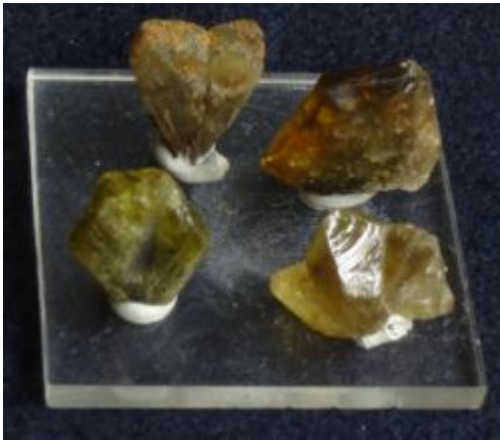


# Chrysoberyl

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## General

Category	Mineral
Chemical formula	Beryllium aluminium oxide, $\text{BeAl}_2\text{O}_4$

## Identification

Color	Various shades of green and yellow; brownish, reddish; rarely, blue
Crystal habit	slender prisms and tabular form, dimensions are thin in one direction.
Crystal system	Orthorhombic $2/m2/m2/m$
Twinning	Contact and penetration twins common, often repeated forming rosette structures
Cleavage	[110] Distinct, [010] Imperfect
Fracture	Conchoidal to uneven
Mohs Scale hardness	8.5
Luster	Vitreous
Refractive index	Biaxial (+) $n_\alpha=1.745$ $n_\beta=1.748$ $n_\gamma=1.754$
Pleochroism	Strong in alexandrite
Streak	White
Specific gravity	3.5 - 3.84

## Major varieties

Alexandrite	Color change; green to red
Cymophane	Chatoyant

The mineral or gemstone **chrysoberyl**, not to be confused with beryl, is an aluminate of beryllium with the formula  $\text{BeAl}_2\text{O}_4$ . The name chrysoberyl is derived from the Greek words *chrysos* and *beryllos*, meaning "golden" and "gem crystal". Despite the similarity of their names, chrysoberyl and beryl are two completely different gemstones. Chrysoberyl is the third hardest naturally occurring gemstone and lies between corundum and topaz on the hardness scale. Chrysoberyl is a mineral consisting of ordinary colorless or yellow transparent chrysoberyl, cymophane (chrysoberyl cat's eye), and alexandrite.

An interesting feature of uncut crystals of chrysoberyl are the cyclic twins called *trillings*. These twinned crystals have a hexagonal appearance, but are the result of a triplet of twins with each "twin" taking up 120 degrees of the cyclic trilling.

There are three main varieties of chrysoberyl; ordinary yellow chrysoberyl, cat's eye or cymophane, and alexandrite. Although yellow chrysoberyl was referred to as chrysolite during the Victorian and Edwardian eras, that name is no longer used in the gemological nomenclature.

Ordinary *chrysoberyl* is a yellowish-green, transparent to translucent *chrysoberyl* and has often been referred to in the literature as chrysolite due to the common olive color of many of its gems, but that name is no longer used in the gemological nomenclature. When the mineral exhibits good pale green to yellow color and is transparent, then it is used as a gemstone.

Alexandrite, a strongly pleochroic (trichroic) gem, will exhibit emerald green, red and orange-yellow colors and tend to change color in artificial light compared to daylight. The color change from red to green is due to strong absorption of light in the yellow and blue portions of the spectrum. Typically, alexandrite has an emerald green color in daylight but exhibit a raspberry red color in incandescent light.

Cymophane is popularly known as cat's eye. This variety exhibits pleasing chatoyant or opalescence that reminds one of an eye of a cat. When cut to produce a cabochon, the mineral forms a light-green specimen with a silky band of light extending across the surface of the stone.

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## 1. Occurrence

Chrysoberyl was formed as a result of pegmatitic processes that occurred at least 250 million years ago. High temperatures and pressures from the outer layers of the earth's mantle forced molten magma towards the surface. As the main magma body cooled, water originally present in low concentrations became more concentrated in the molten rock because it could not be incorporated into the crystallization of the localized minerals. Consequently, the remaining portion of the molten magma was water rich. It was also rich in rare elements and silica that still had not solidified. When this water-rich magma was expelled in the final stages of the crystallization, it solidified in cracks and crevasses to form a pegmatite.

If the pegmatite magma was rich in beryllium, crystals of beryl and chrysoberyl could form but for alexandrite to form, some chromium would also have had to be present. Since beryllium and chromium are extremely rare elements in rocks, this is the only known process which could have concentrated these unusual elements in an environment where crystallization could occur.

The high water content of the magma made it possible for the crystals to grow quickly, so pegmatite crystals are often quite large and this is of course important for gem specimens. Chrysoberyl is always accompanied by quartz. It occurs in granite pegmatites and mica schists and in contact with metamorphic deposits of dolomitic marble. It is also recovered from river sands and gravels in alluvial deposits with corundum, spinel, garnet and tourmaline.

Chrysoberyl has high enough specific gravity that it will concentrate with black sands in active or paleoplacer stream deposits and concentrate with other relatively heavy minerals such as cassiterite, diamond, corundum, topaz and garnet. When found in placers, it will have rounded edges instead of sharp, wedge-shape forms. Much of the chrysoberyl mined in Brazil and Sri Lanka is recovered from placers as the host rocks have been intensely weathered and eroded.

Chrysoberyl deposits can be divided into three types, excluding rare dolomitic hosts. These include chrysoberyl in pegmatites intruded into ultramafic rocks, chrysoberyl hosted by pegmatites intruded into aluminous rocks, and chrysoberyl found as a primary mineral in REE-pegmatites.

There have been very few research projects on the genesis of chrysoberyl due to its rarity in primary host rocks since most chrysoberyl is recovered from placers. However, it may be hypothesized that in order to produce chrysoberyl, metamorphic overprint of some beryllium- and aluminum-rich pegmatites may be necessary.

## 2. Chrysoberyl



Yellow chrysoberyl gemstone featuring oval step cut.

Chrysoberyl was discovered in 1789 and described and named by Abraham Gottlob Werner, in 1790. Werner worked at the Freiberg School of Mining from 1790-1793 and was well known as one of the most outstanding geologists of his time. He is best known today as the loser in the battle of the Neptunists and Vulcanists that raged in the 1780s.

Chrysoberyl is normally yellow, yellow-green, or brownish with its color being caused by the presence of iron. Spectroscopic analysis will usually reveal a strong band where the violet takes over from the blue. As the color darkens from bright yellowish-green to golden-yellow to brown, this band increases in strength. When the stone has a strong color, two additional bands can be seen in the green-blue. The most common inclusions are liquid-filled cavities containing three-phase inclusions. Stepped twin planes may be apparent in some cases. Some very rare minty bluish-green chrysoberyls from Tanzania owe their color to the presence of Vanadium.

Despite the similarity of their names, chrysoberyl and beryl are two completely different gemstones. Members of the beryl group include emerald, aquamarine, and morganite while members of the chrysoberyl group include chrysoberyl, cymaphane (cat's eye) and alexandrite. Beryl is a silicate and chrysoberyl is an oxide and although both beryl and chrysoberyl contain beryllium, they are separate gemstone species unrelated in any other way. Because of the confusion between chrysoberyl and beryl, chrysoberyl is relatively unknown in its own right and the alexandrite variety is much more widely recognized. The only well-known natural gemstones harder than chrysoberyl are corundum and diamond.

### 3. Alexandrite



Alexandrite step cut cushion, 26.75 cts. Alexandrites this large are extremely rare.

The **alexandrite** variety displays a color change (*alexandrite effect*) dependent upon light, along with strong pleochroism. Alexandrite results from small scale replacement of aluminium by chromium oxide, which is responsible for alexandrite's characteristic green to red color change. Alexandrite from the Ural Mountains in Russia is green by daylight and red by incandescent light. Other varieties of alexandrite may be yellowish or pink in daylight and a columbine or raspberry red by incandescent light. The optimum or "ideal" color change would be fine emerald green to fine purplish red, but this is exceedingly rare. Because of their rarity and the color change capability, "ideal" alexandrite gems are some of the most expensive in the world.

According to a widely popular but controversial story, alexandrite was discovered by the Finnish mineralogist Nils Gustaf Nordenskiöld, (1792 -1866) on the tsarevitch Alexander's sixteenth birthday on April 17, 1834 and named alexandrite in honor of the future Tsar Alexander II of Russia. Sometimes, Nils Gustaf Nordenskiöld is confused with his son, Adolf Erik Nordenskjöld (1832-1901), also a famous Finnish geologist, mineralogist and arctic explorer who accompanied his father to the Ural Mountains to study the iron and copper mines at Tagilsk in 1853. However, Adolf Erik Nordenskjöld was only two years old when Alexandrite was discovered and only ten years old when a description of the stone was published under the name of Alexandrite for the first time.

Although it was Nordenskjöld who discovered alexandrite, he could not possibly have discovered and named it on Alexander's birthday. Nordenskjöld's initial discovery occurred as a result of an examination of a newly found mineral sample he had received from Perovskii, which he identified as emerald at first. After the discovery of emeralds in the roots of an upturned tree, the first emerald mine had been opened in 1831, not long before Nordenskjöld had received this particular sample.

Confused with the high hardness however, he decided to continue his examinations. Later that evening, while looking at the specimen under candlelight, he was surprised to see that the color of the stone had changed to raspberry-red instead of green. Later, he confirmed the discovery of a new variety of chrysoberyl, and suggested the name "diaphanite"(from the Greek "di" two and "aphanes", unseen or "phan", to appear, or show).

The name of the first person to actually find this stone has been lost in the mists of time. However, the first person to bring it to public attention, and ensure that it would be forever associated with the Imperial family was Count Lev Alekseevich Perovskii (1792-1856.)

The finest alexandrites were found in the Ural Mountains, the largest cut stones being in the 30 carat (6 g) range, though many fine examples have been discovered in Sri Lanka (up to 65 cts.), India (Andhra Pradesh), Brazil, Myanmar, and especially Zimbabwe (small stones usually under 1 carat (200 mg) but with intense color change). Overall, stones from any locale over 5 carats (1 g) would be considered extremely rare, especially gems with fine color change. Alexandrite is both hard and tough, making it very well suited to wear in jewelry.

The gem has given rise to the adjective "alexandritic", meaning any transparent gem or material which shows a noted change in color between natural and incandescent light. Some other gem varieties of which alexandritic specimens have been found include sapphire, garnet, and spinel.

Some gemstones described as lab-grown (synthetic) alexandrite are actually corundum laced with trace elements (e.g., vanadium) or color-change spinel and are not actually chrysoberyl. As a result, they would be more accurately described as simulated alexandrite rather than synthetic but are often called Czochralski Alexandrite after the process that grows the crystals.

Synthetic alexandrite is used as an active laser medium. Alexandrite laser crystals tend to be round, with a pale brown tint.

Genuine alexandrite is one of the most expensive gemstones available commercially, with the stronger color changes being more highly valued. The following are average retail prices for alexandrite in December 2004 from The International Gem Society

<b>Faceted (Alexandrite)</b>	<b>0.5 to 1 carat</b>	<b>1 carat plus</b>
Top Red/Green	\$5,000 to \$15,000/ct	to \$100,000/ct
Medium Red/Green	\$3,000 to \$9,000/ct	to 60,000/ct
Slight Red/Green	\$100 to \$2,500/ct	to \$6,000/ct
Other colors	\$1,100 to \$8,000/ct	to \$10,000/ct
<b>Cabochon (Alexandrite)</b>	<b>0.5 to 1 carat</b>	<b>1 carat plus</b>
Strong red/green	\$500 to \$2,500/ct	to \$30,000/ct
<b>Cabochon (Cat's Eye)</b>	<b>0.5 to 1 carat</b>	<b>1 carat plus</b>
Strong red/green	\$1,500 to \$5,000	N/A

#### 4. Cymophane



Fine color Cymophane with a sharp and centered eye.

Translucent yellowish chatoyant chrysoberyl is called **cymophane** or *cat's eye*. Cymophane has its derivation also from the Greek words meaning 'wave' and 'appearance', in reference to the chatoyancy sometimes exhibited. In this variety, microscopic tubelike cavities or needlelike inclusions of rutile occur in an orientation parallel to the c-axis producing a chatoyant effect visible as a single ray of light passing across the crystal. This effect is best seen in gemstones cut in cabochon form perpendicular to the c-axis. The color in yellow chrysoberyl is due to  $Fe^{3+}$  impurities.

Although other minerals such as tourmaline, scapolite, corundum, spinel and quartz can form "cat's eye" stones similar in appearance to cymophane, the jewelry industry designates these stones as "quartz cat's eyes", or "ruby cat's eyes" and only chrysoberyl can be referred to as "cat's eye" with no other designation.

Gems lacking the silky inclusions required to produce the cat's eye effect is usually faceted. An alexandrite cat's eye is a chrysoberyl cat's eye that changes color. "Milk and honey" is a term commonly used to describe the color of the best cat's eyes. The effect refers to the sharp milky ray of white light normally crossing the cabochon as a center line along its length and overlying the honey colored background. The honey color is considered to be top by many gemologists but the lemon yellow colors are also popular and attractive. Cat's eye material is found as a small percentage of the overall chrysoberyl production wherever chrysoberyl is found.

Cat's eye really became popular by the end of the 19th century when the Duke of Connaught gave a ring with a cat's eye as an engagement token, this was sufficient to make the stone more popular and increase its value greatly. Up to that time cat's eye had predominantly been present in gem and mineral collections. The increased demand in its turn created an intensified search for it in Ceylon. Early 20th century prices could go up as high as \$ 8000 for a cut stone.