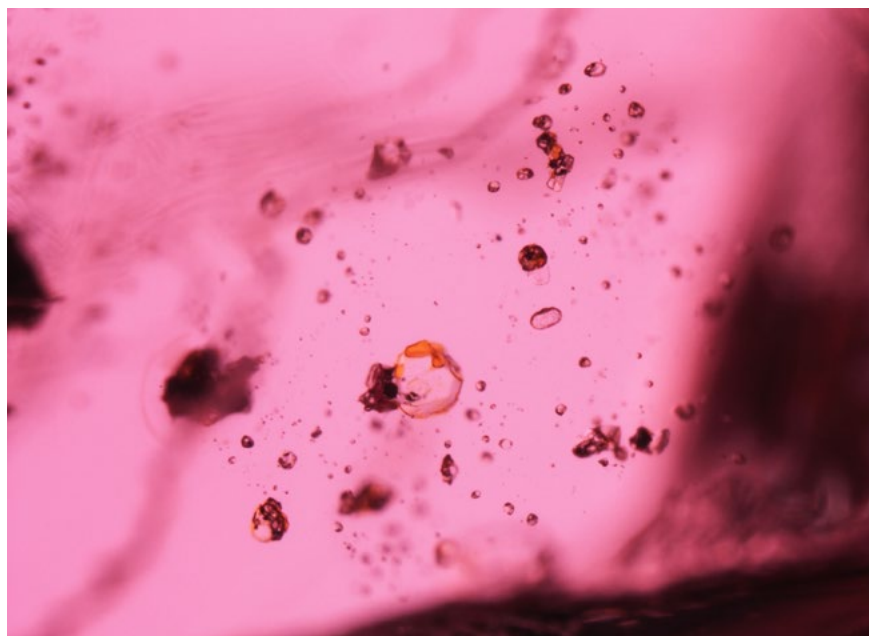
Spinel

Localities

Tajikistan – especially in the region of Badakhshan, in the Pamir Mountains, remains a classic source for the gem and the main source for large sized gems. Neighbouring Afghanistan is also a known source. Myanmar (Burma) is also a classic source and remains a strong producer of the material. Sri Lanka, Cambodia, Thailand, Vietnam, Kenya, Tanzania, and Russia have all produced spinel. Recent spinel finds in East Africa and Asia have reinvigorated interest in the gem.

Cutting, care and cleaning

Spinel is resilient and tough – more so than many gems (except corundum or diamond.) They may be cleaned in an ultrasonic cleaner or steam cleaned. It is preferable to simply use a damp soft cloth or a soft bristle toothbrush to clean the gemstones and spinel jewellery.



This scene exhibits a carbonate inclusion in spinel from Mogok.
Field of view: 34 mm

Tanzanite



Tanzanite crystal

History, lore and appreciation

Tanzanite, a variety of the mineral zoisite, is a relatively new gemstone on the market so it does not share the depth of history presented by other gems. Its beauty, though, is no less appealing, and the history it does have is intriguing. In years to come, tanzanite's find will clearly be looked back upon as one of the most significant new gem discoveries of the 20th Century.

Several stories relate the discovery of tanzanite. The one most often told is that of Manuel De Souza, a tailor from Goa, India, living in Arusha, Tanzania. On July 7, 1967, De Souza (who doubled as a gold and gemstone prospector) found himself in the hilly region of Merelani in the company of four Masai tribesmen he had hired to help him prospect. The region, at the foothills of majestic Mount Kilimanjaro, was dangerous: poisonous snakes, Cape buffalo, lions and other African animals roamed the area. Accounts say De Souza was unarmed but for a few prospecting tools, seeking only what providence might offer. But rather than being discovered by

man-eating beasts, De Souza made a startling discovery himself. Around noon, he discovered a blue crystal lying on the ground. The crystal was unknown to him, though after consulting a few books, De Souza soon discounted sapphire and the mineral cordierite (iolite) as possibilities. He finally decided it was a form of olivine, or at least was the closest gemmological match, and on July 25 pegged a claim for it. Soon other claims were made near his – but the material was now being called something else: zoisite. Though it may have originally been confused with it, zoisite is a different mineral than olivine. According to John Saul, a geologist and gem miner from Tanzania, confirmations of the mineral zoisite soon came from the Gemological Institute of America and from other experts around the world.

Henry Platt, vice president of Tiffany & Co., who had been shown the material and admired it, was the first to call it "tanzanite," in honour of the country where it was found; the name was soon duly inscribed in new gemmological texts. Indeed, tanzanite is not mined elsewhere on a commercial basis. While almost all

of the material coming out of the mines at Merelani was (and is) a somewhat drab purplish to yellowish brown, it was soon found that low grade heating turned the gems into a deep purplish blue. While some blue zoisite is that colour naturally, it is understood that virtually all of the commercially mined zoisite today is heated to induce the deep, velvety, blue to violet blue colours associated with the gem.

There is much to appreciate about tanzanite: its deep blue to violet colours is, of course, paramount. It can be found in sizable crystals suitable for centre stones in jewellery. It is also trichroic, meaning that it shows three different colours in the three crystallographic directions. As a result, tilting the gem in three different directions one is sometimes able to discern deep purple/red, blue, and yellow/brown. Viewed in a polariscope, these colours become even more evident.

Tanzanite

Birthstones and anniversaries

Tanzanite has been added as a birthstone for the month of December, along with zircon and turquoise.

Description and properties

A variety of the mineral species zoisite (in the epidote group) forming in the orthorhombic crystal system with the following approximate chemical composition: $\text{Ca}_2\text{Al}_3(\text{SiO}_4)_3(\text{OH})$.

Colour(s): Transparent blue to violet to bluish purple zoisites are called tanzanite. However, other colours are also mined in Merelani, including pink, purple, yellow, and green. These are sometimes referred to as “fancy tanzanites” in the trade. While they are all zoisite, only the deep purplish-blue colours can be called tanzanite.

Refractive Index: 1.691 to 1.700 (± 0.005)

Birefringence: 0.008 to 0.013

Specific Gravity: 3.35 (+0.10, -0.25)

Cause(s) of colour: Blue: vanadium.

Mohs Hardness: 6 to 7

Internal identifying characteristics:

Tanzanite tends to be remarkably clean and transparent. Fingerprint inclusions are sometimes present. On very rare occasions, tiny, parallel, hollow tubes in some tanzanite causes chatoyancy (cat’s eye effect).

Treatments

Heating at relatively low temperatures (up to 600°C) causes a change of colour from brown, purple or grey to bluish purple to purplish blue. Sometimes tanzanite is coated to improve its colour, although this is uncommon.

Localities

Merelani, Tanzania. At the time of writing, Merelani is the only known commercial locality for tanzanite in the world. While zoisite does occur in other places, no material matches the colour intensity of tanzanite.

Collector quality

Tanzanite in large sizes with rich colour is desirable for collections. Multi-colour transparent zoisite is also sought, particularly green and pink. On extremely rare occasion, collectible cat’s eye tanzanite is fashioned.

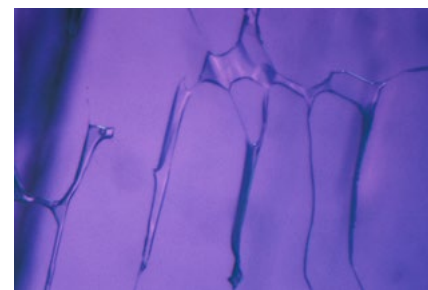
Cutting, care and cleaning

Tanzanite is delicate and should be worn with great care. Tanzanite should never be cleaned in an ultrasonic cleaner or steam cleaned. Warm soapy water or a damp soft cloth is considered a safe way to clean tanzanite jewellery.



Zoisite can be almost any colour.

The name “tanzanite” is reserved for the blue to violet colours



A fluid inclusion in tanzanite also contains a small gas bubble. (Field of view unavailable)

Topaz



A classic "imperial" topaz crystal and faceted gem

History, lore and appreciation

There is an unmistakable characteristic about the colour of imperial topaz: a deep pink orange verging on red. While some enthusiasts considered golden colour the classic colour, pink to reddish orange hues are more highly desired today. Pablo Neruda, the Chilean poet, likened topaz to honey:

*I invite you to a topaz.
To the honeycomb of yellow stone,
To its bees,
To the frozen honey of a topaz,
To its golden day...*

Origin of the word topaz is quite mysterious as it was once reserved for greenish gemstones – most likely peridots. *Topazos* is Greek in origin, and refers to the gems from the island of "Topazios," which is known today as Zabargad. However, that Red Sea island is identified as the classic source of peridot. Dating back to Pliny the Elder's time, *topazos* was described as a gem the colour of fresh green olive oil. Slowly, over time, other colours were included within the definition of *topazos*, including yellowish gems. It was not until

the 11th Century that the name began to clearly point to a yellow or golden colour. Scholars suggest that this definition could have encompassed several other yellow gems that weren't necessarily the topaz we identify as such since the 18th century.

Yellow and orange colours are iconic for today's definition of topaz, as Neruda clearly identifies in his poem. Actually, the species occurs in a broader range of colours, as well as colourless. Topaz sometimes includes a soft blending of pinkish orange to reddish orange colours, which the gem trade has called "imperial topaz." These colours have been found especially near Ouro Preto, Brazil, although pink to red topaz has been reported at various sources around the world, particularly in Russia and Pakistan. But curiously, the rich green colour with which topaz was first identified, does not exist today – except rarely in very pale stones.

Topaz, in its purest colourless state was sometimes mistaken for diamond in ancient times. The so-called "Braganza Diamond," a rounded pebble centrepiece of the Portuguese Crown Jewels in the late 1700s, was said to be the largest diamond

in the world at 1680 old-carats. It was thought at one time to have actually been a topaz but a recent inventory of the crown jewels uncovered a rounded pebble of aquamarine. It was of a similar weight and description, leading to current hypothesis that this might have been the gem in question.

While natural bluish topaz exists, it is generally quite pale and it tends to fade in daylight. But one of the most prolific treated gemstones on the market today is a range of light to deep blue coloured topaz that is treated with a combination of irradiation and heating to achieve a broad range of popular blue colours.



Topaz is often colourless, such as this crystal from Myanmar (Burma)

Topaz

Birthstones and anniversaries

Topaz is a birthstone for the month of November. Blue topaz is given for a 4th wedding anniversary and Imperial topaz is given for a 23rd anniversary.

Description and properties

Topaz is a mineral species that crystallises in the orthorhombic crystal system. Its chemical composition is $\text{Al}_2(\text{F,OH})_2\text{SiO}_4$

Colour(s): Colourless, yellow, orange, brown, pink to red to purple red, light blue to dark blue and light green.

Refractive Index: 1.619 to 1.627 (± 0.010); red, pink, and purple stones typically 1.629 to 1.637.

Birefringence: 0.008 to 0.010

Specific Gravity: 3.53 (± 0.04)

Cause(s) of colour: Pink and red topaz is principally coloured by chromium. Blue, yellow and brown owes their perceived colour to various colour centres, and possibly combined with traces of chromium in orange hues.

Mohs Hardness: 8

Internal identifying characteristics: Fluid inclusions that contain two and three phase inclusions are the most common, particularly in reddish or orange gems. Insipient cleavage plans and etch channels are common. Occasionally trapped minerals such as biotite, chlorite, hematite or phenakite, can be found in topaz. In very rare cases, tiny ribbon like hollow tubes, forming in parallel fashion, cause cat's eye effect.

Treatments

Heating: In some cases, chromium-bearing yellow or brown topaz may be changed to pink or red colours.

Irradiation (followed by heating): This treatment begins with induced irradiation causing colourless topaz to turn brown or brownish green. Heat treatment follows, turning the material blue. In very rare cases, and depending on the irradiation process, some material may retain residual radioactivity and require a quarantine before it can be used safely.

Coating: Some colourless topaz is coated with metal oxides to create the appearance of a variety of different colours.

Collector quality

Colour is the principal feature of topaz with pink to orange to reddish orange combinations being among the most desirable. Size is also an important attribute, even in irradiated material where huge museum quality gems are occasionally available.

Topaz has perfect cleavage in one direction, so carvings are rare. When they do occur, especially by known artists, they are soon collected.



Topaz is considered rare in natural pink and orange colours; less so in blue colours that are generally treated from colourless to achieve saturated blue hues

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Topaz

Localities

Brazil – particularly the area near the town of Ouro Preto in Minas Gerais, produces much of the world's supply of classic yellow to orangey pink colours. Other states produce it as well, but mostly in the colourless to pale blue range. Schneckenstein, a village in Germany, was a major classic source of European topaz in the 1700s. Pakistan produces some of the strongest pink to reddish colours at Katlang, near Peshawar. Sarnaka in the Urals, Russia, was an important historical source of pink topaz in the mid-1800s. Topaz is also found at sources all around the world, such as Nigeria, Australia, Myanmar (Burma), Madagascar, Mexico, Namibia, Sri Lanka, Ukraine and the United States and Russia.

Cutting, care and cleaning

While topaz is quite hard, its toughness and resistance to blows is considered poor because of its perfect directional cleavage. Treated gems may be even more vulnerable to cleaving. Ultrasonic cleaners and steamers should be avoided. A soft, damp cloth remains the best way to clean topaz and topaz jewellery.



This topaz from Utah has a black octahedron magnetite inclusion.
Field of view: 0.288 mm



A range of irradiated and heat-treated topaz

Tourmaline



A rubellite tourmaline crystal
with embedded mica platelets

History, lore and appreciation

Tourmaline is a group of closely related minerals composed of several species and varieties. The celebrated gemmologist and author, Eduard Gübelin, referred to it as a “crystallized kaleidoscope” because of the diversity of colours that make up this rich family. Tourmaline comprises colours of the spectrum from red to violet and practically any degree of variations in between. Tourmaline can also be bicoloured, colourless or black. Tourmaline’s variety names are often designated by these hues. However, most of the gem tourmaline used in jewellery today belongs to the elbaite, rossmanite, fluor-liddicoatite and dravite mineral species, which exhibit the strongest and brightest colours.

The name tourmaline derives from the Sinhalese word *turamali*, meaning gemstone with mixed colours. In the early 1700s, traders from the Netherlands brought *turamali* back to Europe from Ceylon (Sri Lanka). They were fascinated with the material’s apparent electrical characteristics – which later were scientifically determined as this gem’s

unique piezoelectric and pyroelectric properties. When tourmaline is heated, it develops positive and negative charges at opposite ends of the crystal. Those who smoked pipes appreciated the gem’s apparent magnetic ability to draw ashes out of their pipes, which gave it the nickname *aschentrecker*, meaning “ash puller.”

Curiously, tourmaline had already arrived on European shores at the time of Pliny the Elder. In his famous series of books on natural history, Pliny described similar electrical properties in a gemstone he named “lychnis.” Because he also noted that it was reddish or violet in colour, it is believed the gem was probably tourmaline.

Confusion was sown in the 1500s when Portuguese explorers looking for emeralds in Brazil chanced upon rich, green, emerald-looking gemstones. Swiss naturalist, Conrad Gessner, saw this material in Europe. Though he classified it as “emerald,” he also included the word “Brazilian” in front of it. Obviously, in this case, Brazilian “emerald” wasn’t quite the same as the Colombian material. It was tourmaline.

In recent years, tourmaline has witnessed a true renaissance, particularly after the discovery of a copper-rich elbaite tourmaline from the State of Paraíba, Brazil. While the locality produced a modest quantity of material for a short time, its vivid colours, (described in the trade as “neon” or “electric”) caused by copper impurities, were considered so unique that they revolutionized the tourmaline business. Demand for all varieties of tourmaline has enjoyed an increase since the late 1980s, when cuprian elbaite was first discovered. Since then, similar coloured copper and/or manganese rich tourmaline has been found elsewhere in Brazil as well as in Nigeria and Mozambique.

Birthstones and anniversaries

Tourmaline is one of the birthstones for the month of October, along with opal.

Tourmaline

Description and properties

Tourmaline is a vast and complex mineral group that has many species, including the following with relevant gem varieties: dravite, uvite, rossmanite, schorl, tsilaisite, elbaite and fluor-liddicoatite. Tourmaline crystallizes in the trigonal crystal system, mostly as trigonal, prismatic crystals. Tourmalines are extremely complicated borosilicates, and the formula for many of the mineral varieties varies considerably. By way of example, International Mineralogical Association (IMA) approved formulas for some tourmalines are as follows:

Dravite:

$\text{NaMg}_3\text{Al}_6(\text{BO}_3)_3\text{Si}_6\text{O}_{18}(\text{OH})_3(\text{OH})$

Fluor-Liddicoatite: $\text{Ca}(\text{Li}_2\text{Al})$

$\text{Al}_6(\text{BO}_3)_3\text{Si}_6\text{O}_{18}(\text{OH})_3\text{F}$

Elbaite: $\text{Na}(\text{Li}_{1.5}\text{Al}_{1.5})$

$\text{Al}_6(\text{BO}_3)_3\text{Si}_6\text{O}_{18}(\text{OH})_3(\text{OH})$

Principal colour varieties:

Rubellite: Pink to red range, may also be brownish, orangey, or purplish.

Verdelite: Yellow green to bluish green.

Indicolite: Violetish to greenish blue.

Paraíba tourmaline: Vividly coloured blue to green gems in which the unusual hues result from traces of copper and/or manganese.

Dravite: Yellow to brown; the bright yellow colour has been called "canary tourmaline" in the trade.

Achroite: Colourless

Parti-colour: Two or more colours (if only two colours are seen, these gems are called bi-coloured).

Watermelon: Pink centres with green around the outer margins of the stone.

Chrome tourmaline: A deep, solidly green, chromium-containing gem.

Cat's eye tourmaline: Tiny hollow growth tubes in some cabochon-cut tourmaline cause a cat's eye effect in direct lighting.

Liddicoatite: This is the fluor-liddicoatite species of tourmaline, a calcium-rich, lithium tourmaline that was named in 1977 in honour of one of GIA's founding fathers, the noted gemmologist, Richard T. Liddicoat. This is a usually a parti-colour tourmaline par excellence and often exhibits many colours in strongly zoned, geometric patterns.

Refractive Index: 1.624 to 1.644 (+0.011, -0.009)

Birefringence: 0.018 to 0.040

Specific Gravity: 3.06 (+0.20, -0.06)

Cause(s) of colour: Blue: iron. Red and pink: manganese and some titanium. Green: iron, chromium and vanadium.

Paraíba colours: copper and/or manganese.

Mohs hardness: 7 to 7.5

Internal identifying characteristics: Tourmaline has abundant fluid inclusions, which look like thin, threadlike and elongated fingerprints. Some tourmaline also contains elongated hollow tubes that form in parallel fashion during growth, and these exhibit cat's-eye phenomena.

Treatments

Heating: This treatment aims to produce lighter green and blue green colours from overly dark gems. In cuprian elbaite, heating causes some dark manganese-bearing purple material to become strongly greenish blue or deep blue. There are some undesirable effects of heating: some pink and red tourmaline may fade to nearly colourless upon heating.

Irradiation: This treatment can be used to reportedly produce darker manganese-bearing red gems from light pink. However, it is not possible to determine treatment gemmologically.

Fracture filling: This treatment is used to conceal surface reaching fractures and fissures.

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Tourmaline

Collector quality

The term "Paraíba", derives from the Brazilian state in which particular copper-bearing tourmalines were first found. However, it soon became a widespread descriptor for the saturated colours caused by copper and/or manganese, even those found in different localities. Later, more copper bearing tourmalines were found in the neighbouring state of Rio Grande do Norte, Nigeria and Mozambique. Ultimately, copper and manganese bearing tourmaline may be called "paraiba tourmaline" in the trade. Regardless of their geographic origin, such gems highly sought after by many collectors.

Rubellite with strong colour, especially from sources that produced high qualities for short times, such as Nigeria, is collectible. Indicolite, sometimes also called indigolite, that exhibits strong blues are also very popular.

Bi-colour or parti-colour tourmaline shows strong colour zoning, parti-colour gems and cat's eye tourmaline is also collected. In rare instances when "chrome" green tourmaline is found, they are collectible, especially in larger sizes because of their vivid green colour.

Localities

Brazil remains the world's largest producer of tourmaline in all colours. The States of Paraíba and Rio Grande do Norte have produced Brazil's most coveted cuprian (copper bearing) tourmaline. Afghanistan is known for a very bright blue green quality of tourmaline, though it also produces some green and pink material. Myanmar (Burma), India, Kenya, Mozambique, Pakistan, Nigeria, Sri Lanka, Russia, Tanzania all produce significant quantities of material in various colours. The United States – California and Maine, and particularly the Pala district in Southern California, is known for producing rich pink tourmaline and rubellite. Madagascar primarily produces rubellite and liddicoatite tourmaline. Namibia, Zambia, and Zimbabwe are also sources.



Rubellite tourmaline



A bi-coloured green blue tourmaline crystal

Tourmaline

Cutting, care and cleaning

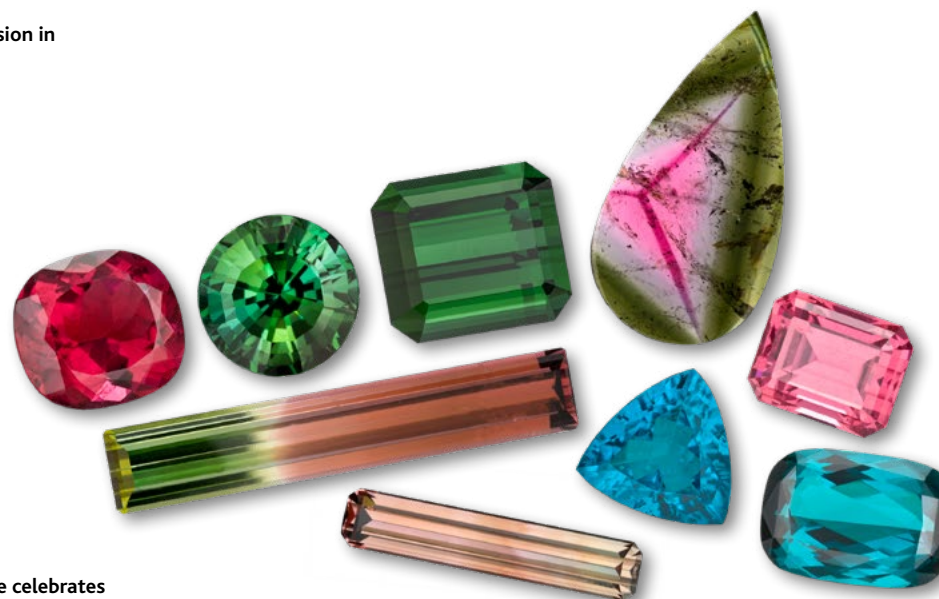
Tourmaline's elongated, prismatic crystals dictate how the gemstones are cut, often resulting in very long, rectangular shapes. While tourmaline can be cut in all shapes and sizes, rectangular shapes predominate. Crystals often exhibit more than one colour; in such cases bi-colour or parti-colour gemstones result. On occasion, tourmaline is also carved.

While tourmaline has adequate hardness, there may be zones of weakness in some gems, particularly those that have many inclusions. Some bi-colour tourmaline is weaker along the colour boundaries.

Tourmaline should not be steam cleaned or placed in an ultrasonic cleaner for these reasons. Instead, it should be cleaned with a soft damp cloth or a soft bristle toothbrush.



Pyrochlore crystal inclusion in tourmaline 1.44mm



This group of tourmaline celebrates the species' vast diversity in colour

Turquoise



Rough turquoise material as well as fashioned beads and cabochons

History, lore and appreciation

Turquoise's startling blue colours and soft, slightly porous texture may be the reasons why it has been such an important opaque gem for thousands of years and across so many civilisations. Excavations from Pharaoh mummies dating up to seven millennia ago contain evidence (turquoise bracelets) that the gem was highly prized in ancient Egypt – both as a gemstone and as an ornamental material. Successive Egyptian dynasties since then used also the gem as a symbol of good fortune, with historical sources in the Sinai Peninsula and in today's Iran.

China was a source for turquoise during the time of Marco Polo's travels, and he found that turquoise beads were traded and bartered all along the Silk Road. Along the same trading routes, magnificent Persian turquoise made its way to both the East and West. In Asia, turquoise beads were used for adornment, and also as a form of currency and protection, until the 1800s. In the West, ancient Aztecs and Mayas traded turquoise from sources now known as Southwestern U.S., and Mexico, and throughout the Americas. Further

south, in Peru, the pre-Columbian Chimú culture traded turquoise beads throughout the Southern hemisphere.

Given its colour, it comes as no surprise that many civilizations felt turquoise embodied elements of both the sky and sea. However, that colour comparison needs amplification: the colour of highly desired turquoise is described as the blue of a robin's egg, pale blue to blue-green to dark blue. Further subtle variations of colours exist. Deposits in China, for example, are known to produce a light to dark green turquoise with little or no blue component.

The name, "turquoise," comes from the 16th century French expression, *pierre de turquie*, which translates to stone from Turkey. While turquoise did not occur there, French merchants trading at Turkish bazaars likely believed that Persian turquoise traded there was from Turkey.

Birthstones and anniversaries

Turquoise is one of the birthstones for December, along with zircon and tanzanite. It is also used to celebrate an 11th wedding anniversary.

Description and properties

Turquoise is a hydrous copper phosphate mineral that crystallises in the triclinic crystal system; however turquoise is generally known in its cryptocrystalline and aggregate form. Its chemical composition is $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 5\text{H}_2\text{O}$

Colour(s): Light to medium blue, greenish blue to green; colour is often mottled and may show dark splotches or veins of matrix.

Refractive Index: 1.610 to 1.650

Birefringence: Usually not detectable.

Specific Gravity: 2.76 (+0.14, -0.36)

Cause(s) of colour: Copper for the bluish colours, whereas greens are caused by a combination of copper and iron.

Mohs hardness: 5 to 6

Turquoise

Internal identifying characteristics:

Because turquoise is always opaque, internal characteristics are not noticeable. However, turquoise may contain areas of deeper colour or variations of colour in the same gem. Matrix, a dark veining pattern that permeates some types of turquoise, is natural evidence of the element or substance in which turquoise was formed. Because matrix is softer than turquoise, it tends to weather (or erode) more quickly. As a result, the darker matrix areas are often deeper than the surrounding turquoise. Likewise, if natural turquoise is polished, matrix tends to be undercut. This means that the darker areas are generally deeper – not flush with the surface that is being polished.

Treatments

Polymer impregnation: This treatment introduces a polymer into the porous areas of turquoise. The result is a darker, more durable material.

Surface Waxing: This treatment is effective because of the porous nature of turquoise. The waxy substance used gives the turquoise a more homogenous appearance, but does not make the gem more durable. The treatment is sensitive to even low heat.

Dyeing: This treatment also works because of turquoise's porosity. The dyeing is sometimes used to deepen the colour of turquoise, or to simulate matrix.

Surface coating: Some lacquers or polymers may be used to coat the surface of the gem, deepening the colour.

Pressed turquoise, while not a treatment in the traditional sense (and thus not listed above) produces an artificial product from low quality turquoise fragments. Here, smaller sizes of turquoise are sometimes combined with chrysocolla and variscite and ground into a powder. Following this,

the powder is bonded together in a solid mass using polymer resins. Its use in jewellery is widespread. Some imitation turquoise material is represented as pressed or "reconstructed" turquoise.

Collector quality

Natural, untreated turquoise with a bright lustre and deep, blue homogenous colour – and no matrix veining is also highly collectible. The same holds true with turquoise that has known provenance.

"Spiderweb" matrix, containing fine dark lines with an attractive, even pattern surrounded by deep blue turquoise is preferred by some collectors. While turquoise from Iran (Persia) was historically a standard for the finest turquoise, material from the United States – specifically Arizona – has proven to be a fine source as well. Collectors of Native American turquoise jewellery prize material from assorted top artists who use material from several mines across the Southwest. Large carvings of superb turquoise, especially when these have been fashioned by known artists, are also highly collectible.

Localities

The United States (mainly Arizona, New Mexico, California and Nevada) and Mexico are sources for material that has been traded through the Americas for centuries. Most of the world's supply of turquoise comes from the United States and China today. Iran, notably in Neyshabur, remains the classic source for fine turquoise, though little material is presently mined there. New deposits, namely in Kerman, have been recently found. The historical Sinai Peninsula deposits in Egypt are exhausted. China, Australia and Chile are also sources for turquoise.

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Turquoise

Cutting, care and cleaning

Turquoise can be fashioned into any shape, including carvings, though in most cases the material is cut in cabochon form. They are often fashioned as free-form beads (mostly with matrix) or perfectly homogenous, round beads with little or no matrix. Because of turquoise's soft and porous nature, ultrasonic cleaners and steam cleaners should never be used to clean turquoise jewellery. The gem should be cleaned with a soft, dampened cloth. Turquoise beads may darken over time if they are in direct contact with skin.



Turquoise, rough and cut



Turquoise is most often cut in the form of a cabochon

Zircon



A zircon crystal with etch marks along the surface of its crystal face

History, lore and appreciation

Zircon is winning over fans because of its unique colours and brilliant optical characteristics. The first thing to know about zircon is that it has nothing to do with cubic zirconia (a man-made product that has been used as a diamond simulant since the 1970s). Zircon is a natural gem that might be confused with diamond in its colourless varieties, but easily separated upon closer examination. The appeal of zircon's many colour varieties lies in its extraordinary lustre, brilliance and fire, a product of high refractive indices and very high dispersion.

Three types of zircon have been identified: high-type, or alpha; low-type, or gamma; and intermediate-type, or beta. The classification is related to the degree of alteration of the crystal structure. High-type zircon has an un-altered crystal structure, like most other crystalline gems. Low-type zircon is "metamict," which means the crystal structure has been changed towards an amorphous state by natural irradiation. Partially crystalline gems, meanwhile, are in the intermediate-type classification. The appeal of

metamict zircon lies in its unique, often phenomenal effects. The word zircon derives from the Arabic *zargun*, meaning gold coloured, though, zircon is found in many colours. A range of red to orange, yellow to brown, and blue to green are found, though natural blue zircon is quite rare.

Another optical characteristic of zircon (except in metamict types) is its extreme double refraction, which is often easily visible when looking through a gem's table with the naked eye. The result is a perceived doubling of the pavilion facets and facet junctions. Its very high dispersion is behind the gem's well known fire.

Birthstones and anniversaries

Zircon is a birthstone for the month of December, together with turquoise and tanzanite.

Description and properties

Zircon is a mineral species that crystallises in the tetragonal crystal system. Its chemical composition is ZrSiO_4 .

Colour(s): Colourless, blue, yellow, green, brown, orange, red, and rarely purple

Refractive Index: The RI varies, as follows: High: 1.925 to 1.984 (± 0.040) Medium: 1.875 to 1.905 (± 0.030) Low: 1.810 to 1.815 (± 0.030) On rare occasions the RI reading is below 1.80.

Birefringence: 0.000 to 0.059 (low type has low birefringence, high type has higher birefringence).

Specific Gravity: 3.90 to 4.73 (Increases from low to high type).

Cause(s) of colour: Various colour centres.

Mohs Hardness: 6 for low type; 7.5 for high type.

Zircon

Internal identifying characteristics:

In metamict zircon, angular colour zoning or angular markings can be seen, as well as an unusual milkiness in some stones. In some metamict gems, discoid fractures within the gem result in an unusual aventurescent effect. Apatite and garnet crystals are sometimes found in zircon.

Treatments

Heat treatment: Most brown zircon is heat treated to result in different colours, including blue, red, orange or yellow. Green zircon is occasionally heated to produce a lighter tone. Induced changes in zircon's colour are not always stable; especially long-wave ultra violet radiation, and colours may revert to their original colour upon exposure.

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Collector quality

Zircon is sometimes collected in colour groups to exhibit an array of colours, and red zircon, especially in large sizes, is particularly prized. Vivid blue colours from Ratanakiri (Sri Lanka) are also highly desirable. Some collectors buy metamict gems that exhibit unique phenomenal characteristics such as aventurescence or cat's eye. Cat's eyes do occur in included material but the eye is generally indistinct.

Localities

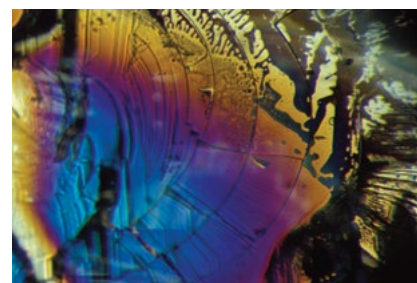
Cambodia, Sri Lanka, Myanmar (Burma), Australia, Madagascar, Tanzania, China, Brazil and Thailand are the principal sources of zircon. Reddish brown zircon from East Africa has also entered the market in recent years.

Cutting, care and cleaning

Zircon, whose optical characteristics are sometimes compared to diamond, differ greatly in terms of hardness and toughness. Zircon is quite brittle and it is recommended that zircon jewellery not be subjected to rough wear because facet junctions abrade over time with careless use. Warm soapy water or a damp cloth should be used to clean zircon. Ultrasonic or steam cleaners should not be used.



Zircon is available in a wide variety of colours



A stress fracture in zircon exhibits iridescent colours. 45X (Field of view not available)

