Directions

1. Read the handouts first so the diagnostic features are fresh in your mind.

2. On the blank charts provided, fill in all the physical properties for the suite of mineral specimens supplied in the lab by making your own observations. When you have completed your observation of the physical properties, use the mineral identification tables provided to assign each mineral a name.

Many minerals have easy features that are diagnostic of that mineral; if you can tell what the mineral is by some outstanding feature, you don't have to worry about getting the cleavage angle or number of cleavages exactly correct. Write down what other features you can easily identify and move on. (Remember that you will most likely have to identify some of these minerals on a test.)

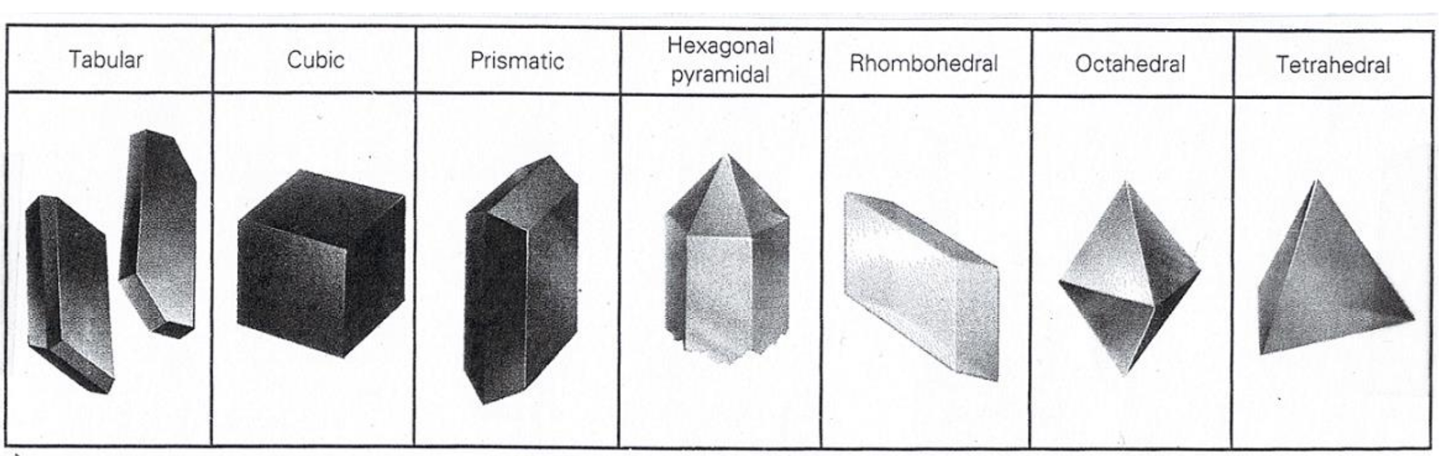
PHYSICAL PROPERTIES OF MINERALS

Mineral: A naturally-occurring inorganic crystalline solid with definite (although not fixed) chemical composition.

Although more than 2,000 different mineral species have been identified, only 25 or 30 are abundant constituents of rocks. The purpose of this exercise is to acquaint you with these common rock-forming minerals. The most diagnostic physical properties of these minerals are listed in the Mineral Identification Index.

Crystal Habit

If a mineral crystallizes without any impediments to its growth, the mineral may assume a characteristic shape (or crystal habit) that reflects its internal crystal structure. For example, muscovite will often display a book-like tabular habit that results from the arrangement of it silicate tetrahedra in a sheet structure, and halite forms nearly perfect cubes with flat square crystal faces, reflecting the cubic arrangement of its atoms. Other common crystal habits are illustrated on the diagram below. The term *anhedral* is used to describe minerals without well-formed crystal faces.



Luster

The way the fresh surface of a mineral reflects light is called its luster. Most minerals may be divided by their luster into *metallic* and *nonmetallic* groups. The luster of nonmetallic minerals may be further divided using descriptive terms such as *pearly* or *resinous*. Varieties of luster and mineral examples are provided below.

TYPE	DESCRIPTION	MINERAL EXAMPLES
Metallic		Galena, pyrite
NONMETALLIC:		
Vitreous	Shiny like glass	Quartz
Pearly	Milky reflectance like pearl	Talc
Silky	Fibrous appearance	Asbestos
Resinous	Appearance of resin	Sphalerite, sulfur
Dull	Earthy appearance	Kaolinite, limonite
Greasy	Oily appearance	

Color

Color is the most obvious physical characteristic of any mineral specimen. For some mineral species, such as pyrite or galena, it provides a useful clue for identification. Unfortunately the color of most minerals is highly variable. Although color should always be considered in the course of mineral description, it should never be used as a principle identifying characteristic.

Streak

The color of a powdered portion of a mineral is known as its streak. Generally, the streak color is different from the color observed in hand sample, and it can be much more diagnostic for identification purposes. Mineral powder may be easily obtained by rubbing a corner of the specimen against a white porcelain surface (or streak plate). Unfortunately, because many light-colored minerals have white or pastel streaks, a streak test is not particularly useful in identifying nonmetallic minerals. Also, minerals which are harder than a streak plate will not be powdered during a streak test.

Hardness

Hardness is the ability of a mineral to resist abrasion. A mineral's hardness may be measured by determining how easily it scratches or is scratched by a material of known hardness. The most common standard is the Mohs' scale of hardness. The scale consists of 10 minerals of different hardness, each assigned a number from 1 to 10. Ten is the hardest and most difficult to scratch. Other materials such as a fingernail, penny, glass, or knife blade may be used to test the unknown mineral's hardness. Remember that each mineral on the Mohs' scale has an assigned number and the scale is relative. For example, although fluorite is number 4 on the scale, it is not twice as hard as gypsum (number 2 on the scale), nor is it half as hard as topaz (number 8 on the scale). Also, two minerals with the same hardness will scratch each other.

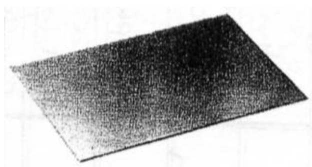
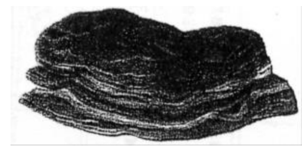
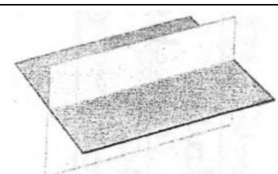
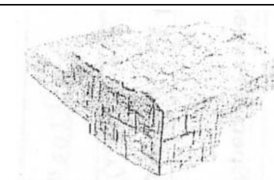
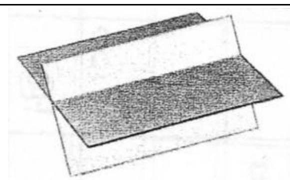
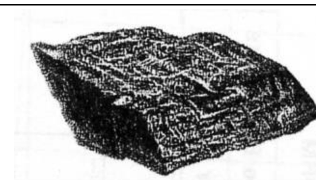
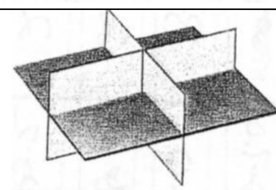
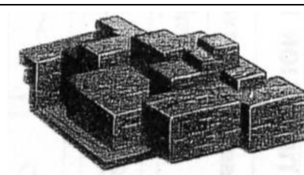
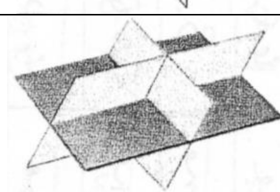
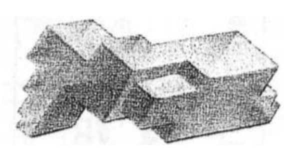
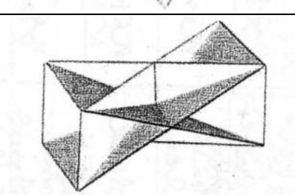
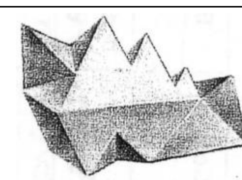
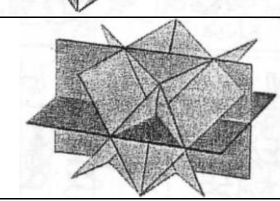
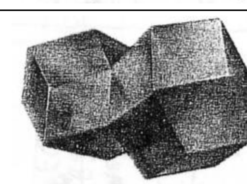
MOHS' MINERAL HARDNESS SCALE:

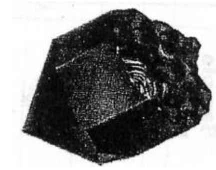
MATERIAL	HARDNESS	MOHS' NUMBER	MINERAL
		1	Talc
Fingernail	2.5	2	Gypsum
Penny	3.5	3	Calcite
		4	Fluorite
Glass Plate	5.5	5	Apatite
Knife Blade	6	6	Orthoclase
		7	Quartz
		8	Topaz

		9 10	Corundum Diamond

Cleavage

Cleavage is a mineral's tendency to break along planes of weakness within its atomic structure. The chemical bonds in muscovite, for example, are strong within the planes of the silicate sheets but weak between them, causing muscovite crystals to cleave easily into thin sheets. Some minerals, such as mica, feldspar, and fluorite, have good to excellent cleavage in one, two, three four or even six different directions.

Number of cleavage directions	Angles between cleavage directions	Sketch	Shapes of broken crystals	Sketch
1	180°		Tabular	
2	90°		Rectangular Prism	
2	Not at 90°		Non-rectangular prism	
3	90°		Cubes	
3	Not at 90°		Rhombohedrons	
4	Varied		Octahedrons (8 sided)	
6	Varied		Dodecahedrons (12 sided)	

None	Conchoidal, fibrous or uneven	

Fracture
Fracture describes the way in which a crystal breaks in an irregular manner. Some minerals fracture in a regular and identifiable way: Quartz and glass, for example, both display conchoidal fracture, and asbestos shows splintery fracture.

Specific Gravity
Specific gravity is defined as the ratio of the mass of a mineral to the mass of an equal volume of water. It is essentially a measure of the density of a mineral and this reflects its chemical composition. The specific gravity of a mineral can be measured precisely in a laboratory, and it can be estimated by feeling the heft of a mineral. This trait is especially useful in identifying very dense minerals such as galena.

Distinctive properties of some minerals

MINERAL	PROPERTY
Calcite	Reacts vigorously with hydrochloric acid (HCl) – Excellent rhombohedral cleavage; often transparent, and when it is you can see double refraction through the crystals
Dolomite	When in powdered form, reacts with HCl
Magnetite	Strongly magnetic with metallic luster
Sphalerite	Smells of sulphur especially when scratched as it is ZnS – Pale yellow streak, on a generally dark yellow-brown to black mineral (don't confuse it with yellow-colored pure sulphur)
Barite	Surprisingly dense (high specific gravity) for a light colored mineral; crystal habit tends to be tabular
Bauxite	Often made of pea-like, concentric blobs – Looks earthy
Garnet	Usually has equant (equidimensional) crystal habit
Galena	Look for cubic cleavage, metallic luster, and very high specific gravity
Talc	Soft (easily scratches with a fingernail), and "soapy" feel (just like talcum powder)
Plagioclase v. Orthoclase	*Orthoclase (K–Feldspar)* comes in many colors, especially salmon and white, plagioclase is usually white to light gray – *Plagioclase (Na–Ca Feldspar)* will often (but not always) have fine striations (twinning) that reflect in the light on cleavage faces
Muscovite v. Biotite	Micas! Both have perfect, planar cleavage and separate in extremely thin sheets - *Biotite* is dark colored, *muscovite* is lighter colored
Amphibole v. Pyroxene	*Amphibole* has 60 and 120 deg. cleavage planes, and the intersection of these planes often looks splintery on the surface – *Pyroxene* has 90 deg. cleavages
Halite	Rock salt – Often transparent to translucent, cubic cleavage, feels like salt, tastes like salt
Kyanite	Bluish gray color – Hardness is about 4.5 when scratched parallel to the long axis of the crystal and approximately 6.5 when scratched perpendicular to (or across) the long axis

MINERAL CLASSES

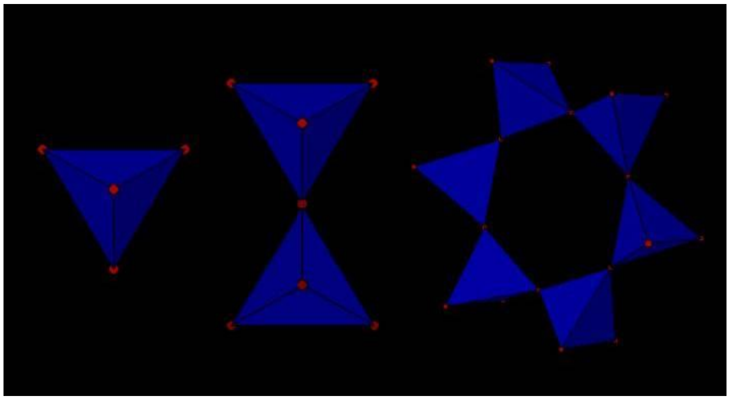
Silicate Class

Although 92 natural chemical elements are known (the rest are manmade and unstable), more than 98% of the earth's crust is composed of only 8 elements. Oxygen and silicon are by far the most abundant, and together constitute more than 74 weight percent of the earth's crust. Their abundance indicates that most crustal minerals are compounds which include these two elements. Such minerals are call *silicates*.

A silicon atom is much smaller than an oxygen atom, about like comparing the relative sizes of a ping pong ball and a basketball. Because of this size difference and their particular electrical properties, silicon atoms within minerals are commonly surrounded by four strongly-bonded oxygen atoms. This arrangement has a tetrahedral configuration, and it is the basic structural unit of all silicate minerals. SiO_4 tetrahedra bond together at their corners to form chain, sheet, or framework atomic structures. The different patterns of tetrahedra linkage provide a basis for division of silicate minerals into individual *families*.

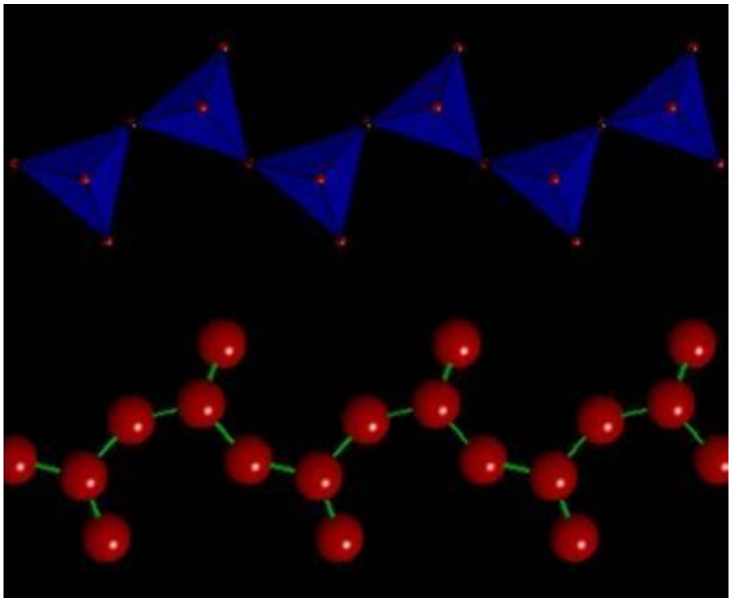
Independent Tetrahedra Family

The simplest type of silicate atomic structure is characterized by SiO_4 tetrahedra which are not directly bonded together. They occur as independent SiO_4 groups which are interconnected through their bond with other elements. Because constituent atoms are closely packed and strongly bonded, minerals within this silicate family are typically hard and dense and lack cleavage. *Olivine* and *garnet* are members of this silicate family.



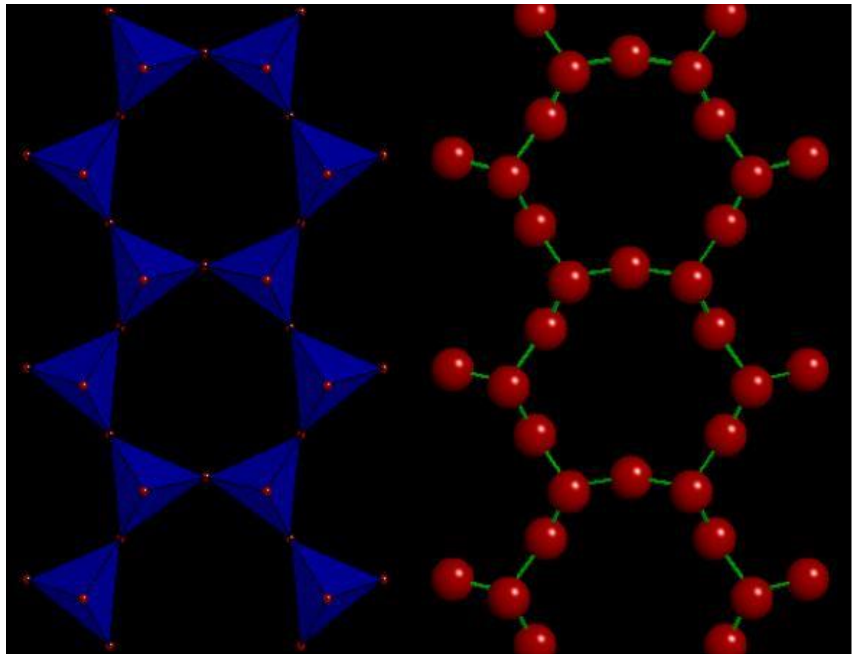
Single-Chain Tetrahedra Family

An SiO_4 tetrahedron may share two of its oxygen atoms in strong bonds with adjacent tetrahedra to produce a chainlike structure. Unshared oxygen atoms are more weakly bonded to other elements which interconnect the SiO_4 chains into three-dimensional networks. This tetrahedra pattern is characteristic of another silicate family of which the *pyroxene mineral group* is an example. Physical properties of minerals within this family reflect the internal chainlike atomic structure because most occur as elongate, needle-shaped crystals. In addition, most have two directions of cleavage. These cleavages result from zones of structural weakness which occur because of differences in bond strength between shared and unshared oxygen atoms within the tetrahedra chains.



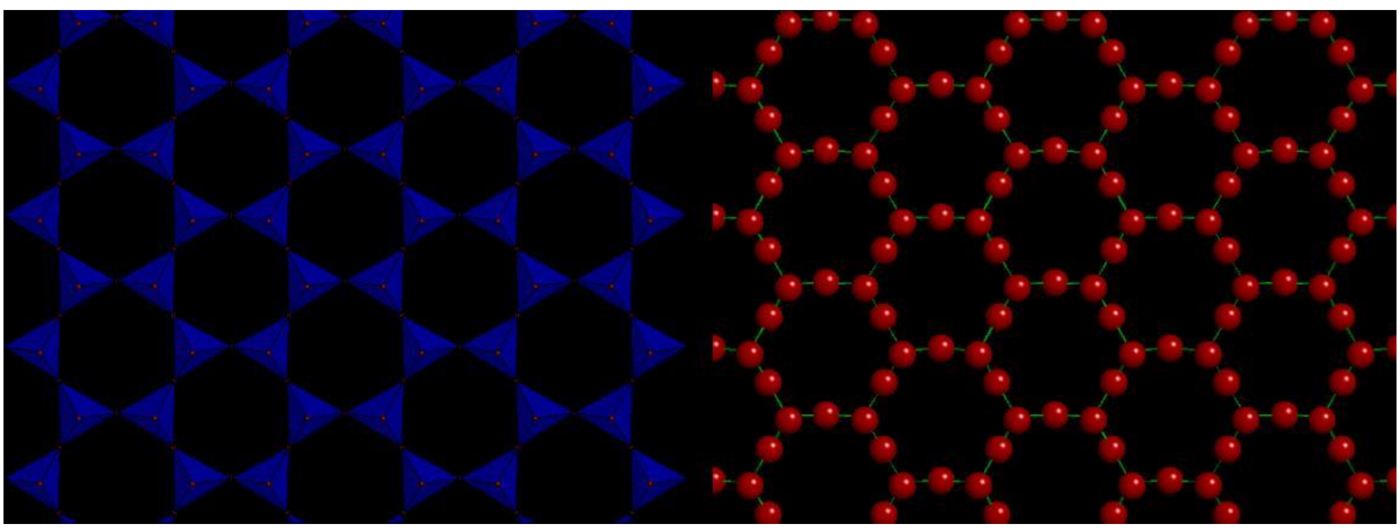
Double-Chain Tetrahedra

Another silicate structure is characterized by some SiO_4 tetrahedra sharing two oxygen atoms in bonds with adjacent tetrahedra and other sharing three. This results in direct cross-linkage of individual chains and produces a double-chain structure. This structure is characteristic of another silicate family of which the *amphibole mineral group* is the most common example. Because of their atomic structure, most minerals within this family occur as elongate, bladelike crystals. Differences in bond strength produce systematic zones of atomic weakness, and minerals within this silicate family usually have two directions of cleavage.

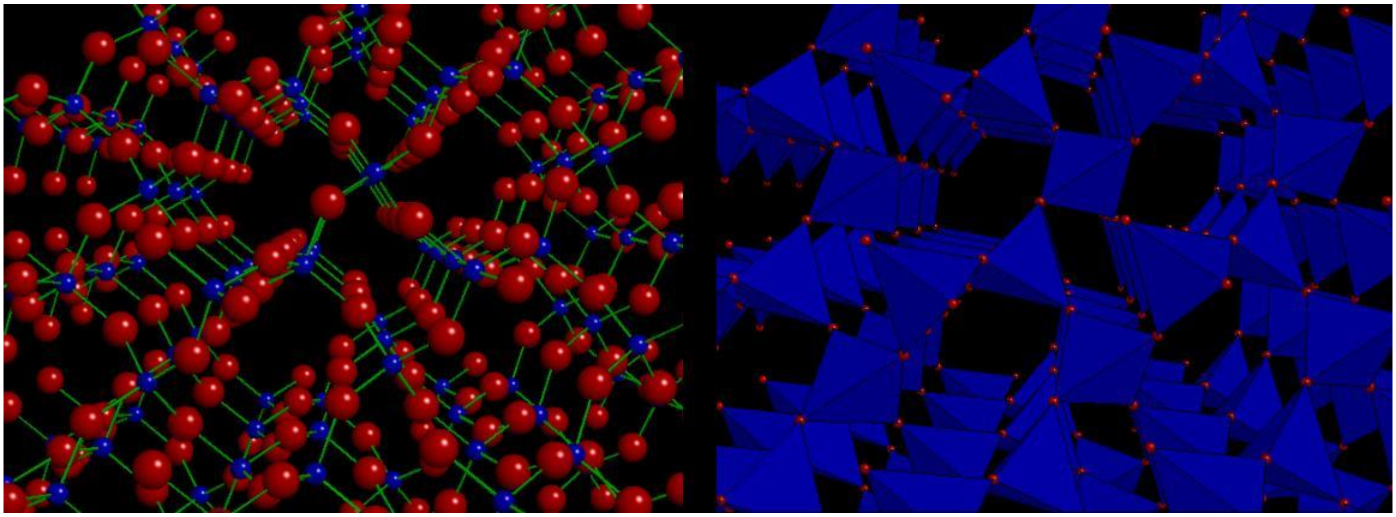


Sheet Tetrahedra Family

It is possible for all SiO_4 tetrahedra and produce a sheet like structure. Unshared oxygen atoms within each tetrahedra sheet are more weakly bonded to other elements and join tetrahedra layers into three-dimensional structures. Because bonds within tetrahedra layers are much stronger than bonds between layers, most minerals within this silicate family have one direction of well-developed cleavage. *Biotite* and *muscovite* are members of the sheet silicate family.



Framework Tetrahedra Family
An SiO_4 tetrahedron may share all four of its oxygen atoms in bonds with adjacent tetrahedra to produce an interlocking framework which is characteristic of another family of silicate minerals. Most framework silicates are rather hard because of the interlocking and strongly bonded nature of their constituent tetrahedra. However, because constituent atoms are not closely packed, members of this silicate family are not dense. *Quartz* and members of the *feldspar mineral group* are examples of frameworks silicates.



Oxide Class
An oxide mineral contains oxygen in combination with an element other than silicon. In view of the abundance of oxygen within the earth's crust, it is not surprising that members of this mineral class are common. Examples include compounds of iron and oxygen (*magnetite*, Fe_3O_4, *hematite*, Fe_2O_3), of aluminum and oxygen (*corundum*, Al_2O_3), and of hydrogen and oxygen (*ice*, H_2O). Some oxide minerals contain water in their atomic structure and are termed *hydrated oxides*. *Limonite* is a hydrated iron oxide [$FeO(OH) \bullet H_2O$].

Carbonate Class
Members of the carbonate minerals class are compounds of carbon, oxygen, and other elements. Carbon and oxygen atoms occur as a carbonate ion [$(CO_3)^{-2}$] which is the basic building block of the mineral class, just as SiO_4 was the basic chemical unit of silicate minerals. Common examples of carbonate minerals include *calcite* (calcium carbonate, $CaCO_3$), *dolomite* (magnesium-calcium carbonate, $(Mg,Ca)CO_3$), and *siderite* (iron carbonate, $FeCO_3$).

Sulfide Class
Sulfide minerals contain sulphur (S) in combination with metal elements. Economically important metals such as copper, zinc, and lead are most often found as sulfide minerals. These include *galena* (lead sulfide, PbS), *sphalerite* (zinc sulfide, ZnS), *chalcopyrite* (copper-iron sulfide, $CuFeS_2$), and *pyrite* (iron sulfide, FeS_2).

Sulphate Class
The sulphate mineral class is characterized by combinations of sulphur and oxygen with other elements. Sulphur and oxygen atoms occur as a sulphate ion [$(SO_4)^{-2}$] which is the basic chemical unit of this mineral class. Examples include *anhydrite* (calcium sulphate, $CaSO_4$) and *barite* (barite sulphate, $BaSO_4$). Some sulphate minerals contain water within their crystalline structures and are termed *hydrated sulphates*. *Gypsum* is such a mineral (hydrated calcium sulphate, $CaSO_4 \bullet H_2O$).

Halide Class

Minerals within the halide mineral class contain ions of the halogen elements (fluorine, chlorine, bromine and iodine) in weakly bonded attachment with other elements. The most common representatives of this mineral class include *halite* ($NaCl$), *sylvite* (KCl), and *fluorite* (CaF_2).

Phosphate Class

Phosphate minerals are compounds of phosphorus (P) and oxygen with other elements. Phosphorus and oxygen atoms occur as a phosphate ion [$(PO_4)^{-3}$]. A common example of this mineral class is *apatite* [$Ca_5(PO_4)_3F$].

Hydroxide Class

Hydroxide minerals are compounds which contain a hydroxide ion [$(OH)^{-1}$] in combination with other elements. The mineral *gibbsite* (aluminum hydroxide, $Al(OH)_3$) is an example.

Native Elements Class

Native elements are concentrations of single elements. Those which most often occur in nature include *gold, silver, copper, platinum, carbon* and *sulphur*.