

CLASSIFICATION OF MINERALS

Minerals in nature as classified into the following groups:

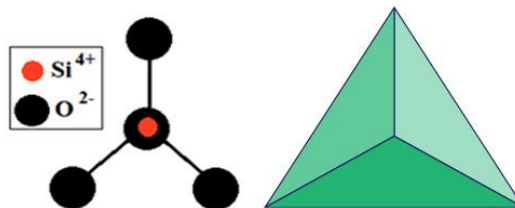
1. Native Elements.
2. Sulphides.
3. Oxides and hydroxides.
4. Halides.
5. Carbonates, nitrates, borates, iodates.
6. Sulphates, chromates, molybdates, tungstates.
7. Phosphates, arsenates, vanadates.
8. Silicates

Silicate Minerals

Silicate minerals form about 95% of Earth's crust and mantle, occurring as the major constituents of most igneous rocks and in appreciable quantities in sedimentary and metamorphic rocks.

Tetrahedron: The basic structural unit of all silicate minerals and consists of one silicon cation Si^{4+} at the center surrounded by four oxygen anions O^{2-} at the corners, giving it four negative charges $(\text{SiO}_4)^{4-}$.

Two ways of drawing the silica tetrahedron:



Ball and stick model, showing the silicon cation in red surrounded by 4 oxygen anions in black. Geometric shorthand

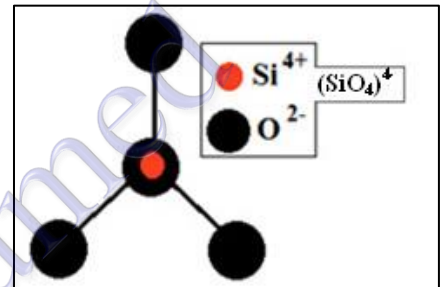
Classification of Silicate Minerals

Tetrahedron is linked with each other and with a variety of cations in many different ways to form the silicate minerals, which results in different structures; these structures form the basis for silicate classification.

Silicate minerals are classified into 6 groups:

1) Nesosilicates

Nesosilicates consist of isolated tetrahedral $(\text{SiO}_4)^{4-}$, with a ratio of Si:O = 1:4, that are connected only by cations.



Characteristics of Nesosilicates:

- 1- Isolated silicate tetrahedra SiO_4 are bound to each other only by cations (e. g. Fe^{2+} , Mg^{2+} , Al^{3+}).
- 2- The ratio of Si:O = 1:4.
- 3- Generally dense.
- 4- Relatively high hardness.
- 5- Relatively high specific gravity.
- 6- Generally, cleavages are absent.

Mineral Examples:

A) Olivine group

The most common series are Forsterite (Mg_2SiO_4) and Fayalite (Fe_2SiO_4).
Crystallography: Orthorhombic.

Color: Forsterite is pale yellow-green to olive-green; Fayalite is dark brownish-green.

Luster: Vitreous.

Fracture: Conchoidal.

Diagnostic features: Color, luster, and fracture.

Occurrence: Olivine is a common mineral found in basic and ultrabasic igneous rocks (basalt, gabbro, and peridotite). Also found in some metamorphic rocks (metamorphosed-dolomitic limestones).

Uses: The clear green variety (peridot) is used as a gem.

B) Garnet group

This group of minerals is very common, especially in metamorphic rocks.

The structural formula may be represented $A_3 B_2 (SiO_4)_3$, where:

A-site is occupied by divalent cations (Ca^{2+} , Mg^{2+} , Fe^{2+} , or Mn^{2+}).

B-site is occupied by trivalent cations (Al^{3+} , Fe^{3+} , or Cr^{3+}).

This group can be classified into:

Pyrope: $Mg_3Al_2Si_3O_{12}$

Almandite: $Fe_3Al_2Si_3O_{12}$

Spessartite: $Mn_3Al_2Si_3O_{12}$

Grossularite: $Ca_3Al_2Si_3O_{12}$

Garnet:

Crystallography: Isometric.

Color: Varied color, red, brown, yellow, green, and black.

Luster: Vitreous to resinous.

Streak: White color.

Hardness: 6.5-7.5.

Diagnostic features: Streak, hardness, and specific gravity.

Occurrence: Garnet occurs in metamorphic rocks (Schist, Gneiss), also found in igneous rocks as an accessory mineral.

Uses: As gemstones and for abrasive purposes (garnet paper) due to a high hardness.

C) Al_2SiO_5 group

This group is composed of three polymorphs: Andalusite, Sillimanite, and Kyanite. All three minerals are specially found in metamorphosed aluminous rocks, such as pelitic schist.

Andalusite:

Crystallography: Orthorhombic.

Color: Flesh-red, reddish-brown, or olive-green.

Cleavage: (110) good.

Hardness: 7.5.

Diagnostic features: Cleavage and hardness.

Occurrence: Contact metamorphic rocks.

Uses: in the manufacture of spark plugs and porcelains, also used as gemstones.

Sillimanite:

Crystallography: Orthorhombic.

Color: Brown, pale-green, or white.

Cleavage: (010) perfect.

Diagnostic features: Cleavage.

Occurrence: Contact metamorphic rocks (Hornfels) and regional metamorphic rocks (Schist).

Kyanite:

Crystallography: Triclinic.

Color: Usually blue.

Cleavage: (100) perfect.

Diagnostic features: Color, cleavage, and habit (bladed crystals).

Occurrence: Regional metamorphic rocks (Eclogite).

Uses: Kyanite is used as is andalusite in the manufacture of spark plugs and porcelains, also used as gemstones.

D) Zircon - ZrSiO_4

Crystallography: Tetragonal.

Color: Brown, gray, green, red, or colorless.

Hardness: 7.5.

Specific gravity: $G = 4.7$.

Diagnostic features: Crystals, hardness, and high specific gravity.

Occurrence: it is a common accessory mineral in igneous rocks (granite, pegmatite), also found in some metamorphic rocks (gneisses, schist).

Uses: Transparent crystals used as a gemstone, also used as the source of metallic zirconium (pure zirconium is used in the construction of nuclear reactors).

E) Topaz - $\text{Al}_2\text{SiO}_4(\text{F}, \text{OH})_2$

Crystallography: Orthorhombic.

Color: Colorless, yellow, or pink.

Cleavage: (001) perfect.

Hardness: 8.

Luster: Vitreous.

Diagnostic features: Crystals, cleavage, and hardness.

Occurrence: Found in siliceous igneous rocks (rhyolite, granite) and is a characteristic mineral in pegmatite.

Uses: as a gemstone.

F) Sphehne (Titanite) - $\text{CaTiO}(\text{SiO}_4)$

Crystallography: Monoclinic.

Color: Gray, brown, green, yellow, or black.

Cleavage: (110) distinct.

Luster: Resinous to adamantine.

Diagnostic features: Wedge crystals, and luster.

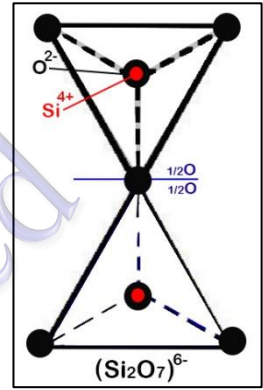
Occurrence: Found in small crystals as accessory mineral in igneous rocks (granite, syenite, diorite) and also found in metamorphic rocks (schist, gneiss).

Uses: As a source of titanium oxide.

2) Sorosilicates

The sorosilicates consist of two silicate tetrahedrons linked together by one oxygen; because one oxygen atom is shared by two tetrahedrons, the chemical formula is Si_2O_7 (ratio of silicon to oxygen is Si:O = 2:7).

Over 70 minerals are known in this group, but most of them are rare.



Mineral Examples:

A) Epidote - $\text{Ca}_2(\text{Al, Fe}) \text{Al}_2\text{O}(\text{SiO}_4) (\text{Si}_2\text{O}_7) (\text{OH})$

Crystallography: Monoclinic.

Color: Pistachio-green to yellowish-green to black.

Cleavage: (001) perfect.

Diagnostic features: Color and cleavage.

Occurrence: Found in regional metamorphic rocks (amphibolite).

Uses: Sometimes as a gemstone.