Crystalline Structures | Crystal Lattice Structures

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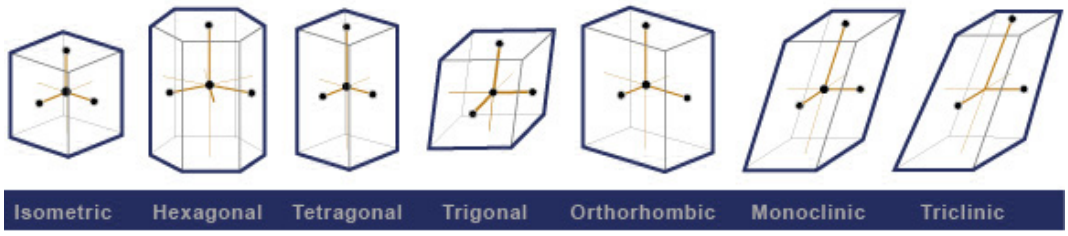
Crystalline Structures

Structural Properties

All gemstones are crystalline structures made from a mixture of different elemental compounds. The shape of a crystal is based on the atomic structure of these elemental building blocks. Atoms within a mineral are arranged in an ordered geometric pattern which determine its "crystal structure". A gem's crystal structure will determine a its symmetry, optical properties, cleavage and geometric shape. The recipe or mixture of these compounds becomes the blueprint for how the crystal will grow. This growth pattern is call a crystal's "habit."

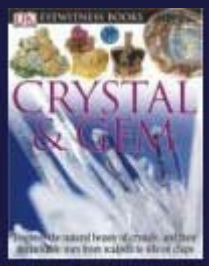
Unit Cell

The "unit cell" is the smallest divisible unit of a mineral with symmetrical characteristics unique to a crystalline structure. A structure's "unit cell" is a spatial arrangement of atoms which is tiled in three-dimensional space to form the crystal. The unit cell is determined by its lattice parameters, the length of the cell edges and the angles between them, while the positions of the atoms inside the unit cell are described by the set of atomic positions (xi,yi,zi) measured from a lattice point.



Crystal System

The crystal system is a grouping of crystal structures that are categorized according to the axial system used to describe their "lattice". A crystal's lattice is a three dimensional network of atoms that are arranged in a symmetrical pattern. Each crystal system consists of a set of three axes in a particular geometrical arrangement. The seven unique crystal systems, listed in order of decreasing symmetry, are: 1. Isometric System, 2. Hexagonal System, 3. Tetragonal System, 4. Rhombohedric (Trigonal) System, 5. Orthorhombic System, 6. Monoclinic System, 7. Triclinic System.

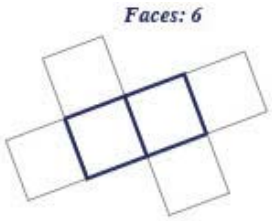


Gem & Diamond Books

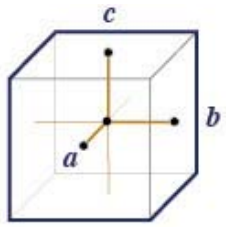
The Seven Crystal Systems

1. Cubic

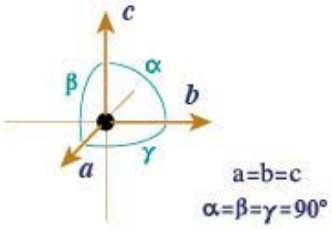
The Cubic crystal system is also known as the "isometric" system. The Cubic (Isometric) crystal system is characterized by its total symmetry. The Cubic system has three crystallographic axes that are all perpendicular to each other and equal in length. The cubic system has one lattice point on each of the cube's four corners.



Flat Cubic System



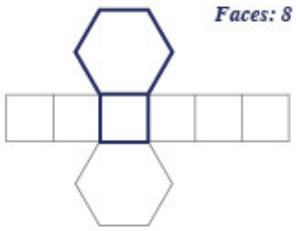
Cube (Isometric) Unit-Cell



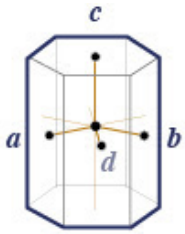
Crystallographic Axes

2. Hexagonal

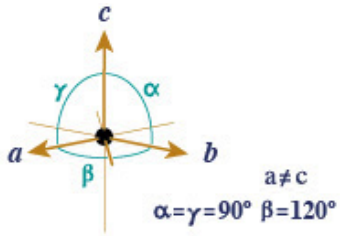
The Hexagonal crystal system is has four crystallographic axes consisting of three equal horizontal or equatorial (a, b, and d) axes at 120°, and one vertical (c) axis that is perpendicular to the other three. The (c) axis can be shorter or longer than the horizontal axes.



Flat Hexagonal Crystal



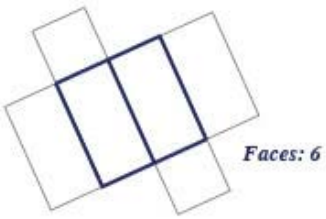
Hexagonal Unit-Cell



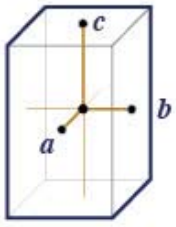
Crystallographic Axes

3. Tetragonal

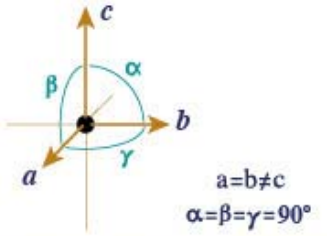
A Tetragonal crystal is a simple cubic that is stretched along its (c) axis to form a rectangular prism. The Tetragonal crystal will have a square base and top, but a height that is taller. By continuing to stretch the "body-centered" cubic one more Bravais lattice of the Tetragonal system is constructed.



Flat Tetragonal System



Tetragonal Unit-Cell

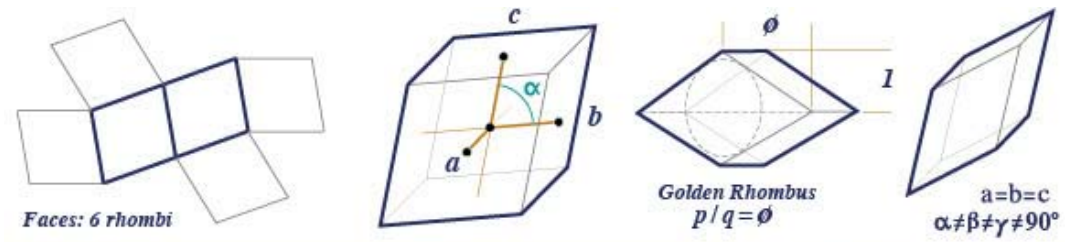


Crystallographic Axes

4. Rhombohedral

A Rhombohedron (aka Trigonal) has a three-dimensional shape that is similar to a cube that has been compressed to one side. Its form is considered prismatic, as all faces are parallel to each other. The faces that are not square are called "rhombi." A

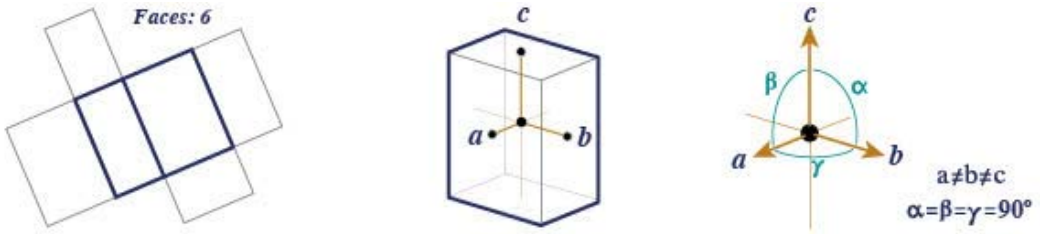
rhombohedral crystal has six faces or rhombi, 12 edges, and 8 vertices. If all of the non-obtuse internal angles of the faces are equal (flat sample, below), it can be called a trigonal trapezohedron.



Flat Rhombohedron | Rhombohedral Unit-Cell | Crystallographic Axes

5. Orthorhombic

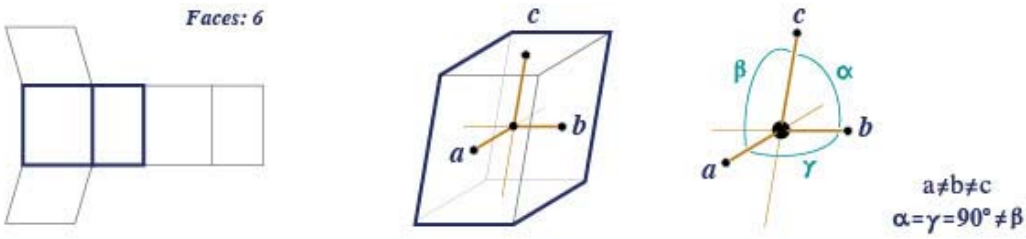
Minerals that form in the Orthorhombic (aka Rhombic) crystal system have three mutually perpendicular axes, all with different or unequal lengths.



Flat Monoclinic System | Orthorhombic Unit-Cell | Crystallographic Axes

6. Monoclinic

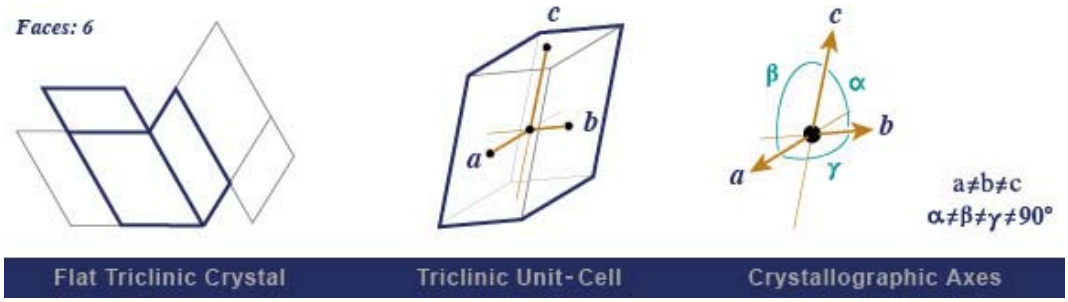
Crystals that form in the Monoclinic System have three unequal axes. The (a) and (c) crystallographic axes are inclined toward each other at an oblique angle, and the (b) axis is perpendicular to a and c. The (b) crystallographic axis is called the "ortho" axis.



Flat Monoclinic Crystal | Monoclinic Unit-Cell | Crystallographic Axes

7. Triclinic

Crystals that form in the Triclinic System have three unequal crystallographic axes, all of which intersect at oblique angles. Triclinic crystals have a 1-fold symmetry axis with virtually no symmetry and no mirrored planes.



Crystal Forms

Closed & Open Forms

Any grouping of crystal faces or facets that are arranged in the same symmetry is called a "form." There are approximately 48 crystal forms broken down into "open" or "closed" categories. There are 30 "closed" and 18 "open" crystal forms. "Closed Forms" are those groupings of facets that are related by symmetry and completely enclose a volume of space.

Vectorial Properties of Crystals

Although a crystal structure is an orderly arrangement of atoms on a lattice, the order may be different along different directions or axis in the crystal. Certain properties of a particular crystal can depend on direction. These variable properties are called "vectorial properties", which are divided into two categories: continuous and discontinuous. An example of a "continuous property" is a crystal's hardness. An example of a "discontinuous property" would be cleavage.

Page 2: Crystal Forms

Page 3: Crystal Habit

Return to General Information

Referance Credits & Suggestions for Further Study on Crystal Geometry

1. University of Wisconsin, The 48 Special Crystal Forms
2. Web Mineral, Minerology Database - Crystallography and Minerals by Crystal Form. webmineral.com
3. Tulane University, External Symmetry of Crystals. www.tulane.edu
4. Rockhounds, Introduction to Crystallography
5. MathWorld, Solid Geometry
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7. Judith Crowe, The Jeweler's Directory of Gemstones. DK Publishing

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9. Renee Newman, Gemstone Buying Guide. International Jewelry Publications; 2nd edition
10. Paul R. Shaffer, Herbert S. Zim, Raymond Perlman, Rocks, Gems and Minerals. Martin's Press

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