Minerals

A mineral is a naturally occurring inorganic solid with a characteristic chemical composition and a crystalline structure. Chemical composition and crystalline structure are the two most important properties of a mineral.

Classification

Most minerals are dominated by the elements silicon (Si) and oxygen (O). These minerals are called silicates, reflecting the importance of the silicon-oxygen anionic group in them. The nonsilicate mineral compounds are also distinguished by the dominant anion or anionic group. Remaining, then, are only those minerals that are composed of uncombined elements. This gives rise to a classification system based upon the chemical compositions of minerals:

Native Elements

About 20 elements occur naturally in their native states as minerals. Fewer than ten, however, are common enough to be of economic importance. Gold, silver, platinum, and copper are all mined in their pure forms. Iron is rarely found in its native state in the Earth’s crust, but metallic iron is common in certain types of meteorites.

Oxides

The oxides are a large group of minerals in which oxygen is combined with one or more metals. Oxide minerals are the most important ores of iron, manganese, chromium, uranium, titanium, and several other industrial metals. Hematite (iron oxide, Fe_2O_3) occurs widely in many types of rocks and is the most abundant ore of iron. Magnetite (Fe_3O_4), a naturally magnetic iron oxide, is another ore of iron.

Sulfides

Sulfide minerals consist of sulfur combined with one or more metals. Many sulfides are extremely important ore minerals. They are the world’s major sources of copper, lead, zinc, silver, cobalt, mercury, nickel, and several other metals. The most common sulfides are pyrite (FeS2), chalcopyrite (CuFeS2), galena (PbS), and sphalerite (ZnS).

Sulfates

The sulfate minerals contain the sulfate complex anion $(SO4)_{2-}$. Gypsum ($CaSO_4$. $2H_2O$) and anhydrite ($CaSO_4$) are two important industrial sulfates used to manufacture plaster and sheetrock. Both form by evaporation of seawater or salty lake water.

Phosphates

Phosphate minerals contain the complex anion $(PO4)_3$-. Apatite, $Ca5(F,Cl,OH)(PO4)_3$, is the substance that makes up both teeth and bones. Phosphate is an essential fertilizer in modern agriculture.

Carbonates

The complex carbonate anion $(CO_3)_2$- is the basis of two common rock-forming minerals, calcite ($CaCO_3$) and dolomite [$CaMg(CO_3)_2$]. Most limestone is composed of calcite, and dolomite makes up the similar rock that is also called dolomite or sometimes dolostone. Limestone is mined as a raw in ingredient of cement.

Silicates

The silicate minerals contain the $(SiO_4)_4$- complex anion. Silicates make up about 95 percent of the Earth's crust. They are so abundant for two reasons. First, silicon and oxygen are the two most plentiful elements in the crust. Second, silicon and oxygen combine readily.

Physical Properties of Minerals

To identify an unknown mineral, you should first determine its physical properties, then match the properties with the appropriate mineral.

1- Color

Color is the most obvious property of a mineral, but it is commonly unreliable for identification. Color would be a reliable identification tool if all minerals were pure and had perfect crystal structures. However, both small amounts of chemical impurities and imperfections in crystal structure can dramatically alter color. For example, corundum (Al_2O_3) is normally a cloudy, translucent, brown or blue mineral. Addition of a small amount of chromium can convert corundum to the beautiful, clear, red gem known as ruby. A small quantity of iron or titanium turns corundum into the striking blue gem called sapphire.

2- Streak

Streak is the color of a fine powder of a mineral. It is observed by rubbing the mineral across a piece of unglazed porcelain known as a streak plate. Many minerals leave a streak of powder with a diagnostic color on the plate. Streak is commonly more reliable than the color of the mineral itself for identification.

3- Luster

Luster is the manner in which a mineral reflects light. A mineral with a metallic look, irrespective of color, has a metallic luster. The luster of nonmetallic minerals is usually described by self-explanatory words such as glassy, pearly, earthy, and resinous.

4- Cleavage

Cleavage is the tendency of some minerals to break along flat surfaces. The surfaces are planes of weak bonds in the crystal. Some minerals, such as mica and graphite, have one set of parallel cleavage planes. Others have two, three, or even four different sets. Some minerals, like the micas, have excellent cleavage. You can peel sheet after sheet from a mica crystal as if you were peeling layers from an onion. Others have poor cleavage. Many minerals have no cleavage at all because they have no planes of weak bonds. The number of cleavage planes, the quality of cleavage, and the angles between cleavage planes all help in mineral identification.

5- Fracture

Fracture is the pattern in which a mineral breaks other than along planes of cleavage. Many minerals fracture into characteristic shapes. Conchoidal fracture creates smooth, curved surfaces. It is characteristic of quartz and olivine. Glass, although not a mineral because it has no crystalline structure, also typically fractures in a conchoidal pattern. Some minerals break into fibrous fragments. Most fracture into irregular shapes.

6- Hardness

Hardness is the resistance of a mineral to scratching. It is easily measured and is a fundamental property of each mineral because it is controlled by bond strength between the atoms in the mineral. To measure hardness more accurately, geologists use a scale based on ten minerals, numbered 1 through 10.

The Mohs hardness scale shows below:

1.Talc	6. Feldspar
2.Gypsum	7. quartz
3.Calcite	8. Topaz
4.Fluorite	9. Corundum
5.Apatite	10. Diamond

The minerals are arranged in order of increasing hardness, although the differences in hardness between minerals of the scale are not uniform in any absolute sense, and the numbers are indicative only of the relative order of hardness.

For example, that a mineral scratched by quartz but not by orthoclase has a hardness between 6 and 7. Because the minerals of the Mohs scale are not always handy, it is useful to know the hardness values of common materials. A fingernail has a hardness of slightly more than 2, a copper penny about 3, a pocketknife blade slightly more than 5, window glass about 5.5, and a steel file about 6.5. If you practice with a knife and the minerals of the Mohs scale, you can develop a “feel” for minerals with hardnesses of 5 and under by how easily the blade scratches them.

7- Specific Gravity

Specific gravity is the weight of a substance relative to that of an equal volume of water. If a mineral weighs 2.5 times as much as an equal volume of water, its specific gravity is 2.5.

*To understand the silicate minerals, remember four principles:

1. Every silicon atom surrounds itself with four oxygens. The bonds between each silicon and its four oxygens are very strong.

2. The silicon atom and its four oxygens form a pyramid-shaped structure called the silicate tetrahedron with silicon in the center and oxygens at the four corners.

3. To make silicate minerals electrically neutral, other cations must combine with the silicate tetrahedral to balance their negative charges. (The lone exception is quartz, in which the positive charges on the silicons exactly balance the negative ones on the oxygens.

4. Silicate tetrahedral commonly link together by sharing oxygens. Thus, two tetrahedral may share a single oxygen, bonding the tetrahedral together.