Al- Karkh University of Science

College of Remote Sensing and Geophysics

Department of Geophysics

Crystallography and Mineralogy

Lec. 2 : An Introduction to Crystallography

Crystal systems

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An Introduction to Crystallography

Crystal systems

The 6 Crystal Systems

The structures of all crystals can be classified according to the symmetry of the unit cells. There are in total 7 groups, collectively called Crystal Systems: Cubic, Tetragonal, Orthorhombic, Hexagonal, Monoclinic, and Triclinic. The symmetry of each group is described by the relationship between the axes a, b, and c and angles α, β and γ.

1- Cubic (Isometric) system:

This is one of the most common and simplest shapes found in crystals and minerals.

The Cubic crystal system has the highest symmetry. The angles between axes are equal 90°, but all the sides have the same length as well.

$a = b = c$

$\alpha = \beta = \gamma = 90°$

Three crystal axes are equal and perpendicular to each other

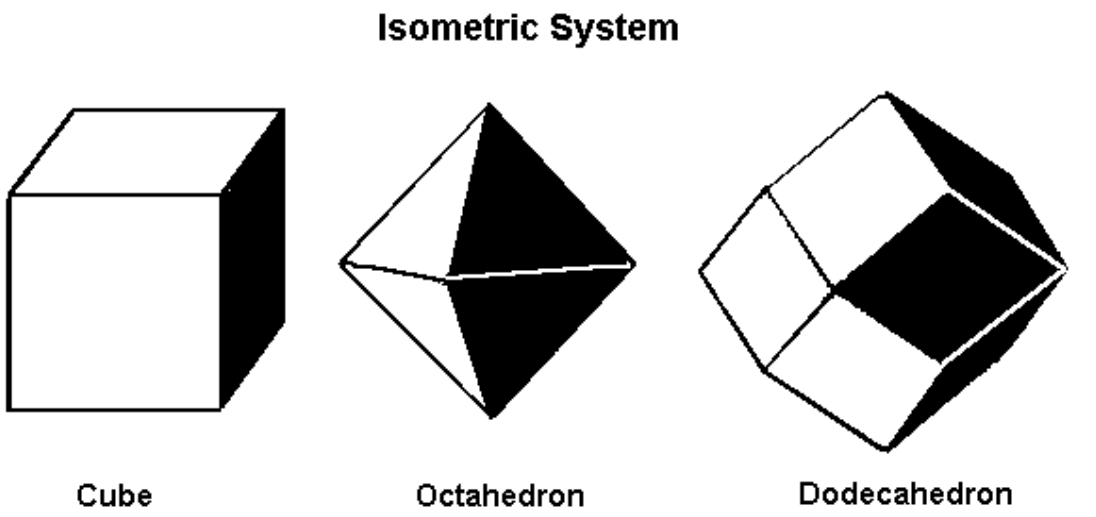
($a = b = c$) or ($a_1 = a_2 = a_3$)

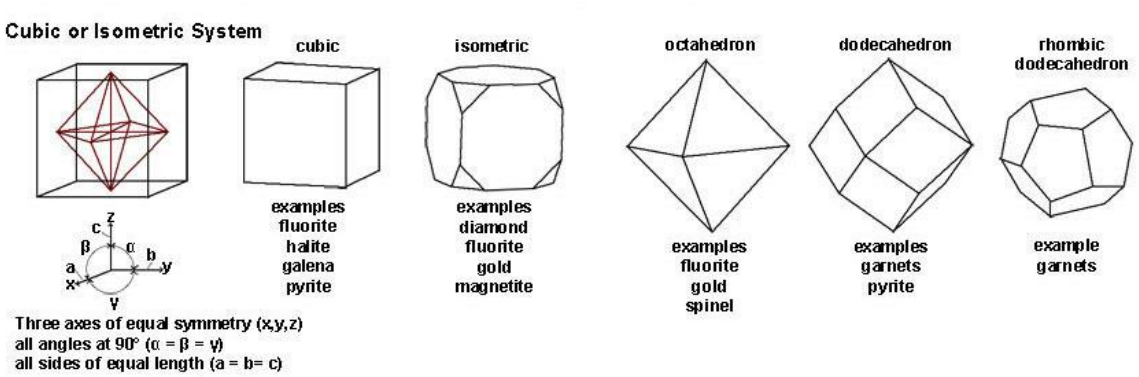
a_1 : from front to back

a_2 : from right to left

a_3 : from top to down

$\alpha = 90°, \beta = 90°, \gamma = 90°$





Some forms of cupic system and mineral examples
1- Cupe, 2- Octahedron, 3- Dodecahedron

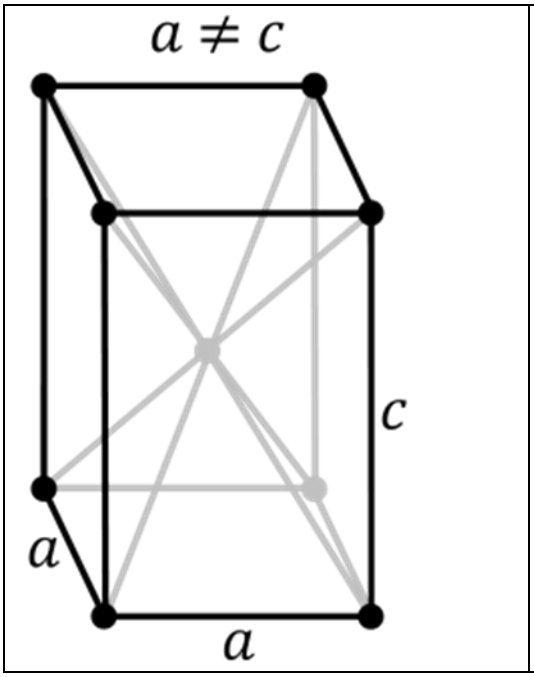
2-Tetragonal system:

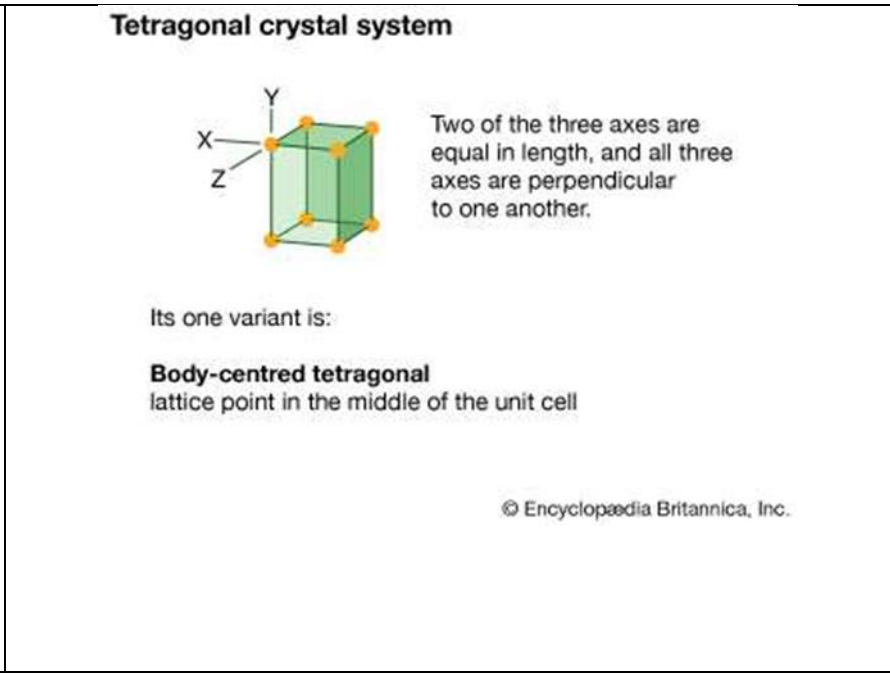
Crystals in this system are referred to three perpendicular axes, two of which are equal in length.

Now, all the angles have to equal 90°, but the two axes a and b have to be the same length too and the length of c axis is difference.

$a = a \neq c$

$\alpha = \beta = \gamma = 90°$

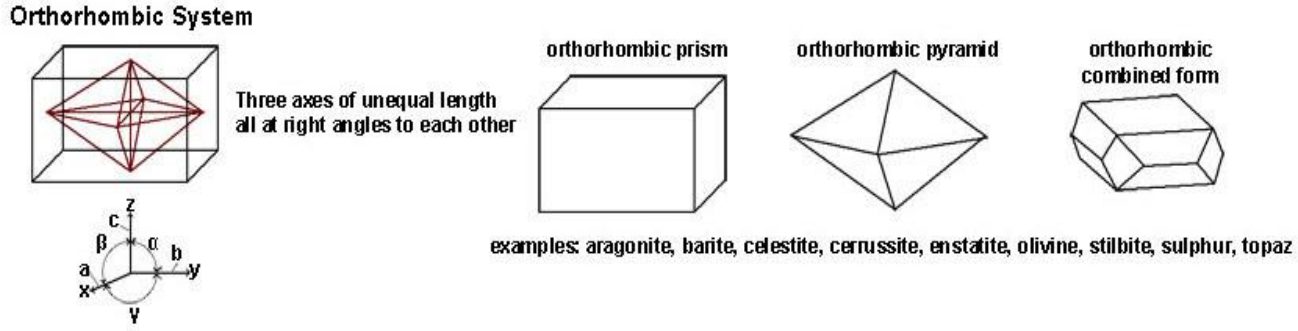




3-Orthorhombic system:

Crystals in this system are referred to three perpendicular axes that are unequal in length.
In the Orthorhombic crystal system, axes a, b, c are not equal in length. All the angles between axes must be 90°.

a ≠ b ≠ c
α = β = γ = 90°



Some forms of orthorhombic system and mineral examples:

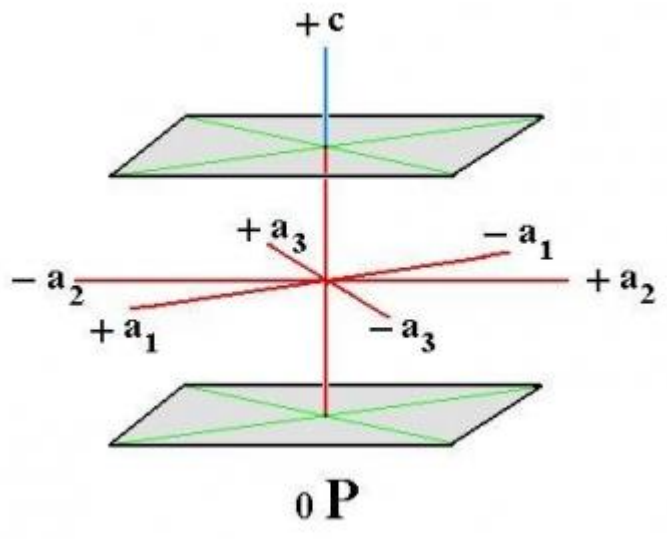
1- Orthorhombic Prism, 2- orthorhombic pyramid,3-orthorhombic combined form

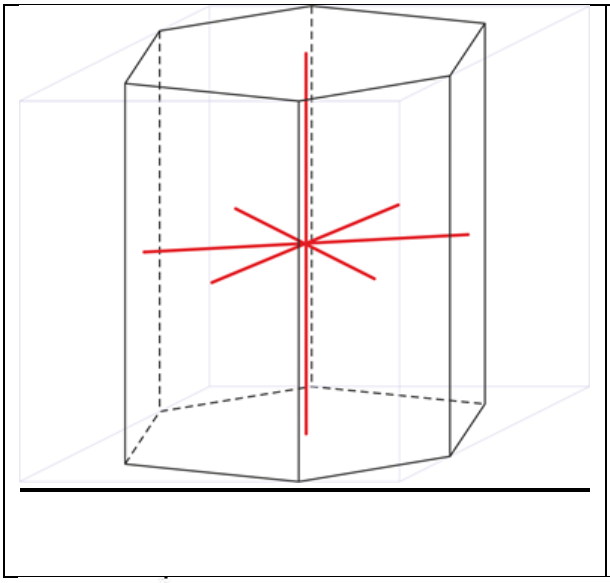
4- Hexagonal system:

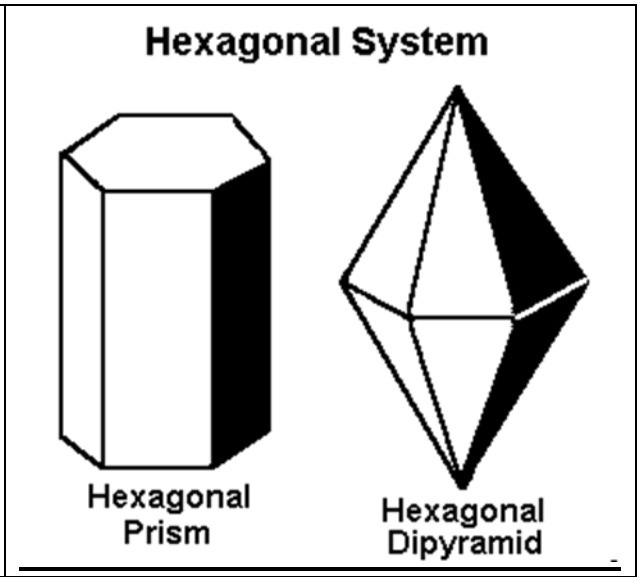
The hexagonal crystal system includes all crystals with a hexagonal inner structure. The word 'hexagonal' is derived from the Greek for 'six-sided body'. Hexagonal minerals in the form of crystals, such as apatite, aquamarine, beryl, morganite and emerald.
The hexagonal system has four crystallographic axes consisting of three equal horizontal, or equilateral axes at 120 degrees to each other, as well as one vertical axis which is perpendicular to the other three. This vertical axis can be longer or shorter than the horizontal axes.

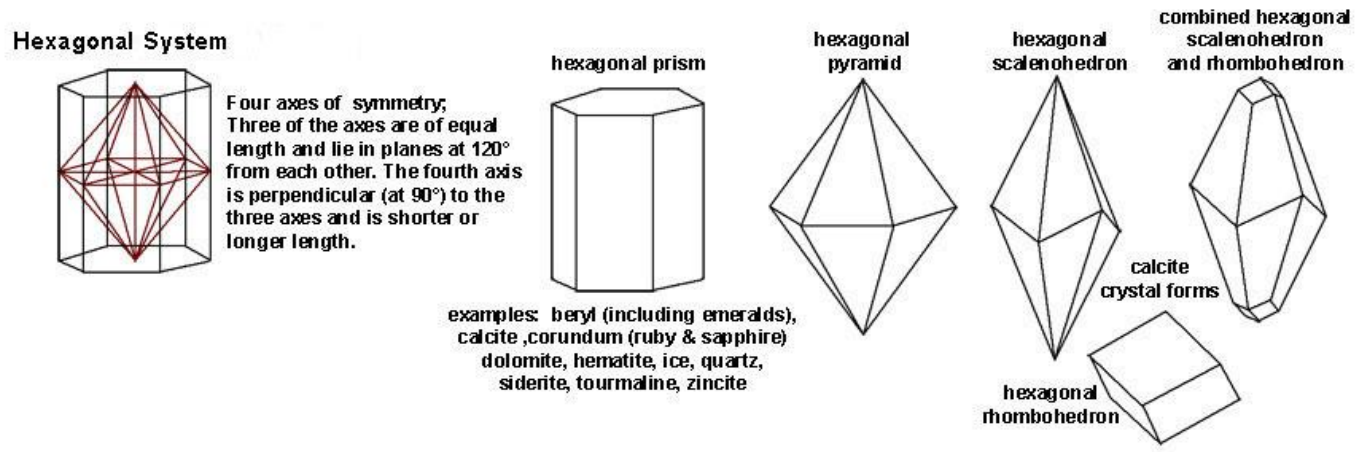
The system has the following forms:

Prism, Pinacoid, Dipyramid, Ditrigonal Pyramid, Trigonal Prism, Ditrigonal Prism.









Some forms of Hexagonal system and mineral examples:

1- Hexagonal Prism, 2- Hexagonal (pyramid) Dipyramid, 3- Hexagonal Rhombohedron.

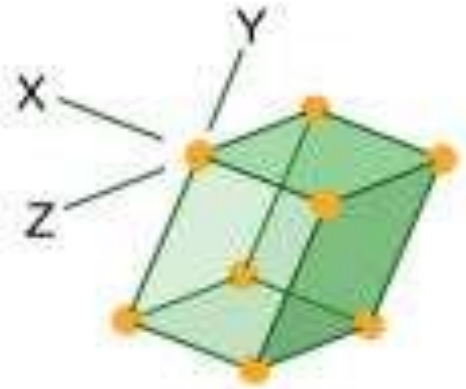
5-Monoclinic system

Monoclinic crystal system, one of the structural categories to which crystalline solids can be assigned. Crystals in this system are referred to three axes of unequal lengths, a, b, and c. a is perpendicular to b and c, but b and c are not perpendicular to each other.

$a \neq b \neq c$

$\alpha = \gamma = 90°$ and $\beta \neq 90°$

Monoclinic crystal system

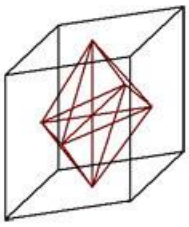


All three axes are unequal in length, and two axes are perpendicular to each other.

Its one variant is:

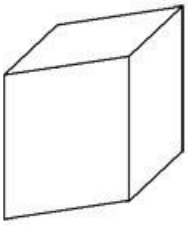
Base-centred monoclinic
lattice points in the middle of each of the two ends

Monoclinic System

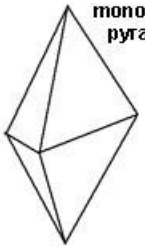


Three unequal axes; two axes are at right angle to each other. These two axes form a plane which the third axis is incline at an angle not at 90°. There is one two-fold axis.

monclinic prism



monoclinic pyramid



examples: azurite, malachite, gypsum, epidote, amphiboles, jadeite, micas, orthoclase

Some forms of Monoclinic system and mineral examples:

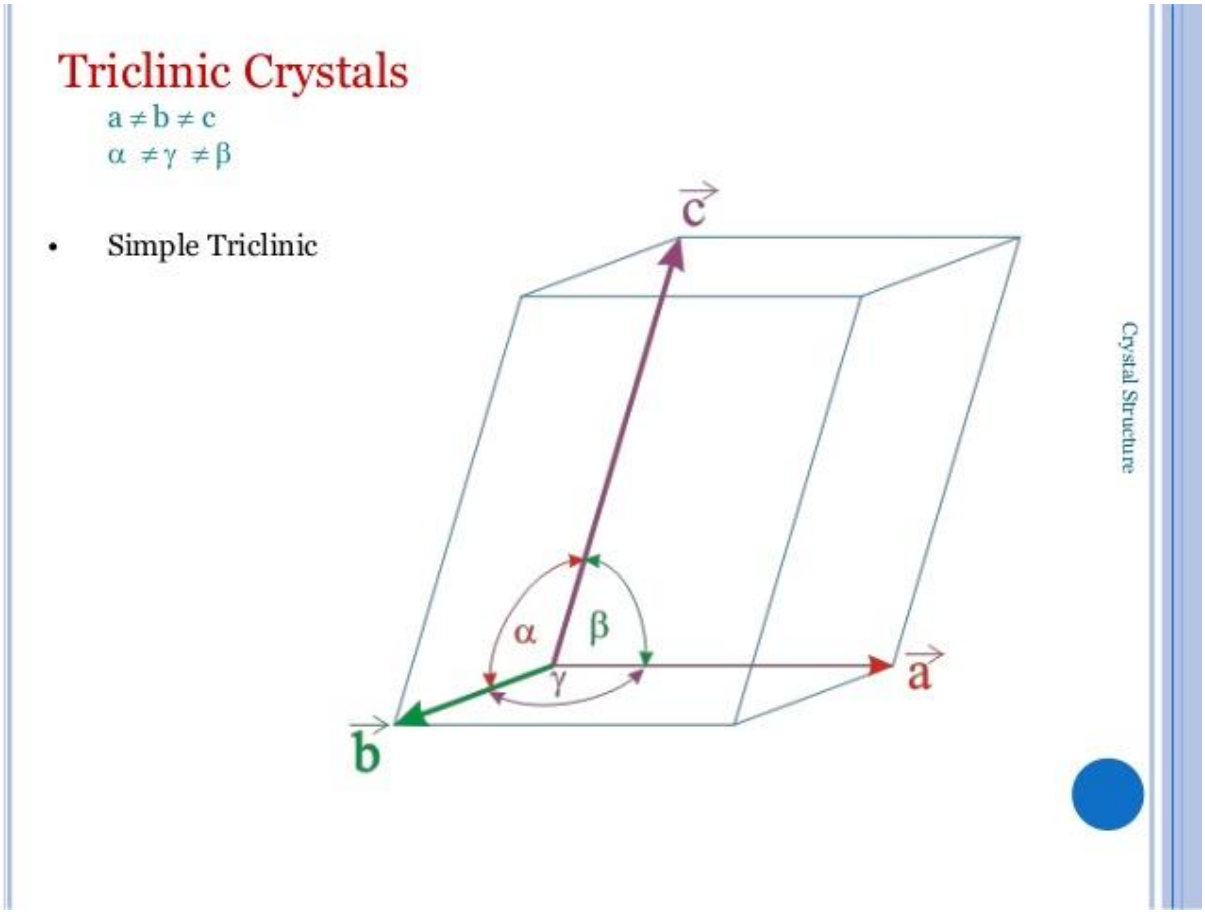
1- Monoclinic Prism, 2- Monoclinic Pyramid.

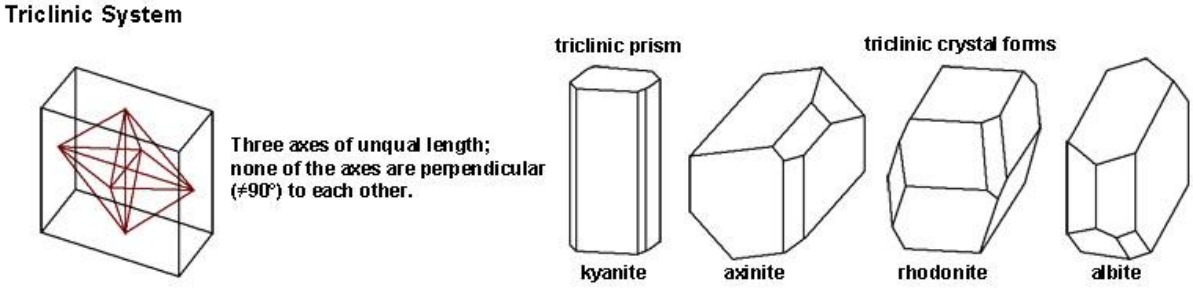
6-<u>Triclinic System:</u>

Crystals in this system are referred to three axes of unequal lengths that are inclined (nonperpendicular) angles relative to each other.

$a \neq b \neq c$

α , γ and $\beta \neq 90°$





Some forms of Triclinic system and mineral examples:

1- Triclinic Prism,