

# The four Cs of calcite

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The four Cs (*color, clarity, cut, and carat weight*) traditionally describe the appearance of faceted diamonds and promote the appreciation of this particular gem to a wide audience.

In a similar fashion, a different set of four Cs can be used to describe calcite and explain why calcite is such a popular collector's mineral. The four Cs of calcite are: **common, colorful, crystal structure** and **collectible**.

## Common

Calcium, carbon and oxygen are abundant elements in the earth's crust that frequently combine to form calcium carbonate. Calcite is the stable form of  $\text{CaCO}_3$  at the surface of the earth. Thus calcite is a widely occurring mineral that is common and abundant in all classes of rocks - igneous, metamorphic and sedimentary. Sedimentary deposits of limestone and chalk are almost entirely composed of calcite; marble is metamorphosed limestone. Calcite occurs in silicate rocks, pegmatites and hydrothermal veins; it precipitates in hot springs and caves and is even found in biologic settings. Rocks, such as granites, that are poor in calcium have little calcite.

Calcite crystals are common and occur in cavities in nearly all rock types. In fact, crystal growth is often so robust that micro-sized crystals are uncommon. Some calcite crystals from Iceland have reached the extraordinary size of 7 meters.

Because calcite occurs abundantly, many mineral collectors have access (either through the mineral marketplace or by collecting) to locations that produce large, beautiful crystals. Availability and abundance often are the key to "low price," another factor in assembling a specialized calcite collection. Thus, I submit that *common* is a key factor that explains the broad collector interest in calcite.

## Colorful

Calcite is colorless and transparent or white when pure; other colors are uncommon and highly desirable.

When colored crystals are found, they are generally yellow to honey-colored. The cause for the yellow color is unknown but is thought to be associated with impurities of iron or perhaps to defect color centers. Localities such as the Malmberget iron mine in Sweden and the Elmwood mine in Tennessee have produced outstanding specimens of honey-colored calcite.

Some of the most colorful calcite crystals result from the replacement of calcium by manganese, iron, zinc, cobalt, lead, strontium, magnesium or barium. Although this substitution is typically on the order of only a few percent, it produces such notable calcite varieties as pink *manganoan* calcite, beige *plumbian* calcite, rose-red *cobaltian* calcite and tan *ferroan* calcite. Substitution of calcium by iron and manganese is far more common than by the other listed cations.

Colorful calcite is also produced by admixtures of other minerals. Clear and transparent crystals of calcite when included by such strongly colored minerals as bolangerite, celadonite, copper, hematite and others can often produce striking specimens. The inclusions may occur either on an early calcite growth surface that has been overgrown by a later generation of clear calcite (a *phantom*), or it may be uniformly disseminated throughout the calcite crystal. Calcite may even contain up to 70% sand within its structure.

Whatever the cause for colorful calcite, all well-crystallized specimens are highly prized and generally priced accordingly. A calcite collection with a wide variety of colored calcites is a major step above a collection of "common" calcites.

### **Crystal Structure**

Calcite's structure consists of alternating layers of calcium atoms and carbonate groups stacked along the *c*-axis. Calcium has octahedral coordination with six oxygens from six different CO<sub>3</sub> groups. The crystal structure and composition determine the properties and appearance that makes calcite so interesting to collectors.

### **Durability**

If calcite has any negatives, they most certainly would be associated with durability. Calcite *hardness* (Mohs scale = 3) and *cleavage* (readily induced) require careful handling of crystals throughout the acquisition, curation and display processes. In addition to the obvious need to avoid contact with harder objects, calcite should never be subjected to freezing conditions, as many crystals are included with small amounts of water. Internal fractures, like external damage, decrease the desirability of specimens.

### **Forms of Calcite**

Crystals are common and occur as various rhombohedra, scalenohedra and dipyramids as well as prisms and pinacoids. Calcite has been described as the mineral with the most forms; in fact more than 600 have been documented. A single crystal of calcite may be bounded by more than one form. It is not uncommon for three, four or even five or more forms to be combined on a single crystal; thus, the number of documented form combinations seen on calcite numbers into the thousands. Although this variety of combinations is greater than that of any other mineral, all of the forms of calcite fall into five groups. They are:

**Pinacoid** – An open form made up of two parallel faces that are each perpendicular to the *c*-axis.

**Prism** – An open form composed of six or twelve faces, all of which are parallel to the *c*-axis.

**Rhombohedron** – A closed form composed of six faces; three at the top of the crystal alternate with three at the bottom. The two sets of faces are offset by 60 degrees.

**Scalenohedron** – A closed form with twelve faces grouped in symmetrical pairs, three pairs above and three below in alternating positions. In perfectly developed crystals, each face is a scalene triangle; the faces meet in a zigzag line around the girdle of the crystal.

**Dipyramid** – A closed form having twelve faces, six on the top of the crystal and six immediately below them on the bottom; each face is an isosceles triangle.

The following are commonly observed habits for calcite:

1. *prismatic* crystals with long or short prisms in which the prism faces are prominent and with a pinacoid termination. Calcite from Andreasberg, Germany, is typical of this habit;
2. *rhombohedral* crystals in which shallow to steep rhombohedral forms predominate. Calcite from Tsumeb, Namibia, is of this habit;
3. *scaleno-hedral* crystals, often with prism faces and rhombohedral terminations are the most common form observed on calcite. More than 200 different scalenohedra have been described, although simple (and photogenic) examples are uncommon.

The *dipyramid*, a form that is elsewhere considered rare for calcite, is found with some abundance at limestone quarries in Ohio and Indiana.

Habits of common calcite crystal aggregates can be described as fibrous, nodular, stalactitic or botryoidal. Stalactitic forms occur in caves and in cavelike openings within mines.

### **Twinning**

When two or more crystals grow in fixed rather than random relationship to one another, they are described as *twins*. Because these relationships are related to the structure of a mineral, the number of laws under which twins can form ranges from none to several. Typically, twins are uncommon and are highly prized by collectors.

There are four *twin laws* for calcite. In one, the *c*-axes of the two twin components are at  $180^\circ$  to one another; under the other three laws, the twin components are inclined at an angle to one another. Identifying the correct inclined-axis twin law can be difficult at times because the habits of twinned crystals are quite different from the habits of untwinned crystals. Rapid growth occurs on faces where the two parts of the twin meet, resulting in modifications of the crystal shape.

When the twin plane is perpendicular to the *c*-axes of both parts of the twin, the *c*-axes are at  $180^\circ$  to one another. These twins are easy to recognize by reentrant notches along the contact at the twin plane. This is the most common twin law for calcite. Recently, some of the most dramatic examples have come from the Elmwood mine in Tennessee.

If the *c*-axes of the twin are inclined at an angle of  $127^\circ 30'$  with respect to one another, the twin plane is parallel to a face of a shallow negative rhombohedron. This is the second most common twin law for calcite. Presumably most of the so-called butterfly twins are of this twin law.

When the *c*-axes of the twin are inclined at an angle of  $90^\circ 46'$  with respect to one another, the twin plane is parallel to a face of the positive rhombohedron, which is defined by the cleavage of calcite. This calcite twin law is rare compared to the two described above. Notable localities for this twin law are few and include the hematite mines of West Cumbria, England, where they are locally described as heart-shaped or (if the reentrant notch is completely filled-in) as axe-head twins; Wheal Wrey in Cornwall, England, and the Leiping mine in China, where they occur as x-shaped twins.

If the *c*-axes of the twin are inclined at an angle of  $53^\circ 46'$  with respect to one another, the twin plane is parallel to a face of a steep rhombohedron. This is another rare twin

law for calcite. Recently, specimens with this twin law have come from a basalt flow in the northern part of Madagascar.

To put crystal structure into perspective, a calcite collection that contains crystals that are damage-free, has a wide representation of crystal forms and that includes the four twin laws is another major step above a collection of common calcites.

### **Collectible**

Because calcite is seemingly everywhere, it has been possible to acquire and preserve excellent calcite crystals from mining ventures operated for metals. As older mines became uneconomic and closed, new mines in new places become the source for metals (and for calcite). Thus, availability of calcite cycles from boom-to-bust at every location.

Consequently, it is challenging to include older classics in a calcite collection without compromising one's budget or quality standards. Specimens from the late 1800's and early 1900's mining operations in Germany, England and Michigan are highly desirable - and command high prices for even mediocre specimens.

In the late 1900s, mines in Mexico and Peru, at Tsumeb and at many of the MVT deposits in the midwestern United States were producing seemingly inexhaustible quantities of minerals, including choice calcite. But where are these specimens now?

Today, mines in the former Soviet Union, India and China and on the African continent are the source for much of the fine calcite available in the marketplace. I suggest you not let this opportunity pass by. Of course, there will eventually be other new localities, but will they meet the standard of older and modern classic localities?

### **Summary**

A calcite collection is, obviously, only as good as the specimens it contains. When careful attention is given to acquiring specimens without damage and those with a wide variety of crystal habits, including the four twin laws of calcite, the collection has a strong foundation. The addition of calcites colored either by substitution or from inclusions, plus specimens from classic localities, both historical and modern, further enhance the collection. Ultimately, it is the collector's taste in aesthetics that completes the collection to his/her satisfaction.