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**Quartz** is the second-most-abundant [mineral](/wiki/Mineral) in [Earth's](/wiki/Earth) [continental crust](/wiki/Continental_crust), after [feldspar](/wiki/Feldspar). Its [crystal structure](/wiki/Crystal_structure) is a continuous framework of SiO4 [silicon](/wiki/Silicon)–[oxygen](/wiki/Oxygen) [tetrahedra](/wiki/Tetrahedron), with each oxygen being shared between two tetrahedra, giving an overall [chemical formula](/wiki/Chemical_formula) of [SiO2](/wiki/Silicon_dioxide).

There are many different varieties of quartz, several of which are semi-precious [gemstones](/wiki/Gemstone). Since antiquity, varieties of quartz have been the most commonly used minerals in the making of [jewelry](/wiki/Jewellery) and [hardstone carvings](/wiki/Hardstone_carving), especially in Europe and the Middle East.

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## Etymology[[edit](/index.php?title=(none)&action=edit&section=1)]

The word "quartz" is derived from the [German](/wiki/German_language) word "Quarz" and its [Middle High German](/wiki/Middle_High_German) ancestor "twarc", which probably originated in [Slavic](/wiki/Slavic_languages), [cf.](/wiki/Cf.) Czech *tvrdý* ("hard"), Polish *twardy* ("hard"), Serbian and Croatian *tvrd* ("hard").[[1]](#cite_note-1) The [Ancient Greeks](/wiki/Ancient_Greece) referred to quartz as κρύσταλλος (*krustallos*) derived from the [Ancient Greek](/wiki/Ancient_Greek) *κρύος* (*kruos*) meaning "icy cold", because some [philosophers](/wiki/Philosopher) (including [Theophrastus](/wiki/Theophrastus)) apparently believed the mineral to be a form of [supercooled](/wiki/Supercooling) ice.[[2]](#cite_note-2) Today, the term *rock crystal* is sometimes used as an alternative name for the purest form of quartz.

## Crystal habit and structure[[edit](/index.php?title=(none)&action=edit&section=2)]

Quartz belongs to the [trigonal crystal system](/wiki/Trigonal_crystal_system). The [ideal crystal shape](/wiki/Crystal_habit) is a six-sided [prism](/wiki/Prism_(geometry)) terminating with six-sided [pyramids](/wiki/Pyramid) at each end. In nature quartz crystals are often [twinned](/wiki/Crystal_twinning), distorted, or so intergrown with adjacent crystals of quartz or other minerals as to only show part of this shape, or to lack obvious crystal faces altogether and appear massive. Well-formed crystals typically form in a 'bed' that has unconstrained growth into a void; usually the crystals are attached at the other end to a matrix and only one termination pyramid is present. However, doubly terminated crystals do occur where they develop freely without attachment, for instance within [gypsum](/wiki/Gypsum). A quartz [geode](/wiki/Geode) is such a situation where the void is approximately spherical in shape, lined with a bed of crystals pointing inward.

α-quartz crystallizes in the trigonal crystal system, [space group](/wiki/Space_group) *P*3121 and *P*3221 respectively. β-quartz belongs to the hexagonal system, space group *P*6222 and *P*6422, respectively.[[3]](#cite_note-3) These space groups are truly chiral (they each belong to the 11 enantiomorphous pairs). Both α-quartz and β-quartz are examples of chiral crystal structures composed of achiral building blocks (SiO4 tetrahedra in the present case). The transformation between α- and β-quartz only involves a comparatively minor rotation of the tetrahedra with respect to one another, without change in the way they are linked.

<gallery> File:a-quartz.png|Crystal structure of α-quartz (red balls are oxygen, grey are silicon) File:b-quartz.png|β-quartz </gallery>

## Varieties (according to microstructure)[[edit](/index.php?title=(none)&action=edit&section=3)]

Although many of the varietal names historically arose from the color of the mineral, current scientific naming schemes refer primarily to the microstructure of the mineral. Color is a secondary identifier for the cryptocrystalline minerals, although it is a primary identifier for the macrocrystalline varieties.

|  |  |
| --- | --- |
| Major varieties of quartz | |
| [Chalcedony](/wiki/Chalcedony) | Cryptocrystalline quartz and moganite mixture. The term is generally only used for white or lightly colored material. Otherwise more specific names are used. |
| [Agate](/wiki/Agate) | Multi-colored, banded chalcedony, semi-translucent to translucent |
| [Onyx](/wiki/Onyx) | Agate where the bands are straight, parallel and consistent in size. |
| [Jasper](/wiki/Jasper) | Opaque cryptocrystalline quartz, typically red to brown |
| [Aventurine](/wiki/Aventurine) | Translucent chalcedony with small inclusions (usually mica) that shimmer. |
| [Tiger's eye](/wiki/Tiger's_eye) | Fibrous gold to red-brown colored quartz, exhibiting [chatoyancy](/wiki/Chatoyancy). |
| Rock crystal | Clear, colorless |
| [Amethyst](/wiki/Amethyst) | Purple, transparent |
| [Citrine](/wiki/#Citrine) | Yellow to reddish orange to brown, greenish yellow |
| [Vermarine](/wiki/Vermarine) | Mint green, transparent |
| [Rose quartz](/wiki/#Rose_quartz) | Pink, translucent, may display [diasterism](/wiki/Asterism_(gemology)) |
| Rutilated quartz | Contains [acicular](/wiki/Acicular_(crystal_habit)) (needle-like) [inclusions](/wiki/Inclusion_(mineral)) of [rutile](/wiki/Rutile) |
| [Milky quartz](/wiki/#Milky_quartz) | White, translucent to opaque, may display [diasterism](/wiki/Asterism_(gemology)) |
| [Smoky quartz](/wiki/Smoky_quartz) | Brown to gray, opaque |
| [Carnelian](/wiki/Carnelian) | Reddish orange chalcedony, translucent |
| Dumortierite quartz | Contains large amounts of [dumortierite](/wiki/Dumortierite) crystals |

## Varieties (according to color)[[edit](/index.php?title=(none)&action=edit&section=4)]

[thumb|right|150px|Clear rock crystals on a white base](/wiki/File:Quartz_2(USA).jpg)

Pure quartz, traditionally called rock crystal or clear quartz, is colorless and [transparent](/wiki/Transparency_and_translucency) or translucent, and has often been used for [hardstone carvings](/wiki/Hardstone_carving), such as the [Lothair Crystal](/wiki/Lothair_Crystal). Common colored varieties include citrine, rose quartz, amethyst, smoky quartz, milky quartz, and others.

The most important distinction between types of quartz is that of *macrocrystalline* (individual crystals visible to the unaided eye) and the [microcrystalline](/wiki/Microcrystalline) or [cryptocrystalline](/wiki/Cryptocrystalline) varieties (aggregates of crystals visible only under high magnification). The cryptocrystalline varieties are either translucent or mostly opaque, while the transparent varieties tend to be macrocrystalline. [Chalcedony](/wiki/Chalcedony) is a cryptocrystalline form of silica consisting of fine intergrowths of both quartz, and its [monoclinic](/wiki/Monoclinic_crystal_system) polymorph [moganite](/wiki/Moganite).[[4]](#cite_note-4) Other opaque gemstone varieties of quartz, or mixed rocks including quartz, often including contrasting bands or patterns of color, are [agate](/wiki/Agate), [carnelian](/wiki/Carnelian) or sard, [onyx](/wiki/Onyx), [heliotrope](/wiki/Heliotrope_(mineral)), and [jasper](/wiki/Jasper).

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### Amethyst[[edit](/index.php?title=(none)&action=edit&section=5)]

[thumb|right|150px|Amethyst crystals on matrix](/wiki/File:Amethyse_de_Guerrero.jpg)

[Amethyst](/wiki/Amethyst) is a popular form of quartz that ranges from a bright to dark or dull purple color. The world's largest deposits of amethysts can be found in Brazil, Mexico, Uruguay, Russia, France, Namibia and Morocco. Sometimes amethyst and citrine are found growing in the same crystal. It is then referred to as [ametrine](/wiki/Ametrine). An amethyst is formed when there is iron in the area where it was formed.

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### Citrine[[edit](/index.php?title=(none)&action=edit&section=6)]

[thumb|right|150px|Citrine from Brazil](/wiki/File:Citrine-sample2.jpg)

Citrine is a variety of quartz whose color ranges from a pale yellow to brown due to [ferric](/wiki/Ferric) impurities. Natural citrines are rare; most commercial citrines are heat-treated [amethysts](/wiki/Amethyst) or [smoky quartzes](/wiki/Smoky_quartz). However, a heat-treated amethyst will have small lines in the crystal, as opposed to a natural citrine's cloudy or smokey appearance. It is nearly impossible to differentiate between cut citrine and yellow [topaz](/wiki/Topaz) visually, but they differ in [hardness](/wiki/Mohs_scale_of_mineral_hardness). Brazil is the leading producer of citrine, with much of its production coming from the state of [Rio Grande do Sul](/wiki/Rio_Grande_do_Sul). The name is derived from the Latin word *citrina* which means "yellow" and is also the origin of the word "[citron](/wiki/Citron)". Sometimes citrine and amethyst can be found together in the same crystal, which is then referred to as [ametrine](/wiki/Ametrine).[[5]](#cite_note-5) Citrine has been referred to as the "merchant's stone" or "money stone", due to a superstition that it would bring prosperity.[[6]](#cite_note-6) [Template:Clear](/wiki/Template:Clear)

### Milky quartz[[edit](/index.php?title=(none)&action=edit&section=7)]

[thumb|right|150px|Milky quartz sample](/wiki/File:QuartzUSGOV.jpg)

Milk quartz or milky quartz is the most common variety of crystalline quartz. The white color is caused by minute [fluid inclusions](/wiki/Fluid_inclusions) of gas, liquid, or both, trapped during crystal formation,[Template:Citation needed](/wiki/Template:Citation_needed) making it of little value for optical and quality gemstone applications.[[7]](#cite_note-7) [Template:Clear](/wiki/Template:Clear)

### Rose quartz[[edit](/index.php?title=(none)&action=edit&section=8)]

[thumb|right|150px|Rose quartz cluster (Size: 3.4 x 3.1 x 1.9 cm)](/wiki/File:Quartz-137772.jpg)

Rose quartz is a type of quartz which exhibits a pale pink to rose red hue. The color is usually considered as due to trace amounts of [titanium](/wiki/Titanium), [iron](/wiki/Iron), or [manganese](/wiki/Manganese), in the massive material. Some rose quartz contains microscopic [rutile](/wiki/Rutile) needles which produces an [asterism](/wiki/Asterism_(gemology)) in transmitted light. Recent [X-ray diffraction](/wiki/X-ray_crystallography) studies suggest that the color is due to thin microscopic fibers of possibly [dumortierite](/wiki/Dumortierite) within the massive quartz.[[8]](#cite_note-8) Additionally, there is a rare type of pink quartz (also frequently called crystalline rose quartz) with color that is thought to be caused by trace amounts of [phosphate](/wiki/Phosphate) or [aluminium](/wiki/Aluminium). The color in crystals is apparently photosensitive and subject to fading. The first crystals were found in a [pegmatite](/wiki/Pegmatite) found near [Rumford](/wiki/Rumford,_Maine), [Maine](/wiki/Maine), USA and in [Minas Gerais](/wiki/Minas_Gerais), [Brazil](/wiki/Brazil).[[9]](#cite_note-9) [Template:Clear](/wiki/Template:Clear)

### Smoky quartz[[edit](/index.php?title=(none)&action=edit&section=9)]

[thumb|right|150px|Smoky quartz from the Alps](/wiki/File:Quartz-168661.jpg)

[Smoky quartz](/wiki/Smoky_quartz) is a gray, translucent version of quartz. It ranges in clarity from almost complete transparency to a brownish-gray crystal that is almost opaque. Some can also be black.

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### Vermarine[[edit](/index.php?title=(none)&action=edit&section=10)]

[thumb|right|150px|Raw natural vermarine](/wiki/File:Green_quartz.jpg) [Vermarine](/wiki/Vermarine), also known as *prasiolite*, is a variety of quartz that is green in color. Since 1950, almost all natural vermarine has come from a small [Brazilian](/wiki/Brazil) mine, but it is also seen in [Lower Silesia](/wiki/Lower_Silesia) in [Poland](/wiki/Poland). Naturally occurring vermarine is also found in the [Thunder Bay](/wiki/Thunder_Bay) area of [Canada](/wiki/Canada). It is a rare stone in nature, most green quartz is heat-treated amethyst.<ref name=Page>[Template:Cite web](/wiki/Template:Cite_web)</ref>

[Template:Clear](/wiki/Template:Clear)

## Synthetic and artificial treatments[[edit](/index.php?title=(none)&action=edit&section=11)]

[thumb|A synthetic quartz crystal grown by the](/wiki/File:Quartz_synthese.jpg) [hydrothermal method](/wiki/Hydrothermal_synthesis), about 19 cm long and weighing about 127 grams

Not all varieties of quartz are naturally occurring. Some clear quartz crystals can be treated using heat or gamma-irradiation to induce color where it would not otherwise have occurred naturally. Susceptibility to such treatments depends on the location from which the quartz was mined.[[10]](#cite_note-10) [Prasiolite](/wiki/Prasiolite), an olive colored material, is produced by heat treatment; natural prasiolite has also been observed in Lower Silesia in Poland. Although citrine occurs naturally, the majority is the result of heat-treated amethyst. [Carnelian](/wiki/Carnelian) is widely heat-treated to deepen its color.

Because natural quartz is often [twinned](/wiki/Crystal_twinning), synthetic quartz is produced for use in industry. Large, flawless, single crystals are synthesized in an [autoclave](/wiki/Autoclave_(industrial)) via the [hydrothermal process](/wiki/Hydrothermal_synthesis); [emeralds](/wiki/Emerald) are also synthesized in this fashion.

Like other crystals, quartz may be [coated with metal vapors](/wiki/Metal-coated_crystal) to give it an attractive sheen.

## Occurrence[[edit](/index.php?title=(none)&action=edit&section=12)]

Quartz is a defining constituent of [granite](/wiki/Granite) and other [felsic](/wiki/Felsic) [igneous rocks](/wiki/Igneous_rock). It is very common in [sedimentary rocks](/wiki/Sedimentary_rock) such as [sandstone](/wiki/Sandstone) and [shale](/wiki/Shale) and is also present in variable amounts as an accessory mineral in most [carbonate rocks](/wiki/Carbonate_rock). It is a common constituent of [schist](/wiki/Schist), [gneiss](/wiki/Gneiss), [quartzite](/wiki/Quartzite) and other [metamorphic rocks](/wiki/Metamorphic_rock). Quartz has the lowest potential for [weathering](/wiki/Weathering) in the [Goldich dissolution series](/wiki/Goldich_dissolution_series) and consequently it is very common as a residual mineral in stream sediments and residual [soils](/wiki/Soil).

While the majority of quartz crystallizes from molten [magma](/wiki/Magma), much quartz also chemically precipitates from hot [hydrothermal](/wiki/Hydrothermal_circulation) [veins](/wiki/Vein_(geology)) as [gangue](/wiki/Gangue), sometimes with [ore](/wiki/Ore) minerals like gold, silver and copper. Large crystals of quartz are found in magmatic [pegmatites](/wiki/Pegmatite). Well-formed crystals may reach several meters in length and [weigh](/wiki/Mass) hundreds of kilograms.

Naturally occurring quartz crystals of extremely high purity, necessary for the crucibles and other equipment used for growing [silicon](/wiki/Monocrystalline_silicon) [wafers](/wiki/Wafer_(electronics)) in the [semiconductor](/wiki/Semiconductor) industry, are expensive and rare. A major mining location for high purity quartz is the Spruce Pine Gem Mine in [Spruce Pine, North Carolina](/wiki/Spruce_Pine,_North_Carolina), [United States](/wiki/United_States).[[11]](#cite_note-11) The largest documented single crystal of quartz was found near Itapore, Goiaz, Brazil; it measured approximately 6.1×1.5×1.5 m and weighed more than 44 [tonnes](/wiki/Tonne).[[12]](#cite_note-12)

## Related silica minerals[[edit](/index.php?title=(none)&action=edit&section=13)]

[Tridymite](/wiki/Tridymite) and [cristobalite](/wiki/Cristobalite) are high-temperature [polymorphs](/wiki/Polymorphism_(materials_science)) of SiO2 that occur in high-silica [volcanic](/wiki/Volcano) rocks. [Coesite](/wiki/Coesite) is a denser polymorph of SiO2 found in some meteorite impact sites and in metamorphic rocks formed at pressures greater than those typical of the Earth's crust. [Stishovite](/wiki/Stishovite) is a yet denser and higher-pressure polymorph of SiO2 found in some meteorite impact sites. [Lechatelierite](/wiki/Lechatelierite) is an [amorphous](/wiki/Amorphous_solid) silica [glass](/wiki/Glass) SiO2 which is formed by [lightning](/wiki/Lightning) strikes in quartz [sand](/wiki/Sand).

## History[[edit](/index.php?title=(none)&action=edit&section=14)]

[thumb|](/wiki/File:Ewer_birds_Louvre_MR333.jpg)[Fatimid](/wiki/Fatimid_Caliphate) ewer in carved rock crystal (clear quartz) with gold lid, c. 1000 [thumb|left|Austrian rock crystal (pure quartz) cornucopia by Karl Rössler. Circa 1890](/wiki/File:Rock_Crystal_Cornucopia_by_Rossler_copy.jpg) [right|thumb|Quartz crystal demonstrating](/wiki/File:Transparency.jpg) [transparency](/wiki/Transparency_and_translucency) The word "quartz" comes from the [German](/wiki/German_language) [Template:Audio](/wiki/Template:Audio),[[13]](#cite_note-13) which is of Slavic origin (Czech miners called it *křemen*). Other sources attribute the word's origin to the [Saxon](/wiki/Upper_Saxon_German) word *Querkluftertz*, meaning *cross-vein ore*.[[14]](#cite_note-14) Quartz is the most common material identified as the mystical substance [maban](/wiki/Maban) in [Australian Aboriginal mythology](/wiki/Australian_Aboriginal_mythology). It is found regularly in passage tomb cemeteries in Europe in a burial context, such as [Newgrange](/wiki/Newgrange) or [Carrowmore](/wiki/Carrowmore) in [Ireland](/wiki/Republic_of_Ireland). The [Irish](/wiki/Irish_language) word for quartz is *grianchloch*, which means 'sunstone'. Quartz was also used in [Prehistoric Ireland](/wiki/Prehistoric_Ireland), as well as many other countries, for [stone tools](/wiki/Stone_tool); both vein quartz and rock crystal were [knapped](/wiki/Knapping) as part of the [lithic technology](/wiki/Lithic_technology) of the prehistoric peoples.[[15]](#cite_note-15) While [jade](/wiki/Jade) has been since earliest times the most prized semi-precious stone for carving in [East Asia](/wiki/East_Asia) and [Pre-Columbian](/wiki/Pre-Columbian_era) America, in Europe and the Middle East the different varieties of quartz were the most commonly used for the various types of [jewelry](/wiki/Jewellery) and [hardstone carving](/wiki/Hardstone_carving), including [engraved gems](/wiki/Engraved_gem) and [cameo gems](/wiki/Cameo_(carving)), [rock crystal vases](/wiki/Rock_crystal_vase), and extravagant vessels. The tradition continued to produce objects that were very highly valued until the mid-19th century, when it largely fell from fashion except in jewelry. Cameo technique exploits the bands of color in onyx and other varieties.

Roman naturalist [Pliny the Elder](/wiki/Pliny_the_Elder) believed quartz to be water [ice](/wiki/Ice), permanently frozen after great lengths of time.[[16]](#cite_note-16) (The word "crystal" comes from the Greek word *κρύσταλλος*, "ice".) He supported this idea by saying that quartz is found near glaciers in the Alps, but not on volcanic mountains, and that large quartz crystals were fashioned into spheres to cool the hands. This idea persisted until at least the 17th century. He also knew of the ability of quartz to split light into a [spectrum](/wiki/Spectrum).

In the 17th century, [Nicolas Steno's](/wiki/Nicolas_Steno) study of quartz paved the way for modern [crystallography](/wiki/Crystallography). He discovered that regardless of a quartz crystal's size or shape, its long prism faces always joined at a perfect 60° angle.[[17]](#cite_note-17) Quartz's [piezoelectric](/wiki/Piezoelectricity) properties were discovered by [Jacques](/wiki/Jacques_Curie) and [Pierre Curie](/wiki/Pierre_Curie) in 1880.[[18]](#cite_note-18)[[19]](#cite_note-19) The [quartz oscillator](/wiki/Crystal_oscillator) or resonator was first developed by [Walter Guyton Cady](/wiki/Walter_Guyton_Cady) in 1921.[[20]](#cite_note-20)[[21]](#cite_note-21) [George Washington Pierce](/wiki/G._W._Pierce) designed and patented [quartz crystal oscillators](/wiki/Pierce_oscillator) in 1923.[[22]](#cite_note-22)[[23]](#cite_note-23)[[24]](#cite_note-24) Warren Marrison created the first quartz oscillator clock based on the work of Cady and Pierce in 1927.[[25]](#cite_note-25) Efforts to synthesize quartz began in the mid nineteenth century as scientists attempted to create minerals under laboratory conditions that mimicked the conditions in which the minerals formed in nature: German geologist [Karl Emil von Schafhäutl](/wiki/Karl_Emil_von_Schafhäutl) (1803–1890)[[26]](#cite_note-26) was the first person to synthesize quartz when in 1845 he created microscopic quartz crystals in a pressure cooker.[[27]](#cite_note-27) However, the quality and size of the crystals that were produced by these early efforts were poor.[[28]](#cite_note-28) By the 1930s, the electronics industry had become dependent on quartz crystals. The only source of suitable crystals was Brazil; however, World War II disrupted the supplies from Brazil, so nations attempted to synthesize quartz on a commercial scale. German mineralogist Richard Nacken (1884–1971) achieved some success during the 1930s and 1940s.[[29]](#cite_note-29) After the war, many laboratories attempted to grow large quartz crystals. In the United States, the U.S. Army Signal Corps contracted with [Bell Laboratories](/wiki/Bell_Labs) and with the [Brush Development Company](/wiki/Brush_Development_Company) of Cleveland, Ohio to synthesize crystals following Nacken's lead.[[30]](#cite_note-30)[[31]](#cite_note-31) (Prior to World War II, Brush Development produced piezoelectric crystals for record players.) By 1948, Brush Development had grown crystals that were 1.5 inches (3.8 cm) in diameter, the largest to date.[[32]](#cite_note-32)[[33]](#cite_note-33) By the 1950s, [hydrothermal synthesis](/wiki/Hydrothermal_synthesis) techniques were producing synthetic quartz crystals on an industrial scale, and today virtually all the quartz crystal used in the modern electronics industry is synthetic.

## Piezoelectricity[[edit](/index.php?title=(none)&action=edit&section=15)]

Quartz crystals have [piezoelectric](/wiki/Piezoelectricity) properties; they develop an [electric potential](/wiki/Electric_potential) upon the application of [mechanical stress](/wiki/Stress_(mechanics)). An early use of this property of quartz crystals was in [phonograph](/wiki/Phonograph) pickups. One of the most common piezoelectric uses of quartz today is as a [crystal oscillator](/wiki/Crystal_oscillator). The [quartz clock](/wiki/Quartz_clock) is a familiar device using the mineral. The resonant frequency of a quartz crystal oscillator is changed by mechanically loading it, and this principle is used for very accurate measurements of very small mass changes in the [quartz crystal microbalance](/wiki/Quartz_crystal_microbalance) and in [thin-film thickness monitors](/wiki/Thin-film_thickness_monitor).

## See also[[edit](/index.php?title=(none)&action=edit&section=16)]

* [Dallasite](/wiki/Dallasite)
* [Fused quartz](/wiki/Fused_quartz)
* [List of minerals](/wiki/List_of_minerals)
* [Shocked quartz](/wiki/Shocked_quartz)
* [Quartz reef mining](/wiki/Quartz_reef_mining)

## References[[edit](/index.php?title=(none)&action=edit&section=17)]

[Template:Reflist](/wiki/Template:Reflist)

## External links[[edit](/index.php?title=(none)&action=edit&section=18)]

[Template:Commons](/wiki/Template:Commons) [Template:Wikisource](/wiki/Template:Wikisource)

* [Quartz varieties, properties, crystal morphology. Photos and illustrations](http://www.lixinsurface.com/)
* [*Arkansas quartz*, Rockhounding Arkansas](http://rockhoundingar.com/quartz.html)
* [Gilbert Hart *Nomenclature of Silica*, American Mineralogist, Volume 12, pages 383–395, 1927](http://www.minsocam.org/MSA/collectors_corner/arc/silicanom.htm)
* [PDF of Charles Sawyer's cultured quartz process description](https://goby.nrl.nav.mil/branch/UFFC_Archive/cd01/fc/proceed/1959/proceed/s5910462.pdf)[Template:Dead link](/wiki/Template:Dead_link)
* [Template:Cite web](/wiki/Template:Cite_web)
* [Terminology used to describe the characteristics of Quartz Crystals when used as oscillators](http://web.archive.org/web/20071012101816/http://www.connogue.com/quartslab/html/terminology.html)

[Template:Jewellery](/wiki/Template:Jewellery) [Template:Silica minerals](/wiki/Template:Silica_minerals)

[Template:Portalbar](/wiki/Template:Portalbar) [Template:Authority control](/wiki/Template:Authority_control)

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