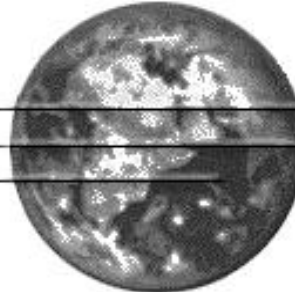


# Geoscience 101

## The Solid Earth



### Lecture 2

F-M-W-F    September    29  
                  October    2, 4, 6

R-T-R        September 28  
                  October 3, 5

## **Minerals: The Ingredients of Rocks**

### CHAPTER 2

This is only an outline of the lecture. You will need to go to class to fill in the outline, although much of the relevant information is also in the text.

# **Minerals: The Ingredients of Rocks**

## **MOTIVATION**

Geologists study rocks to learn how the Earth works.

Geologists study minerals because rocks are made of minerals, and minerals are interesting.

We need to learn how atoms combine because minerals are made of combinations of atoms.

All matter is made of atoms.

## **STATES OF MATTER**

Matter exists in a variety of states. The familiar ones are

Changing from one state to another either uses or releases energy, for example:

Changes of state do not necessarily involve chemical reactions.

## **CHEMICAL REACTIONS**

Chemical reactions occur when atoms combine with each other in new ways.

Examples:

## **CONSERVATION LAWS**

In a chemical process (reaction, change of state):

matter

energy

Nuclear reactions are different: matter can be changed into energy. These aren't "chemical." They happen within atoms, not between them.

## **ATOMS AND ELEMENTS**

The parts of an atom and their charges are:

Every atom of a given element has

1)

2)

An element's atomic number is:

An element's atomic mass is:

Why not electrons?

Chemical reactions involve the exchange of electrons among atoms.

## **ISOTOPES**

Not all isotopes are radioactive. Only a few are.

Definition:

Examples of isotopes:

## **CHEMICAL SYMBOLS**

Every element has its own symbol, consisting of one capital letter and sometimes one lower case letter.

Examples important in earth science (Learn these):

<b>O</b>	<b>Si</b>
<b>Al</b>	<b>Fe</b>
<b>Mg</b>	<b>Ca</b>
<b>K</b>	<b>Na</b>
<b>C</b>	<b>N</b>
<b>P</b>	<b>S</b>
<b>Cl</b>	<b>H</b>

## **COMPOUNDS, MOLECULES, CRYSTALS**

Compounds form when elements combine in exact proportions by reacting chemically to form something with different properties than either of the elements.

example:

A molecule consists of two or more atoms. It is the smallest possible unit of a compound.

examples:

Not all compounds exist as separate molecules.

A crystal is a repeating pattern of atoms combined in exact proportions and arranged in a particular structure.

examples:

A formula expresses the composition of a molecule or the proportions of atoms in crystal.

examples:

## **WHAT ARE MINERALS?** (geologists' definition)

Naturally occurring, solid, crystalline compounds.

By the definition of compound, it's composition is fixed, or varies within certain limits.

By the definition of crystal, a mineral has a specific internal pattern.

A mineral is "inorganic." However,

A mineral can be distinguished by its physical properties. You will learn to do this next week in lab.

## **ROCKS**

Definition:

We commonly divide rocks into three general categories:

Igneous rocks

Sedimentary rocks

Metamorphic rocks

## STRUCTURES OF SILICATE MINERALS

Silicate minerals are:

the most common minerals

based on a structure of silicon and oxygen called a silica tetrahedron.

A silica tetrahedron consists of 1 silicon and 4 oxygen atoms.

### **SiO<sub>4</sub><sup>4-</sup>**

Crystals are held together by the exchange of electrons between atoms.

In the silica tetrahedron, the silicon contributes 4 electrons, and the oxygen atoms try to grab 2 electrons each. Obviously, this doesn't add up:  $4 \times 2$  does not equal 4. Each tetrahedron needs to obtain 4 electrons by combining with other atoms that are inclined give up electrons,

for example:

There are various crystal structures that allow resolution of this charge imbalance.

## **ISOLATED TETRAHEDRA**

Basics:

The silica tetrahedra are combined with atoms of iron (Fe) or magnesium (Mg).

These other atoms are arranged between tetrahedra.

The mineral that results is olivine:



Comments:

Olivine is a hard mineral commonly found as little glassy yellow or green grains in basalt, the black lava rock found in central Oregon. Olivine weathers to a rust red. It has no cleavage.

Olivine is also a very common mineral in the mantle, and sometimes accumulates in large masses in the crust.

## **SINGLE CHAINS**

Basics:

The mineral formed of single chains is called pyroxene. It may be called by the name of one of its varieties, such as augite:



When the silica tetrahedra are linked up to form chains, they each share an oxygen with the two adjacent tetrahedra in the chain.

Sharing an oxygen means giving up half of it. Giving up half of two oxygens means giving up one oxygen. That's why the formula only has 3 oxygens in it, instead of 4.

Pyroxene has relatively more silicon in it than olivine, because of this change in structure.

Comments:

Pyroxene is most commonly found in basalt. Common varieties of pyroxene are black or very dark green.

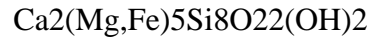
Pyroxene has 2 directions of cleavage, at right angles.

## **DOUBLE CHAINS**

Basics:

Double chains are two chains linked side by side. Some of the tetrahedra share 3 oxygens, where the chains are linked. Never mind the math.

The mineral formed of double chains is amphibole. A common variety of amphibole is called hornblende:



You do NOT need to memorize this!!

A small amount of water is bound into the amphibole structure. It shows up in the formula as (OH)<sub>2</sub>.

Comments:

Amphibole has 2 directions of cleavage, but they are not at right angles.

Amphibole is found in many kinds of igneous and metamorphic rocks.

## **SHEETS**

Basics:

Sheets are made by linking many chains of tetrahedra, side by side, so every tetrahedron is linked to other tetrahedra on 4 sides, but not on the top and bottom.

As a result of the linkage, some sheet silicates have relatively more silicon in them than pyroxene and amphibole.

Sheet silicates have water bound into the structure between the sheets.

Examples of sheet silicates:

Micas:

muscovite

biotite

(others)

Clays

Comments:

Micas are found in many kinds of rocks.  
Clays are very common in sedimentary rocks.

## **THREE DIMENSIONAL FRAMEWORKS**

Basics:

Silica tetrahedra are linked on all sides. This may form a network of pure silica:

Quartz SiO<sub>2</sub>

Comments:

Quartz has no cleavage.

Quartz is a hard mineral like olivine.

Quartz may form long, 6 sided crystals with pointed ends, but usually forms irregular little crystals.

## **MORE FRAMEWORKS: FELDSPAR**

Basics

Feldspars are formed when there are aluminum atoms in place of some of the silicon atoms. This requires addition of atoms that prefer to give up an electron, since aluminum gives up only three (one less than silicon).

There are two varieties of feldspar:

alkali feldspar (K,Na)AlSi<sub>3</sub>O<sub>8</sub>

plagioclase feldspar CaAl<sub>2</sub>Si<sub>2</sub>O<sub>8</sub> - NaAlSi<sub>3</sub>O<sub>8</sub>

Both varieties are mixtures containing varying amounts of potassium, sodium and calcium.

Comments:

Feldspar has two good cleavages, at (nearly) right angles.

It is usually light in color: pink, white or grey.