

March 2001 Mineral of the Month: Topaz

“Ever since man became acquainted with topaz, this noble stone has been paying dearly for the melodiousness of its name, which was formerly bestowed on the whole range of all yellow to brown gemstones . . . The glowing, fiery sparkle of topaz has always enchanted poets and men of taste with its beguiling resemblance to the flaming splendor of a noble wine.”-- Eduard Josef Gubelin, *The Color Treasury of Gemstones*

PHYSICAL PROPERTIES

Chemistry: $\text{Al}_2\text{SiO}_4(\text{F},\text{OH})_2$ Aluminum Silicate Fluoride Hydroxide

Class: Silicates Subclass: Nesosilicates

Dana's: Insular SiO_4 Groups and O, OH, F, and H_2O

Crystal System: Orthorhombic

Crystal Habits: Often in crystals, usually prismatic to equant; Rarely, massive

Color: Colorless, straw to wine-yellow, pink, blue, green, red, and rarely other colors.

Individual crystals may be multicolored

Luster: Vitreous

Transparency: Transparent to translucent

Streak: White

Refractive Index: 1.606-1.644

Cleavage: Perfect in one direction

Fracture: Subconchoidal to uneven; Brittle

Hardness: 8

Specific Gravity: 3.4-3.6, rising with fluorine content

Luminescence: Rarely fluoresces yellow, white, orange, greenish-yellow under both short wave and long wave ultraviolet light

Distinctive Features and Tests: Stubby crystals with wedge-shaped terminations; Prominent basal cleavage; Hardness; Infusible and insoluble.

Dana Classification Number: 52.3.1.1

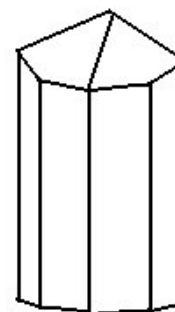


Figure 1. Topaz.

NAME

Pronounced tō'-paz, the name may come from the Greek *Topazos* or *Topazion*, meaning "to seek." *Topazos* was the name of a fogbound, hard-to-find island in the Red Sea, later known as St. John's Island and now known as Zabarah. There is some confusion regarding this origin, as this island was and is known for producing the green gemstone peridot, which the Greeks evidently also called *Topazos*. The Greeks probably used the name *Chrysolithos*, meaning "golden stone," to describe what we know of today as topaz. Until the tenth century, *Topazos* was used to describe a green mineral, again, probably peridot, not topaz. By the eleventh century, *Topazos* was applied to gems of a yellow or golden color, including real topaz as well as citrine, yellow sapphire, zircon, and garnet. It is also quite possible that the name comes from the Sanskrit *tapaz*, meaning "fire."

The first use of the name topaz to describe the mineral we know it as today was by German chemist and mineralogist Johann Friedrich Henckel (1679-1744) in 1737 when describing crystals found at Saxony, Germany. Incidentally, Henckel's collection of more than two thousand specimens was later bequeathed to the mineralogical museum of the Royal Academy of Science in St. Petersburg.

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COMPOSITION

The appeal of topaz is so great both to mineral collectors and gemstone lovers alike that one could easily write a book about its fascinating properties. (In fact, one has, a gentleman named D.B. Hoover in 1992, called simply *Topaz*. The Leon Uris book and Alfred Hitchcock film of the same name evidently have nothing to do with gems or minerals, but rather spies during the cold war.) From its formula, $\text{Al}_2\text{SiO}_4(\text{F},\text{OH})_2$ we recognize these elements in these proportions, by molecular weight: aluminum (Al) 29.61%, silicon 15.41%, oxygen 43.02%, fluorine 11.47%, and hydrogen, .50%. The inclusion of fluorine and hydroxyl in parentheses in the formula indicates that either of these two molecules may occupy the same position in the atomic structure, so that a typical topaz crystal usually has both these molecules in it. Fluorine dominates in most topaz, and no topaz has been found yet with more than 30% hydroxyl substitution for fluorine. (The topaz with the highest hydroxyl content found so far comes from the Brewer gold mine, Jefferson, Chesterfield County, South Carolina.) Scientists have synthesized hydroxyl-rich topaz at high pressures, but collectors have not found any in nature yet.

The ratio of fluorine to hydroxyl affects the crystal structure of topaz, and alters some of its physical properties. As the fluorine content increases, so does the density and the optical angle, while the refractive indices are lowered. Interestingly, the common crystal forms remains constant! Since topaz crystallizes in the orthorhombic system, we can expect to see the diamond-shaped cross section typical of that system. Two minerals are structurally related to topaz, namely, andalusite and danburite. A topaz polymorph with lower symmetry crystallizing in the triclinic crystal system was discovered in 1980. In this polymorph, the basic atomic structure is the same, except that hydroxyl molecules replace fluorine only at certain sites in the structure, causing a decrease in symmetry!

COLLECTING LOCALITIES

In the United States, exceptional topaz crystals are found at several localities in Maine and New Hampshire; in the Pike's Peak region and at Ruby Mountain, Nathrop; Colorado; and at the Little Three Mine, Ramona, and the Blue Lady Mine, Aguanga Mountain, both in San Diego County, California. Both Texas and Utah have selected topaz as their state gems, for good reason: fine natural blue gemstones have been cut from topaz crystals found in pockets in granite in Mason County, west Texas, and blue topaz crystal fragments are found in creek beds there; while sherry-colored topaz crystals are found in abundance in the Thomas Range, Juab County, Utah. The state of Utah has declared this range a special rockhound area, so if you can visit southern Utah, you can dig your own topaz crystals! But be careful with your treasure, as Thomas Range topaz loses their color when exposed to sunlight.

At shows and in collections we might see exceptional topaz specimens from the Volyn region of Ukraine, along with these other localities from Russia: Miask, Ilmen Mountains; in the mineral-rich Ural Mountains, where nearly equant crystals of natural blue topaz come from the Alabaschka-Mursinka region, and pink, and the very rare red topaz are found at Sanarka, Orenburg district; also from the Adun-Tschilon Mountains, Nertschinsk, and the Urulga River area; and in the Transbaikalian region of Siberia. In Pakistan, deep pink crystals are dug at Katlang, Mardan district, suitable for faceting into gorgeous, valuable gemstones, and well-formed, colorless to yellow-brown topaz crystals are abundant in the Shingus and Dusso regions of northern Pakistan. Other worldwide localities include Madagascar, Mozambique, Namibia, Nigeria, Zimbabwe, and Japan.

In Brazil, besides the Ouro Preto region where our crystals were uncovered, topaz is regularly found in a pegmatite belt that extends northward from Minas Gerais through the states of Bahia, Paraiba, and Rio

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Grande do Norte, up to Ceara. These granitic pegmatites (see the September 1997 Star Mica write-up under Other Interesting Facts for a discussion of pegmatites) produce colorless, pale yellow, and pale blue crystals, along with gem tourmaline, aquamarine, morganite, amazonite, chrysoberyl, columbite-tantalite, and cassiterite.

JEWELRY & DECORATIVE USES

Topaz has several properties that make it ideal for gemstone use, especially its hardness, clarity, transparency, and tendency to form in crystals large enough for fashioning of gemstones of several carats or more. Its hardness of eight means it will accept a very high polish, to the extent that its slippery feel helps experienced gem dealers in differentiating it from other gemstones! Its major drawback is its near-perfect basal cleavage. Gemstone cutters must be extremely careful in orienting the stone so as not to pressure it into breaking off at this natural plane of weakness during faceting. Jewelers must exercise the same care when setting topaz so as not to break it. This ready cleavage means topaz is more likely to break when subjected to the natural blows common to stones worn in ring settings, calling for extra care on the wearer's part, and we must all be careful not to drop our specimen lest we experience first hand this perfect cleavage!

Because of the widespread practice of selling heat-treated citrine under misleading names like Citrine Topaz, Gold Topaz, or Madeira Topaz, real topaz is sometimes called Precious Topaz to differentiate it (see the February 2000 citrine write-up under *Jewelry & Decorative Uses* for details). True topaz can often be separated from citrine by its greater luster and warmer, more velvety tone, and is more likely to have an orange or pinkish tone. Let's look at the most common colors found in topaz gemstones, the causes of these colors, and where they are found, in ascending order of value.

Colorless topaz is the most plentiful and the least valuable. This is mainly because all colorless gemstones lack the fire of that most valuable colorless gemstone, diamond. Many amateur stone cutters like to work with colorless topaz because it is abundant, affordable, and has good hardness and luster. Because of its relatively low monetary value, miners will usually only export fine quality rough free of inclusions, casting the rest aside. Colorless topaz is mined in Brazil, Russia, the United States, Germany (where the first crystals to be called Topaz were found,) Japan, Nigeria, Namibia, and Zaire.

As mentioned, pure topaz is colorless. So where do all the lovely shades come from? Scientists still do not fully understand. It is known that chromium partially substituting for aluminum in the topaz structure is the cause of most pink color, that manganese also may substitute for aluminum resulting in a pretty pale pink, and that iron may substitute for aluminum, causing some of the yellow and blue shades. But it is the presence of **color centers** that account for most of the delicately beautiful shades. A color center is a defect in the crystal structure, usually caused by impurities, missing ions, or imperfections in the crystal structure that selectively absorbs a portion of visible light. In topaz, when such a color center is affected by naturally occurring radiation in the earth, electrons are displaced, either becoming trapped to form **hole centers** (absence of an electron) or **electron centers** (an excess electron), resulting in the shades of blue and yellow common in topaz. When both chromium and a color center are present, other shades, such as the gorgeous rich red may occur.

Blue topaz is probably the most common color seen in topaz gemstones today. It is found in sufficient quantities that sizable, inclusion free or nearly so gemstones are common. Natural blue topaz is a uniform sky blue in color, usually pale. Almost all brightly colored or intensely colored blue topaz on the market today is produced by irradiating and then heat-treating colorless topaz, activating the color

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center, as described above. Such stones must be stored to allow the radioactivity to decay, usually just a matter of hours or days, and the color change is permanent. (Irradiated green topaz, however, is unstable, and must be protected from sunlight to prevent color fading.) Irradiated blue topaz is offered for sale under names such as "Sky Topaz," "London Blue Topaz," "Swiss Topaz," "Cobalt Topaz," each signifying a different shade of blue. All are lovely shades of blue and very affordable, while a natural blue stone is of much greater value than an irradiated one. Natural blue topaz is found in the United States, Mexico, Brazil, in the Mogok region of Myanmar where our featured red spinels came from, the Ural Mountains and the Kamchatka Peninsula, Russia, as well as Nigeria and Namibia.

The best-known topaz color in gemstones is yellow, from golden yellow to honey yellow, sometimes with a pink or reddish tinge. Included in this group are the shades known as "Golden Topaz" and "Sherry Topaz." Crystals with these colors are sometimes irradiated to intensify the shade, so if one desires to purchase a natural stone, dealing with an experienced, trusted dealer is always best. Yellow topaz is mined mainly in Brazil, and in small quantities in the United States, Russia, Japan, Myanmar, and Sri Lanka.

The most valuable topaz color is pink. (Actually, the yellow color grades into pink, and there are many intermediates, so that pink topaz often has a yellowish or orange shade.) Light to medium pink is the most common color, and as the color deepens it moves toward red, including wine red, and purple. Occasionally, a crystal with color zoning is found, from which a gemstone of incredible beauty may be fashioned. Pink topaz with intense color is among the most valuable of the "second tier" gemstones. In the recent past, both pink and yellow topaz stones were highly valued, perhaps even more so than today, and are commonly seen in antique jewelry. Pink topaz comes mainly from Brazil, and from Pakistan.

Other shades of topaz, such as green or red, are rare and valuable if the stone is large in size, free of inclusions, and has intense color.

Did we mention large topaz gemstones and crystals? Among huge gemstones are a faceted 36,853-carat champagne colored topaz from Brazil; a 34,650-carat stone cut from a 79-pound Brazilian crystal, a crystal so large that the 21,327-carat "Brazilian Princess" was cut from this same crystal! Also outstanding is a 22,892-carat yellow topaz called the "American Golden" that now resides at the Smithsonian Institute. The faceting of this Brazilian crystal was partially paid for by the American Federation of Mineralogical Societies and this beauty is occasionally displayed at gem and mineral shows around the country! Though dwarfed in size by some of these monsters, the largest faceted red topaz in the world is an oval brilliant-cut gem weighing 70.40 carats, in a shade of red almost too beautiful to believe.

Large crystals? In Russia, a single crystal weighing 248 pounds was unearthed, while a colorless topaz crystal weighing over 600 pounds is on display at the American Museum of Natural History in New York City! This massive beauty sits uncovered and the public is allowed to touch it. After digging a tunnel more than 260 feet long, workers in Brazil were able to bring to the surface what may well be the world's largest topaz crystal. It weighs approximately eight tons, stands over six feet tall, and is nearly that wide/ White in color, its value is estimated at \$4.5 million!

HISTORY & LORE

You may enjoy rereading the opening quotation in the box on page one of this write-up. Mankind's love

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affair with this warm-toned stone dates back at least to Bible times. The Jewish high priest wore a topaz with the name of one of the twelve tribes of Israel engraved on it on his "breastpiece of judgement," the sacred embroidered pouch worn over the heart of the High Priest when he entered the Holy compartment of the tabernacle, and later the temple. Topaz was also loved by the Egyptians and Romans, the latter importing theirs all the way from Sri Lanka. In the description of the holy city New Jerusalem found in the Bible book of Revelation, each of the foundations of the city's walls was adorned with a precious stone, topaz being the ninth foundation stone.

Evidently topaz was underappreciated in Europe during the Middle Ages, although it was occasionally used in royal jewelry. By the eighteenth century, Spanish and French noblemen had reacquainted themselves with the lovely luster of topaz, utilizing it along with diamonds in magnificent jewelry. Augustus the Strong of Poland loved topaz and used it freely in his court jewelry. Soon, topaz and amethyst were the stones of choice for earrings and necklaces in France and Germany. The Braganza Diamond, a 1680-carat colorless stone in the Portuguese Crown Jewels turned out to be large topaz, while a topaz said to be half as big as a pigeon's egg was recognized in 1929 as a yellow diamond! Topaz held onto its popularity through the Victorian Era and right into the Art Deco period of the twentieth century. And, of course, topaz is the November birth stone, perhaps because its best-known color, a warm yellow, resembles the shades of autumn. It is also seen as a symbol of friendship.

Topaz was thought of as a powerful talisman by the Chinese, Burmese, and others. During the Middle Ages, writers ascribed to topaz the power to strengthen the mind, prevent mental problems, and prevent sudden death. It was recommended as a cure for bad vision and madness, a means of increasing one's wisdom, a means of cooling both boiling water and boiling tempers, and, when engraved with a falcon figure, as a means of cultivating the good will of powerful people.

Modern crystal power believers ascribe these powers to the different colors of topaz: blue enhances communication of messages from other planes and diminishes nervousness, colorless strengthens stability and diversity and diminishes impurities, pink strengthens honor and the ability to love honestly, and yellow enhances self-confidence, optimism, creativity, and abundance, and lessens the "blues" and stagnation.

ABOUT OUR SPECIMENS

Onward we go, to the Ouro Preto area, in the state of Minas Gerais, Brazil, original home of our specimens! Gold was discovered here in 1696 by Portuguese adventurers, and not long after, the city of Ouro Preto was founded. The name means "Black Gold" in reference to the black coating, probably niobium oxide, found on the local gold. Ouro Preto is thus one of the oldest cities in Brazil, and said to be the home of the idea of Brazilian independence. It also served as the first capital of Minas Gerais, until the capital was moved to Belo Horizonte. It sits at the foot of the Ouro Preto hill in the mountain range called Serra do Espinhaco, more than 3000 feet above sea level. (The name Ouro Preto is used for the city and for the area or district where the topaz mines are.)

The miners began to notice an abundance of yellow crystals in the area, and in 1751 a "Brazilian ruby" was discovered here. In the years that followed, more topaz deposits were found, but it wasn't until 1768 that the news of the discovery reached the Portuguese Royal Court at Lisbon. Naturally, they were delighted about the new find, and mining has taken place ever since, not just for topaz, but for iron, manganese, and gold.

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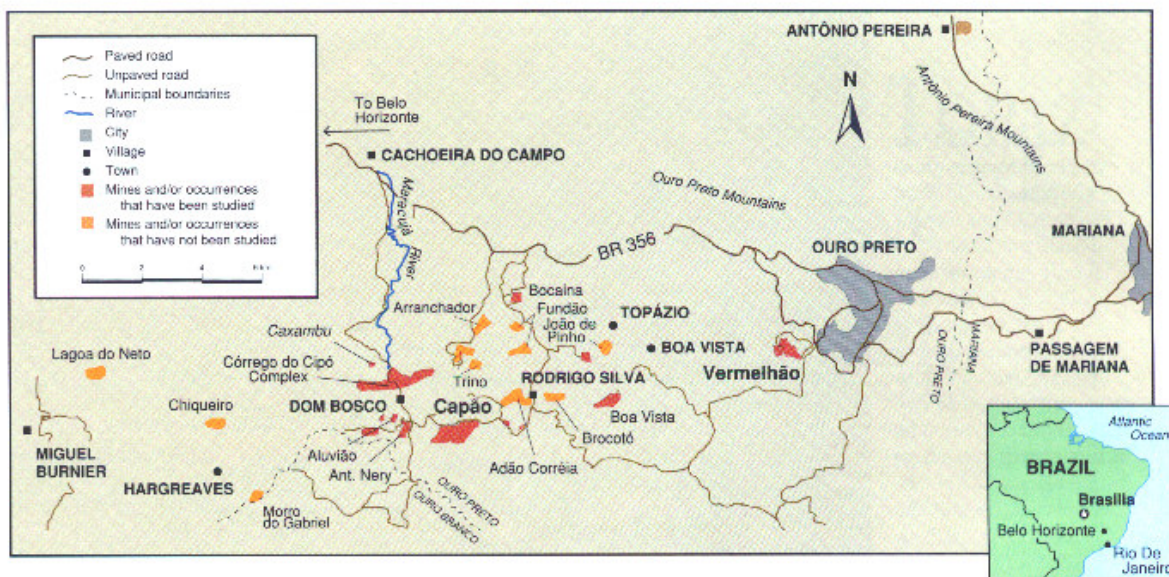


Figure 2. The many topaz deposits in the Ouro Preto area. You can see the large Capão mine to the southwest of the town of Rodrigo Silva. Map based on a 1987 map produced by the Minas Gerais Light and Power Company, used by permission of *Gems & Gemology* magazine.

As a quick glance at the above map shows, topaz is collected at a number of places in the Ouro Preto district. Most of our specimens come from the Capão Mine, just southwest of the city of Rodrigo Silva on the map. The Capão Mine and the Vermelhão Mine are the two major topaz workings in the area, the rest being abandoned mines, minor occurrences, and areas where topaz crystals are found loose in gravel. As of 1996, mining at Capão was being accomplished in two large open pits, one more than a thousand feet wide and ninety feet deep, and one about sixty feet wide and more than fifty feet deep. The pits were being worked with drag scrapers, basically a large bucket attached to an overhead wire. Bulldozers loosen and push the soft soil and rock into the path of the drag scraper, which scoops it up and dumps it in a large bucket at the top of the pit. The soft rock means that blasting is not necessary, which means less destruction of crystals! Water cannons are used to push the material through screens that separate out larger rocks and small particles. The small amount left over is washed again to remove clay, then run through two more screens that remove anything over 1¼", (which is disposed of,) or less than 5/8". The remaining material is thus separated into two size ranges, less than 5/8", and 5/8" to 1¼", and stored in two silos to be inspected during the rainy season, when mining operations slow down.

Work stops when the bulldozers uncover a vein of white **kaolinite**, a soft white clay mineral formed by the alteration of feldspar and mica minerals. This clay makes a soft, cushiony bed for the preservation of crystals here, and in other places, as well. It is in the kaolinite that most of the topaz crystals are found, along with quartz, euclase, fluorite, hematite, specular hematite, rutile, zircon, and others minerals. Occasionally, a translucent topaz crystal is found that has grown right on a quartz crystal in a most striking combination! The Ouro Preto area is the type locality for euclase [BeAlSiO₄(OH)], which was described and named in 1792. Small, gemmy euclase crystals, usually colorless or pale blue, green or yellow, are occasionally found at Capão and the surrounding localities and fetch very high prices. When workers find a kaolinite vein, three special workers wearing red helmets are then sent to scrape the vein

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by hand and recover the topaz crystals. (The rest of the workers wear white helmets.) Because of topaz's easy cleavage, almost every crystal has broken off from its original matrix in the millions of years since they formed. Rarely, a double terminated crystal is found. The largest crystal recovered so far at the Capão Mine was almost three pounds, but was found broken in four pieces. Core samples indicate that the topaz-producing zone goes down at least another 120 to 150 feet, so we may hope to see many more fine Imperial Topaz crystals and gems in the future!

Processing occurs by placing the sorted material on conveyor belts where workers sort out the topaz crystals, which are placed in a tube that runs along the conveyor belt. At the end of the day, a supervisor runs water through the tube and collects all the topaz in a bag at the end, where it is placed in a locked box for final inspection. Because faceted stones and faceting rough are generally of the greatest value, most crystals with good color, translucence, and that are free of fractures and other defects will be set aside for this purpose. The rest will be made available to mineral dealers. Only about one to two percent of all the recovered material is of facet grade. At Capão in 1995, less than 100 kilograms (about 220 pounds) of topaz crystals were recovered, producing about 66,000 carats of Imperial topaz for the year.



Figure 3. Topaz crystals glistening in the sun on the roof of a home of a gem dealer in Brazil.

One collector flies down to the region to meet with the local dealers to purchase the best quality crystals. They get together on the roof of a house so he can inspect each crystal in daylight for good color and undamaged terminations. One such lot is seen in the photo— would you like to sort through these to pick out the best?

“Topaz is found in a broad range of colors at the Capão Mine: light yellow, orange-yellow, brownish orange, pinkish orange (“salmon” or “peach”), pink, reddish orange, orange-red, and “sherry” red. All of these colors of topaz from the Ouro Preto deposits are traded as ‘Imperial’,” says the 1996 *Gems & Gemology*. (In all the references we checked, we found nothing about the origin of the “Imperial” designation, or when it began to be used.) The rarest color found here is pinkish purple to purple, and years have passed between finds of it. Even when a small pocket is discovered, more often than not the crystals are too included for gem use. Very rarely, a bicolored topaz is found, breathtaking when faceted!

The next rarest color found at Capão is a slightly brownish or “sherry” red, the most desired of all topaz colors in the gem market. Less than one half of one percent of the facetable stones found here are of this color! It follows that these are also the most expensive when faceted, and can command hundreds of dollars per carat, especially in larger sizes.

The Brazilians have learned to heat treat some of the brownish yellow or orange topaz to change the color to peach-pink. Heat treating effectively removes the yellow color center. They do this by placing the crystals in a small clay tray in an oven, bringing the temperature up to 1050°, then turning the oven off and letting the crystals slowly cool. Most topaz cannot be heated, however, as they crack due to natural inclusions. The *Gems and Gemology* lists some of these inclusions, mentioning “liquid-and-gas, breadcrumb-like crystal clusters, needle-like voids, transparent-to-translucent rhombohedral crystals or

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negative crystals, and finger-print-like patterns of liquid inclusions.” No doubt, most of these are observable only under high magnification, so if you have access to a 10x or more lens, be sure to take a close look inside your crystal!

Once heat-treated to a peach-to-pink color, the color is permanent and does not fade. Since these colors are also found naturally at the topaz mines, some might argue that the heat-treating is simply imitating what nature does. *Gems & Gemology* points out that heat-treated pink stones fluoresce a strong yellowish-to-greenish white to short-wave ultraviolet radiation, while the same crystals prior to heat-treating show a weak to moderately chalky yellow-green. This was the only difference their laboratories were able to discern as a means of identifying heat-treated stones, and these results are considered only preliminary. (One of the main objectives of the GIA is to examine and identify stones that have been affected by the various gem treatments in practice today, and make known to jewelers and the general public how to distinguish natural from enhanced stones, as the naturals are generally of greater value.) We noticed that some of our topaz crystals showed a light greenish-yellow in short wave ultraviolet light, and that the color seemed to be concentrated along the edges of the crystal faces.

The batch of topaz crystals that we picked out for Club members reflects the wide range of yellow and orange colors mentioned above. We also enjoyed, as you no doubt will too, the perfect symmetry of the diamond cross-section orthorhombic crystals, looking like to drawing to the right. We also enjoyed searching for inclusions and color zones with our 10x power lens. In fact, researching this write-up and examining our crystals has really inspired “Topaz fever” in us, and we will be looking to add other colors of topaz from Ouro Preto and elsewhere to our collection! How about you?

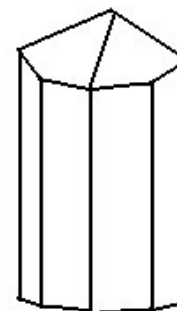


Figure 4. Rendition of topaz crystal showing an ideally symmetrical form.

References: Mineralogy, John Sinkankas, Van Nostrand Reinhold Company; Dana's New Mineralogy, Richard V. Gaines, et al, John Wiley & Sons, Inc.; Fleischer's 1999 Glossary of Mineral Species, Joseph A. Mandarino, The Mineralogical Record, Inc. Minerals, George Robinson, Ph.D., Simon & Schuster; Gems & Crystals of the American Museum of Natural History, Anna S. Sofianides & George E. Harlow, Simon & Schuster; Gem & Lapidary Materials, June Culp Zeitner, Geoscience Press; Gemstones of the World, Waler Schumann, Sterling Publishing Company, Inc.; The Color Treasury of Gemstones, Edward Josef Gubelin, Thomas Y. Crowell Company; Simon & Schuster's Guide to Gems and Precious Stones, Kennie Lyman, editor, Simon & Schuster; Gemstones, Paul O'Neil, Time-Life Books; Sinkankas' Standard Catalog of Gem Values, John Sinkankas, Geoscience Press; The Curious Lore of Precious Stones, George Frederick Kunz, Dover Publications; Insight on the Scriptures, Watchtower Bible & Tract Society of Pennsylvania; Gemstone Enhancement and Detection on the 1990s, Shane F. McClure and Christopher P. Smith, *Gems & Gemology*, Winter 2000; An Update on Imperial Topaz from the Capão Mine, Minas Gerais, Brazil, *Gems & Gemology*, Winter 1996; Topaz: A Mineralogical Review, Michael A. Wise, *Rocks & Minerals* Jan/Feb 1995; Famous Mineral Localities: The Ouro Preto Topaz Mines, J. P. Cassedanne, *Mineralogical Record* May-June 1989; Colored Gemstones '88, Bob Jones, *Rock & Gem*, April 1988; Topaz, Bob Jones, *Rock & Gem* March 1995; Topaz— November's Birth Stone, Chuck Gill, *Gems & Minerals*, November 1980; Imperial Topaz From Brazil, Francisco Müller Bastos, F.G.A., G.G., *Lapidary Journal* November 1976; The Topaz Mines of Ouro Preto, Francisco Miller Bastos, *Lapidary Journal* November 1964; Topaz— Gem of Confusion, *Gems & Minerals*, July 1961