Minerals

Minerals are the building blocks of rocks.

Minerals record the formation and history of a rock and determine it's physical and chemical characteristics

Each mineral is characterized by:

-A specific composition

-A specific crystal structure

-A specific stability range (Pressure und Temperature)

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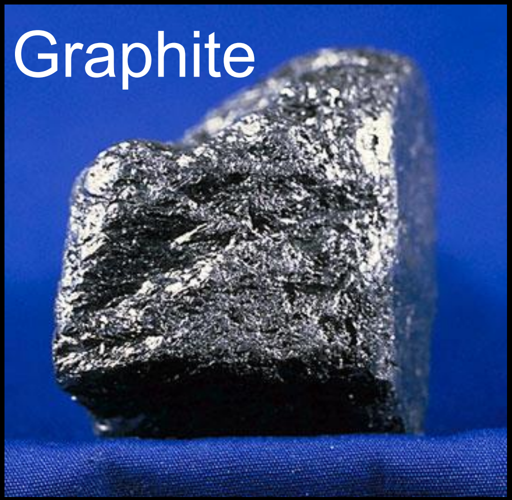
Diamond is pure carbon C,
as is graphite



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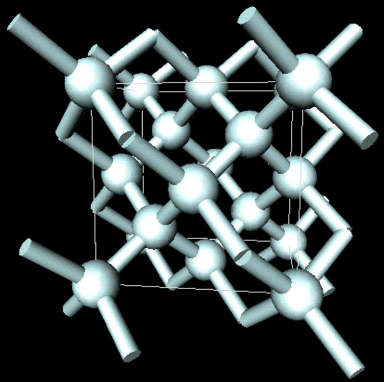
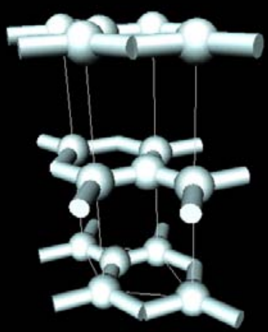
Diamond has a dense, cubic structure



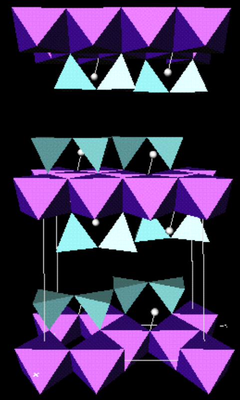
Graphite has a hexagonal structure



There are thousands of minerals....

They are separated into groups based on their:

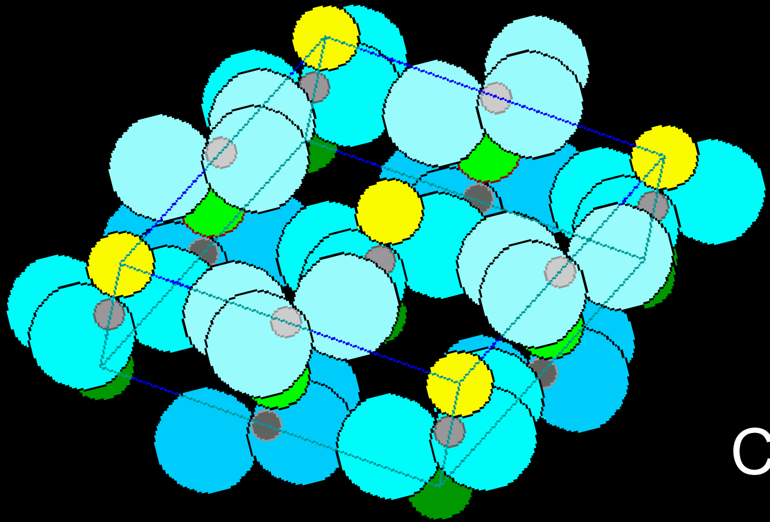
1. Crystal structure



2. Chemistry

SiO_2, $NaCl$, Au, $K_2Al_6Si_6O_{20}(OH)_4$ …

1. Crystal-structure



Calcite

The geometry of the crystal lattice constrains the form of the crystal

Covalent bonds

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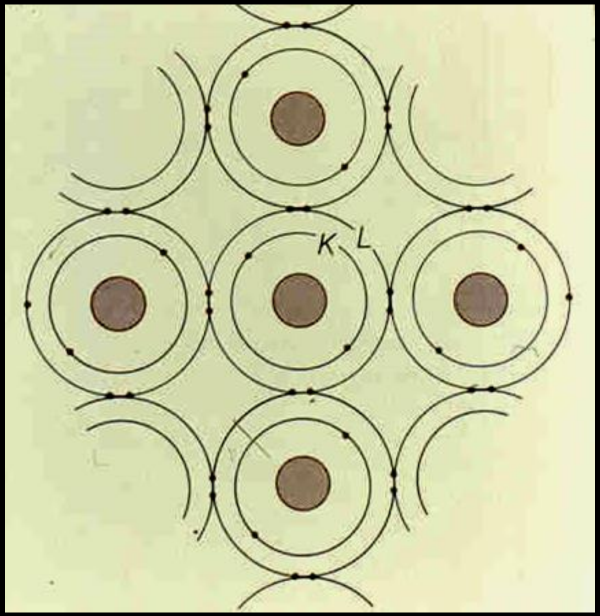
Some minerals are made up of covalent bonds characterized by shared electrons between different atoms. Diamond is a good example.

Covalent bonds

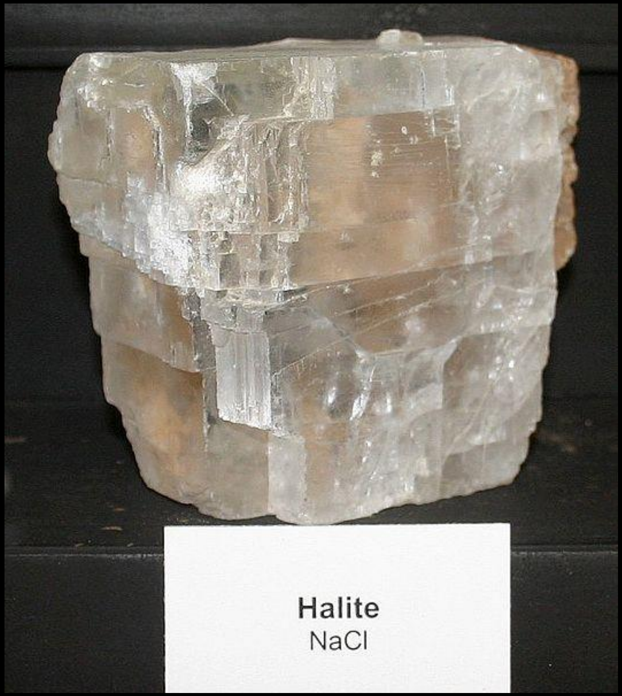


Covalent bonds

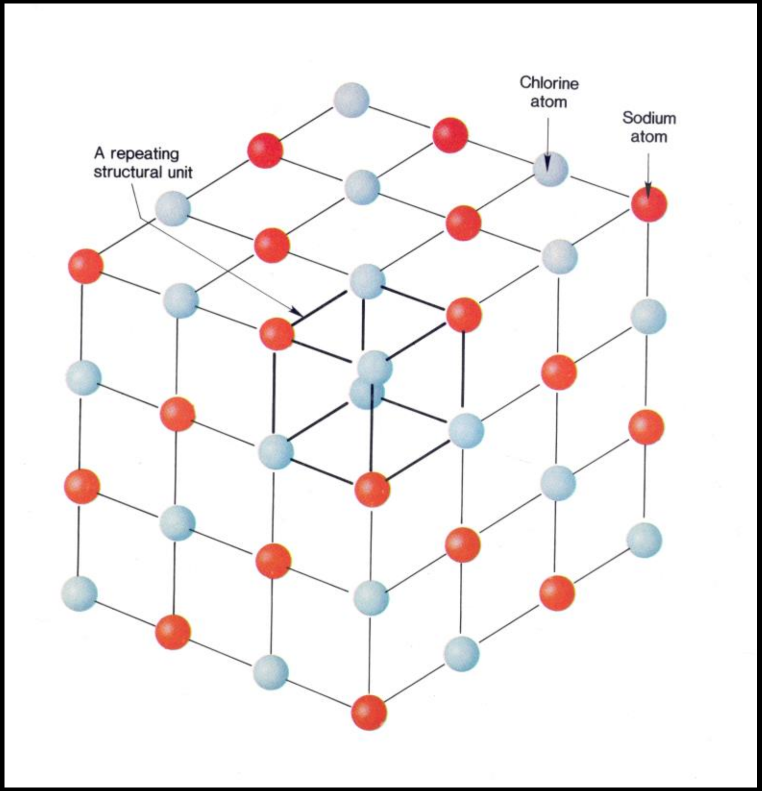
A carbon atom in Diamond shares each one of its four valence electrons with one of its four neighboring carbon atoms and thereby reaches a stable configuration of 8 valence electrons on the L-shell, even while each atom has only 4 electrons.

Ionic bonding

Most minerals, however, are composed of ionic bonds, in which cations and anions attract each other. A simple example is Halite.



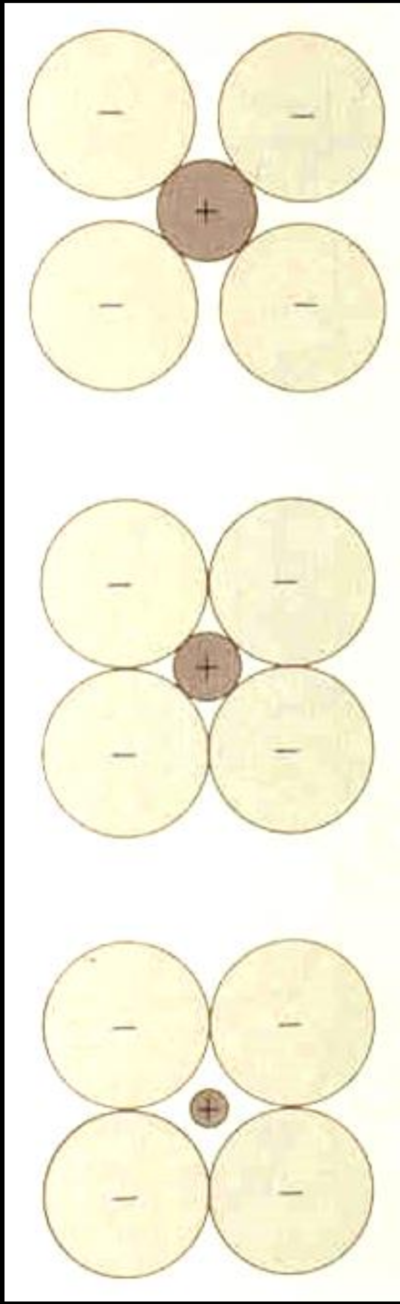
Courtesy of Chris Ralph. Photograph in the public domain.



Halite

NaCl is "Tablesalt" composed of Na^+ and Cl^- Ions.

Ionic bonds



Unstable

Cation larger than the space:
Anions are pushed apart

Most stable

Cation fits perfectly in the space

Stable

Cation smaller than the space
Anions are touching

2. Composition

Diamond

C

Courtesy of the U. S. Geological Survey.
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Halite

Sodium Chloride, NaCl

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Both have the same Structure,
But a different composition (and bonding...)

… and a different value

Systematic Mineralogy:

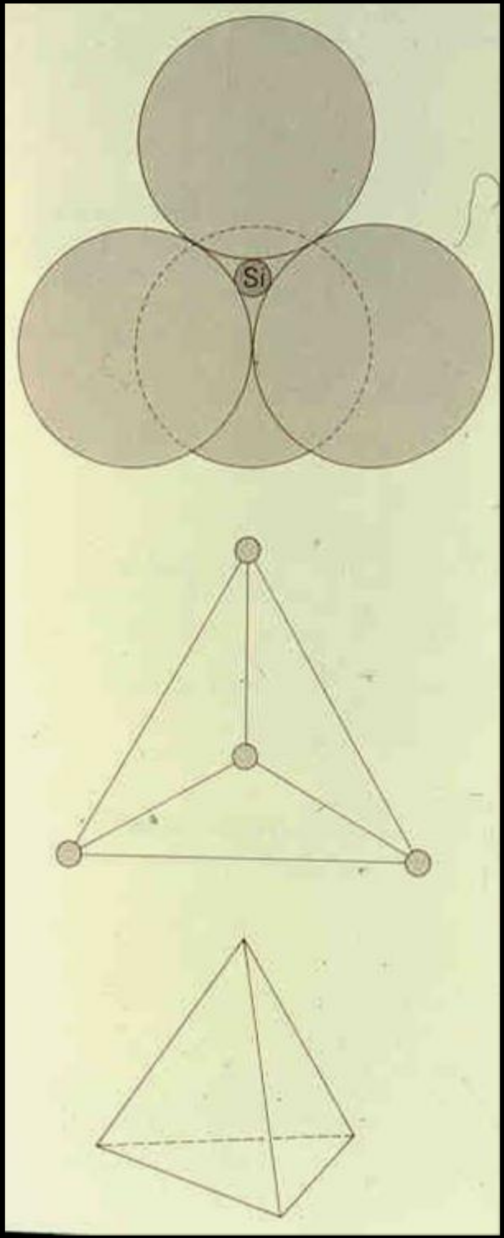
Separation of Minerals in Groups

Silicates

Silicates are the most comon & important rock forming minerals on Earth

Silicates are composed of a combination of SiO_4 Tetrahedrons and Cations:

K^+, Na^+, Ca^{2+}, Mg^{2+}, Fe^{2+} or Al^{3+}



The principal building block of rock forming minerals

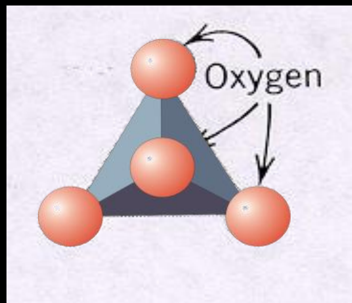
The SiO_4 Tetrahedrons

Silicates are the most important rock forming minerals. They are composed of a very stable molecule made up of Silicon and Oxygen atoms. Those form through covalent bonds a SiO_4 tetrahedron.

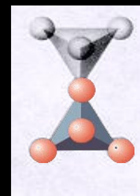
These tetrahedra can be combined in multiple ways. For example, they can be arranged by sharing an oxygen atom or through adding different cations.

Structure of silicate minerals

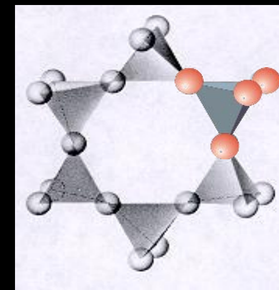
Neso-silicate $[SiO_4]^{4-}$

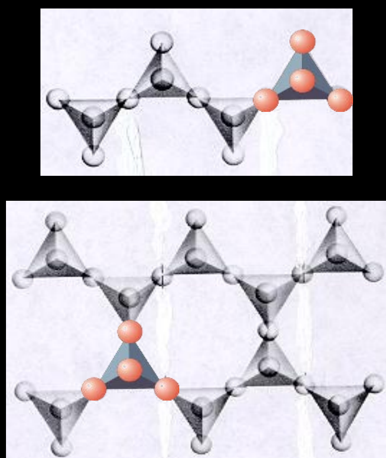


Soro-silicate $[Si_2O_7]^{6-}$

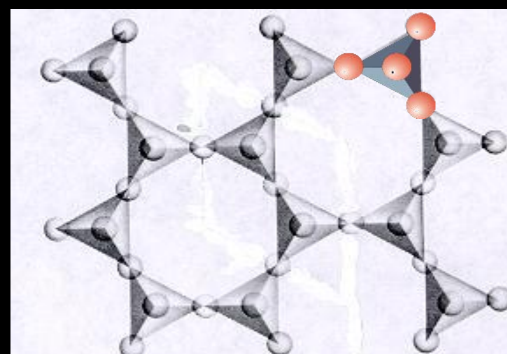


cyclo-silicate

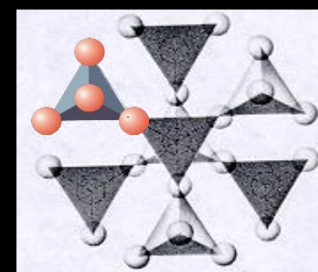




Inosilicates
Single Chain-silicate
Double chain-silicates



Phyllo-silicate



Tecto-silicate
$[Al_xSi_yO_{2(x+y)}]^{x-}$

Tecto-silicate

Quartz

SiO_2

Quartz is one of the most common minerals. Despite that, it is consider semi-precious based on its color and shapes.

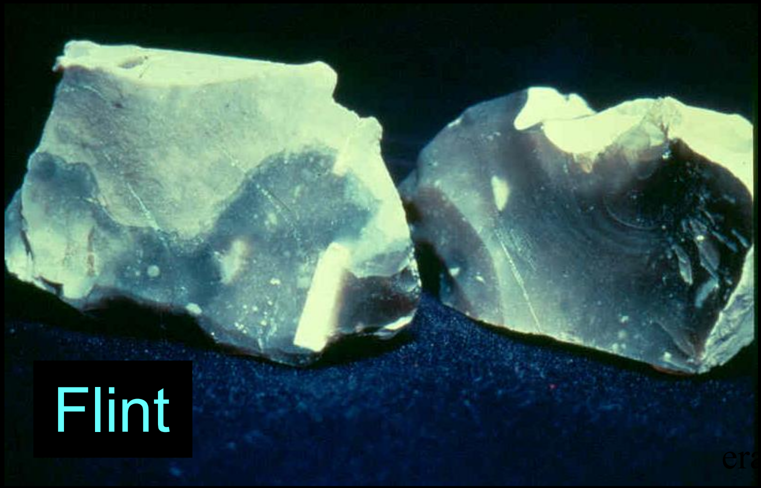
Quartz frequently forms hexagonal prisms and pyramids.

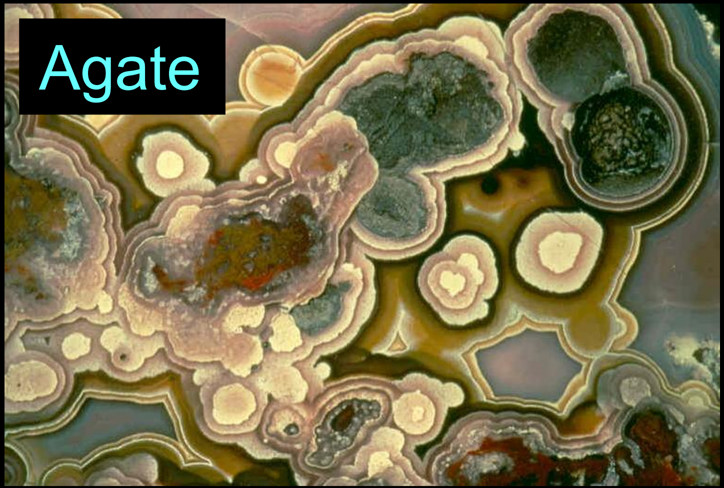
It is the hardest of the most common minerals.

Forms of Silica

Silica (SiO_2) most commonly occurs as quartz.

It can however occur in microcrystaline variaties Flint, Chert and Agate forms, which form from low T fluids.





Feldspars

Alkali-feldspar (or Orthoclase)
(K^+ and Na^+ bearing)

Amazonite is semi-precious

Plagioclase
(Na^+ und Ca^{2+} bearing)

Feldspars are Tectosilicates in which the SiO_4 tetrahedron is combined with K^+, Na^+, Ca^{2+} and Al^{3+}.

Feldspar group

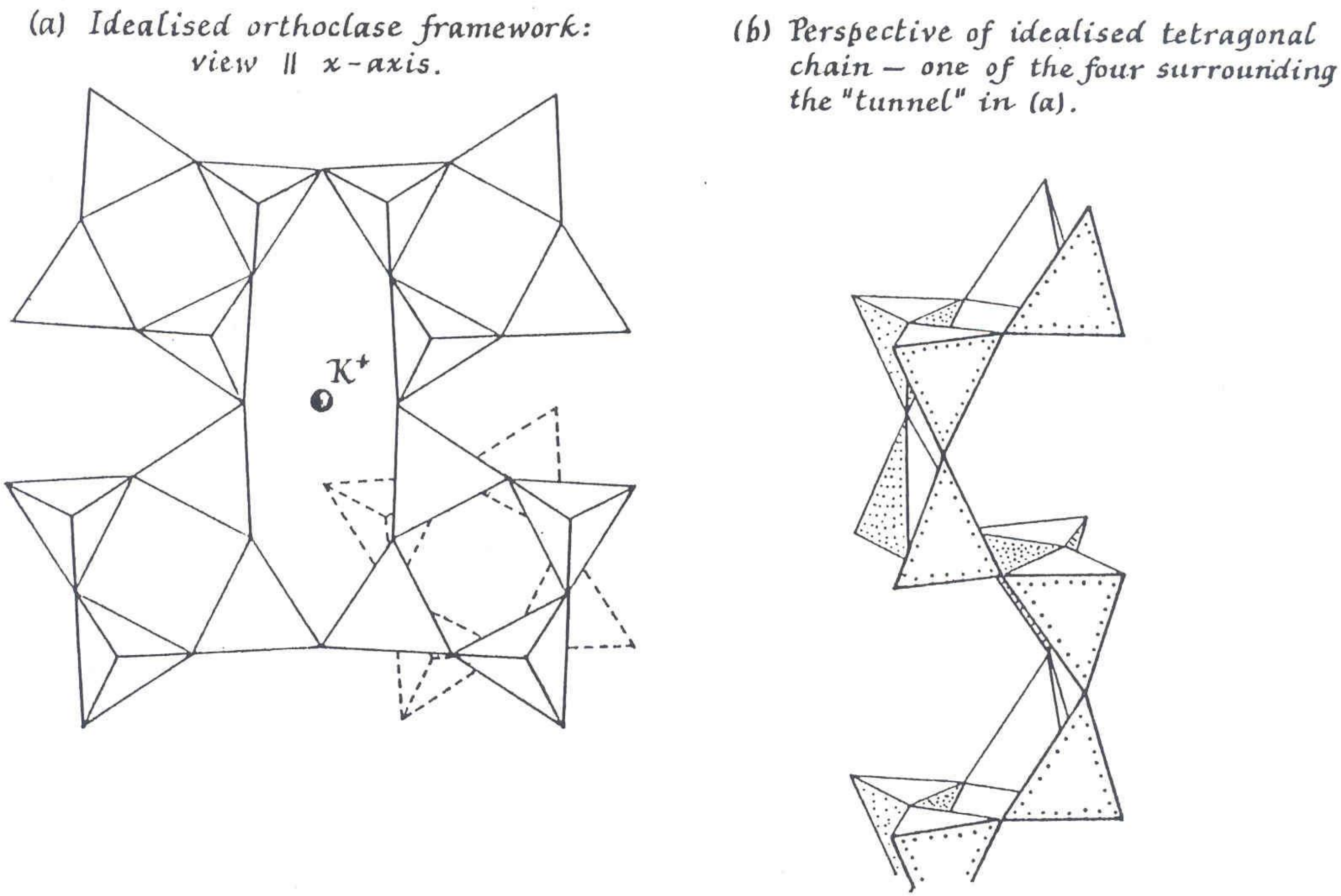


Fig. 244. Idealized structural pattern of orthoclase. In fact, the pseudotetragonal rings are somewhat twisted about their axis, producing the effect shown by the lower dotted tetrahedral ring in (*a*).

Feldspars are Tectosilicates in which the SiO_4 tetrtahedron is combined with K^+, Na^+, Ca^{2+} and Al^{3+}.

Phyllo-silicates

Muscovite
(K^+ and Al^{3+} bearing)

"cleavage"

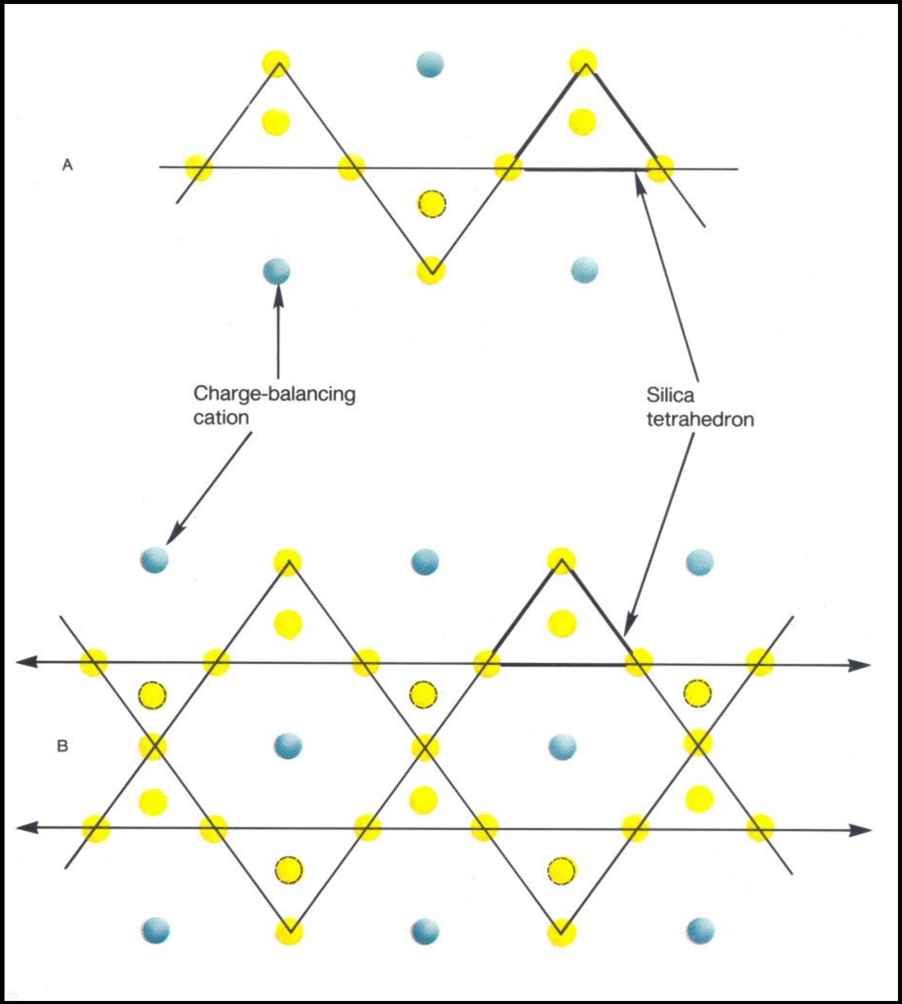
Mica, as clay minerals, are sheet silicates in which SiO_4 tetrahedron layers are combined with K^+, Mg^{2+}, Fe^{2+}, Al^{3+} and OH^-.

Biotite
(K^+, Fe^{2+} and Mg^{2+} bearing)

Ino-silicate

single-chain silicate

double-chain silicate



Ino-silicate

Pyroxenes are single-chain-silicates in which $[SiO_4]^{4-}$ tetrahedrons are combined with Ca^{2+}, Mg^{2+} and Fe^{2+} cations.

Augite is the most common Pyroxene (Ca^{2+}, Mg^{2+} and Fe^{2+} bearing)

Ino-silicate

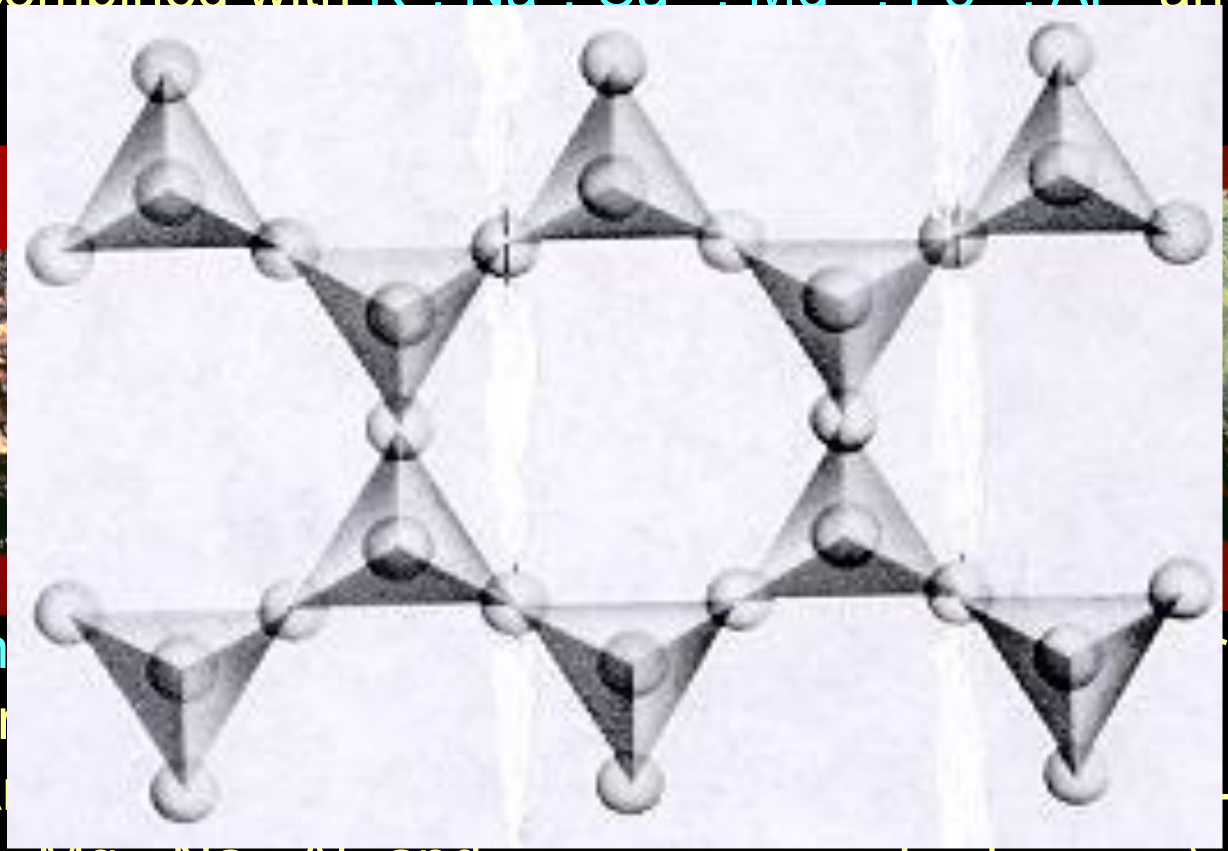
Amphiboles are Double-chain Silicates in which SiO_4 tetrahedra are combined with K^+, Na^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Al^{3+} and OH^-.

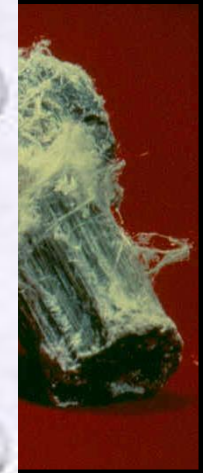
Hornblende is the most common mineral of the Amphibole group (Ca-, Mg-, Na-, Al- and Fe-bearing)

Asbestos is a fibrous Amphibole (Ca-, Mg-, Na-, Al- and Fe-bearing)

Ino-silicate

Amphiboles are Double-chain Silicates in which SiO_4 tetrahedra are combined with K^+, Na^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Al^{3+} and OH^-.





Horn
comm
A
(Ca-, Mg-, Na-, Al- and Fe-bearing)

ous
- and
Fe-bearing)

Neso-silicate

Olivine has isolated SiO_4 tetrahedra, combined by Mg^{2+} and Fe^{2+}

Olivine has a semi-precious variety (Peridote) even though it is the most common mineral in the upper mantle (-> Peridotite).

Neso-silicate

Garnet also has isolated SiO_4 tetrahedra which are combined with Ca^{2+}, Al^{3+} Mg^{2+} and Fe^{2+}

Garnet is common in metamorphic rocks formed under high pressure.

Non-silcate minerals

Luckily there aren't that many which are of importance. But those few are either

Very common

And play an important role in earth processes.

Or

Are an important for economic reasons.

The most important ones are:

Carbonates
Sulfates
Oxides
Fluorides
Sulfides
Phosphates
Native minerals (elements)

Carbonate

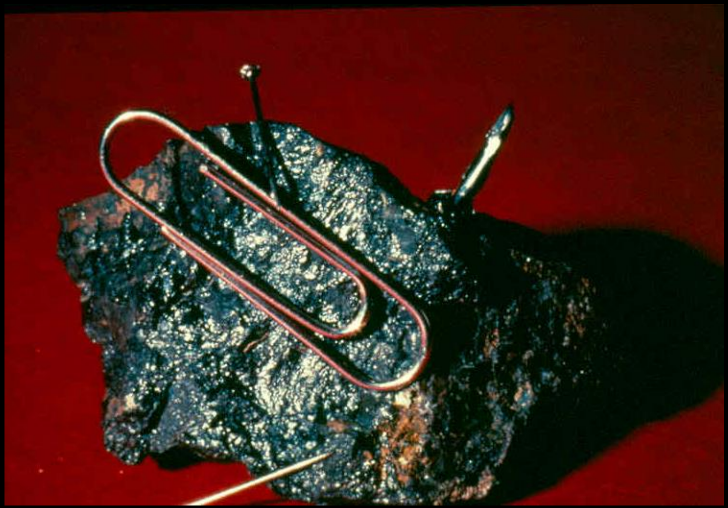
Calcite

Calcite ($CaCO_3$) is the main mineral in carbonates and shells of organisms

Dolomite

Magnesium and Calcium carbonate $(Mg,Ca)CO_3$ common in many old carbonates (as for example in the Dolomites)

Oxide



Magnetite

Iron oxide (Fe_3O_4) is the most common Metal-oxide in most plutonic rocks. Strongly magnetic.

Hematite

Iron oxide (Fe_2O_3), common ore mineral responsible for the red color in many Sandstones. Has been used as pigment for centuries.

Sulfide

Galena

Lead-sulfide PbS

Pyrite

Iron-sulfide FeS_2 is very common, known as fool's-gold....

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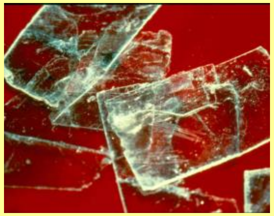
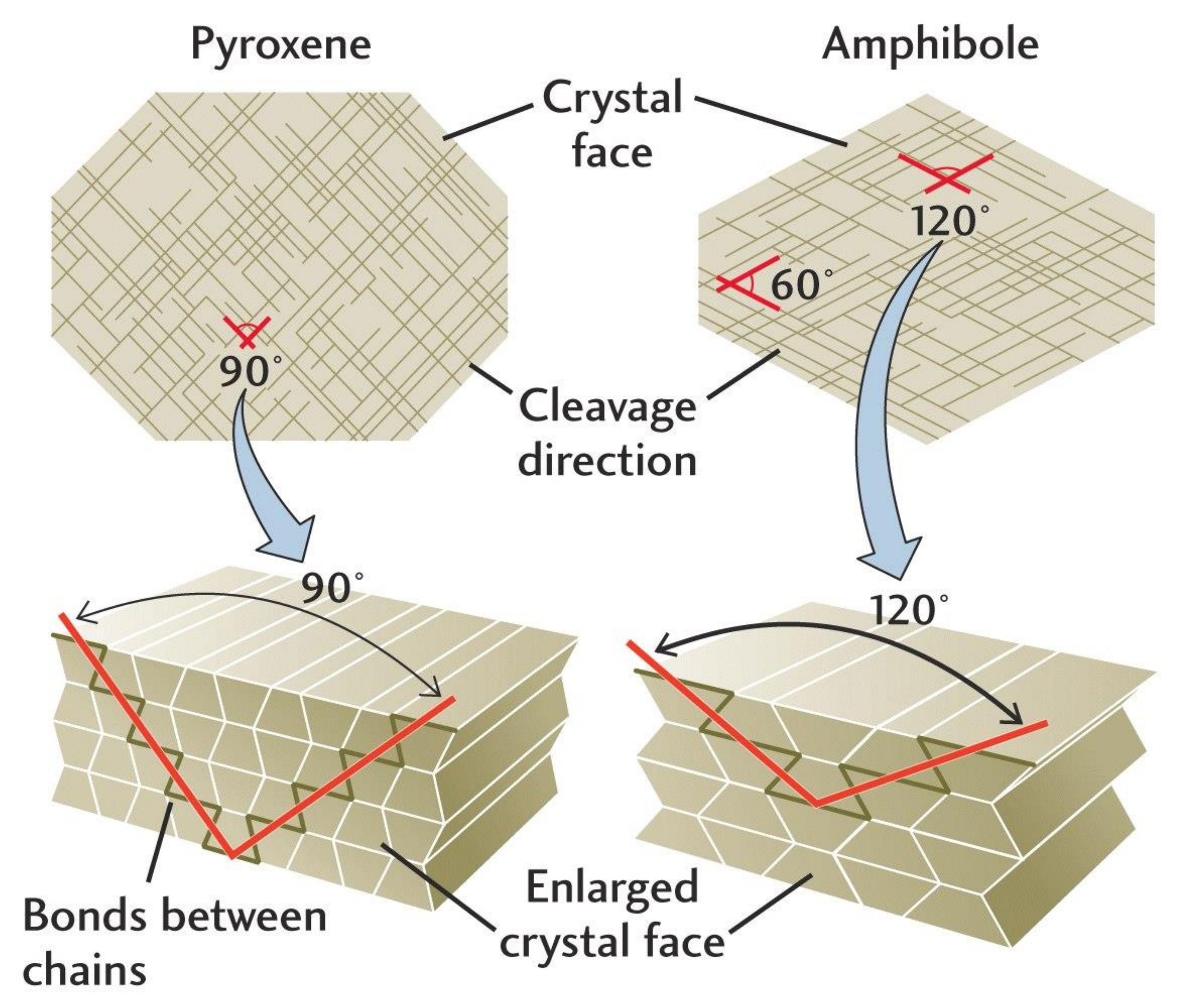
How do I distinguish a diamond from glass?

Criteria to identify minerals:

- hardness
- density
- habit
- cleavage
- color/streak
- association
- taste
- odor




Pyroxene
Amphibole
Crystal face
120°
60°
90°
Cleavage direction
90°
120°
Bonds between chains
Enlarged crystal face

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