EESC 2200
The Solid Earth System

Minerals & Rox

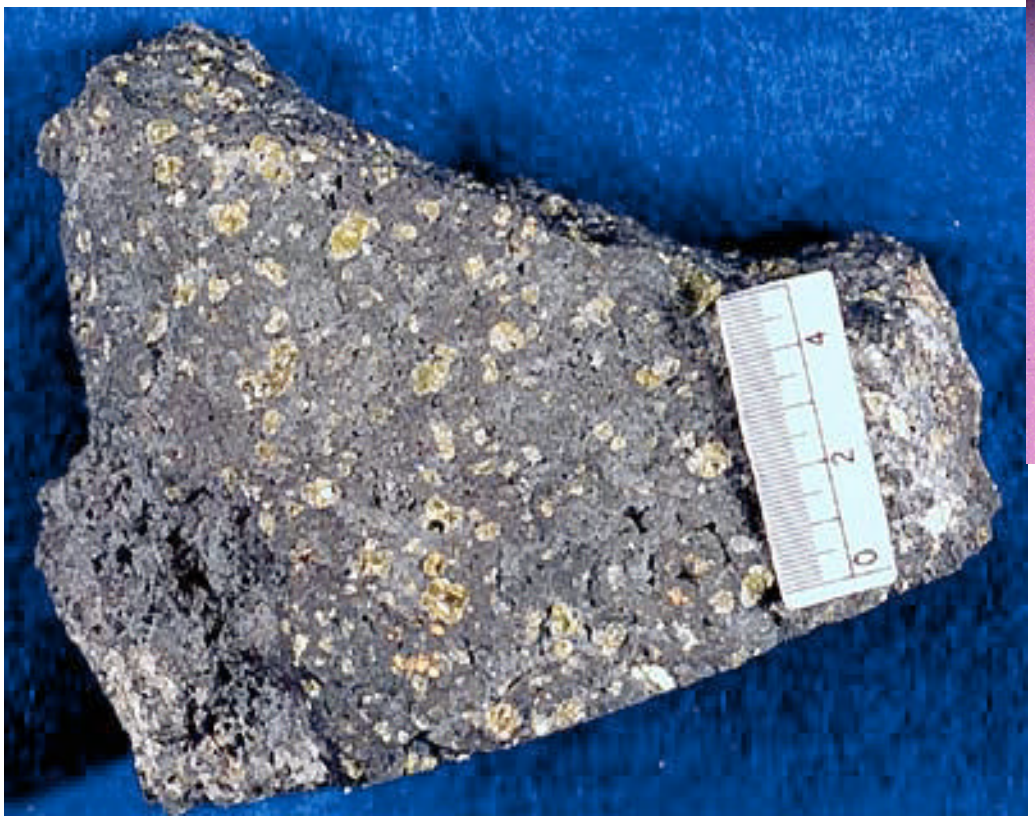
22 Sep 08

Homework 1: Due Today

Isostasy
Continental Tectonics

Minerals

gems & ores

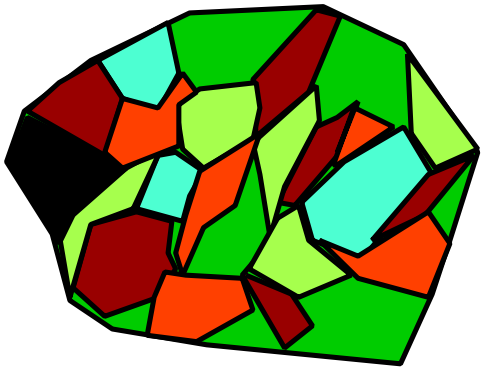


rock forming

Plate Tectonics can produce all rock classes:

- **igneous**
- **sedimentary**
- **metamorphic**

Earth is made of **rocks**

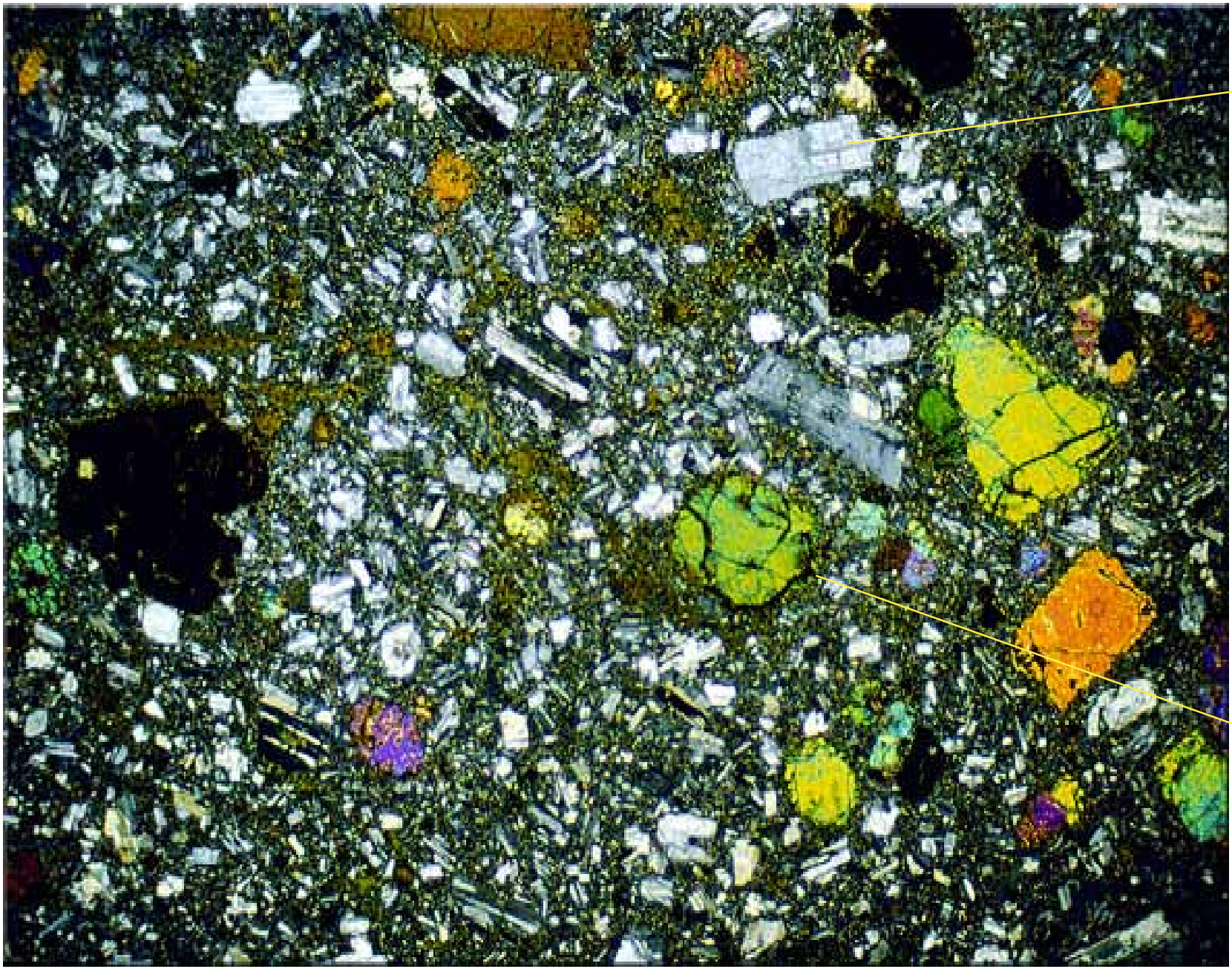


Each rock is made up of grains
minerals


Feldspar
Quartz
Mica
2 cm
Echantillon ENS Lyon

basalt
from Hawaii
with
olivine

basalt



photomicrograph of basalt (x-polars)

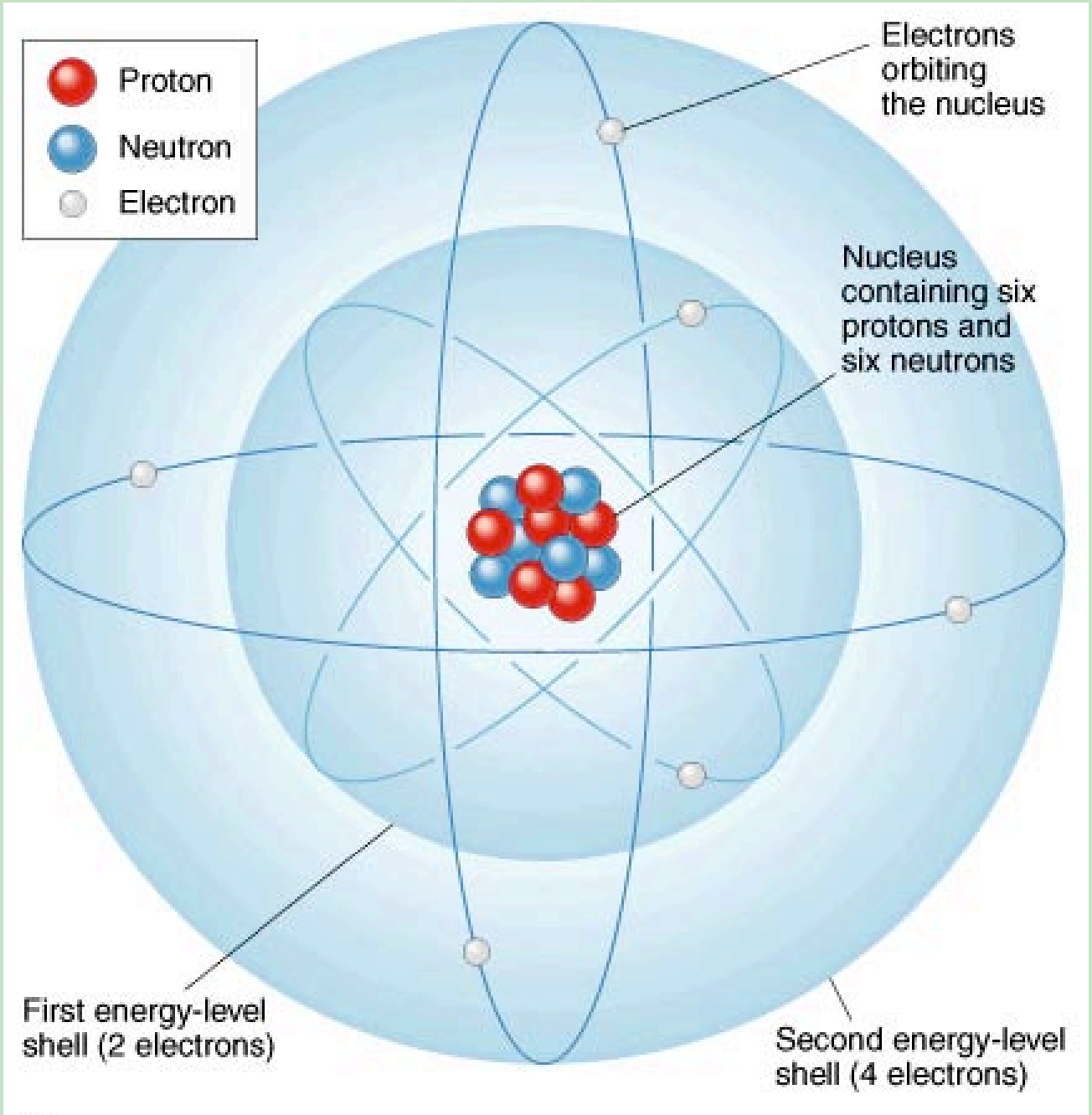
What Are Minerals?

Naturally occurring,

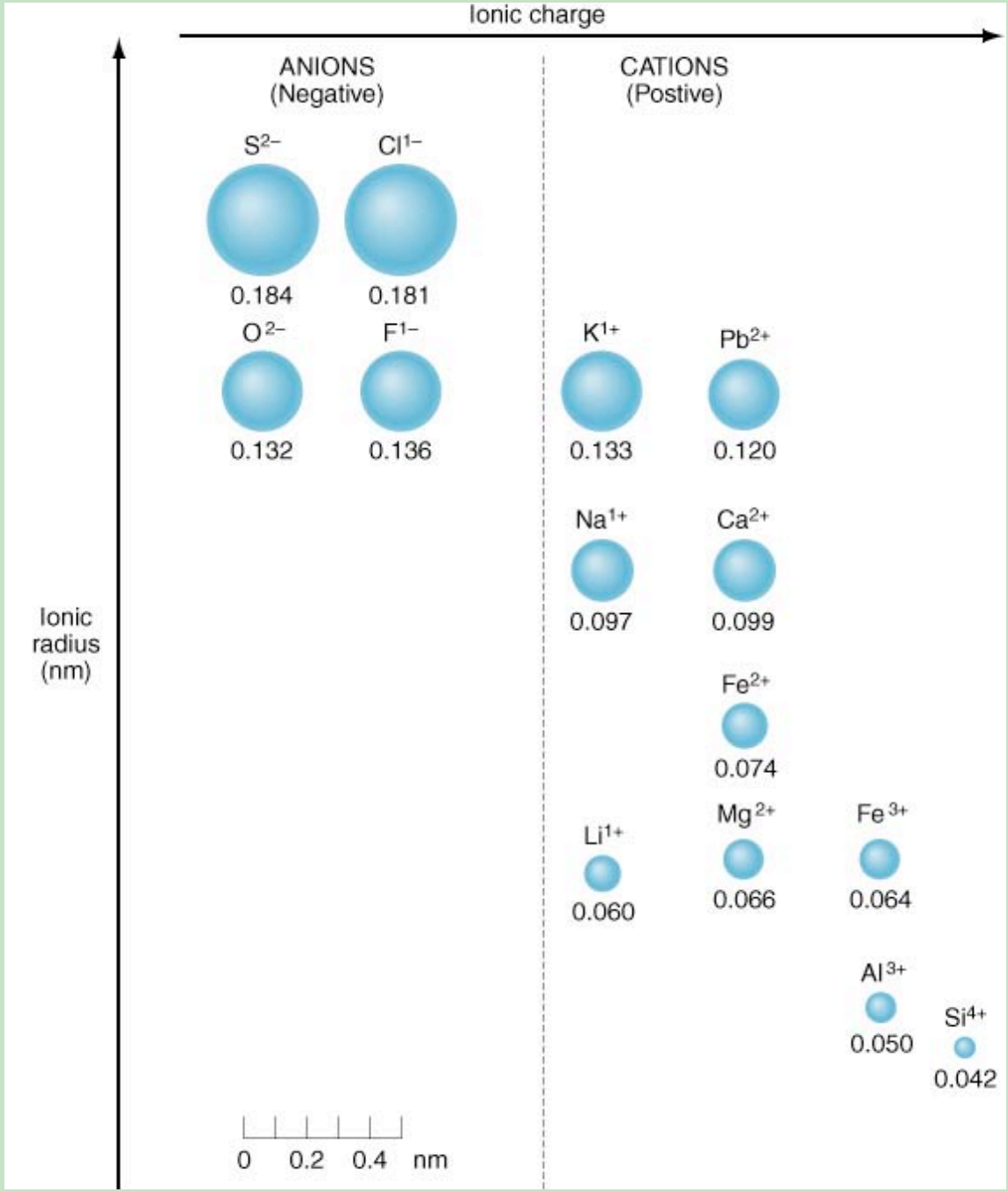
solid substances,

with a specific chemical compositions

and crystal structure.



Structure of an Atom

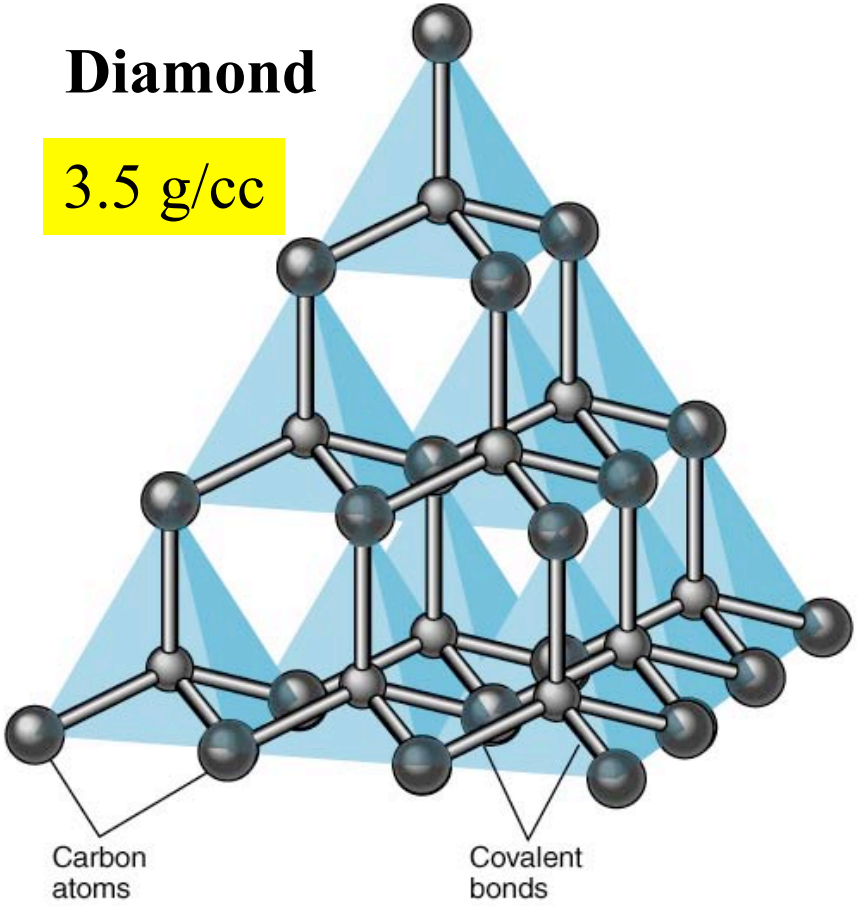


Ionic Radii of some geologically important ions

Carbon Atoms in Diamond and Graphite

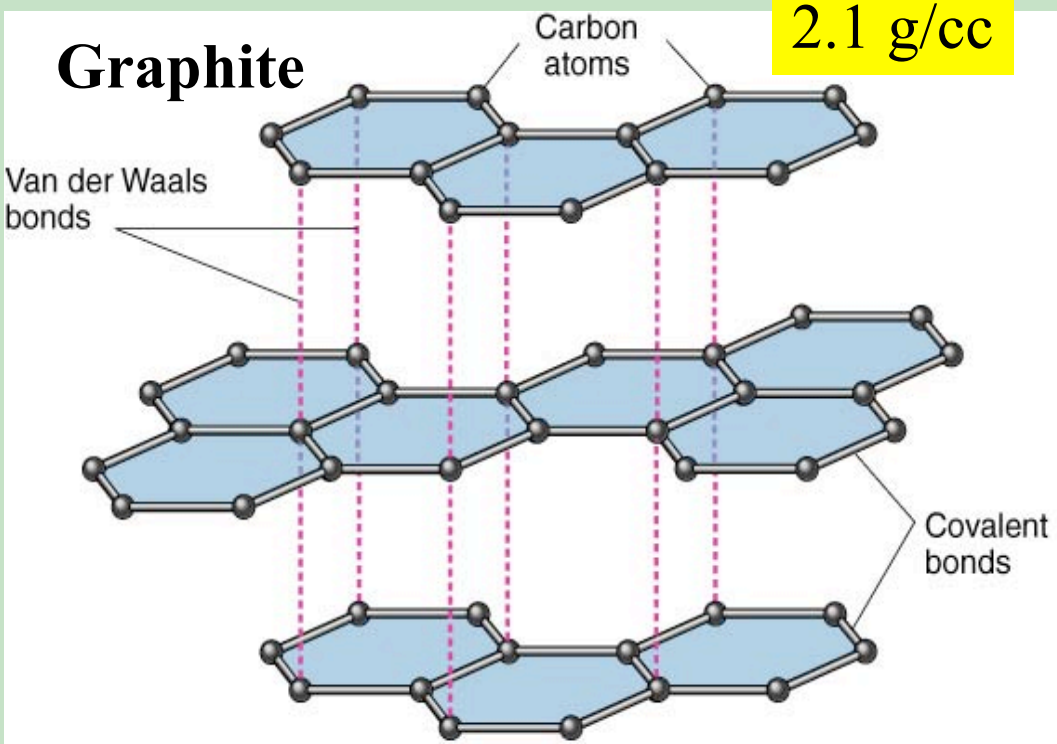
Diamond

3.5 g/cc



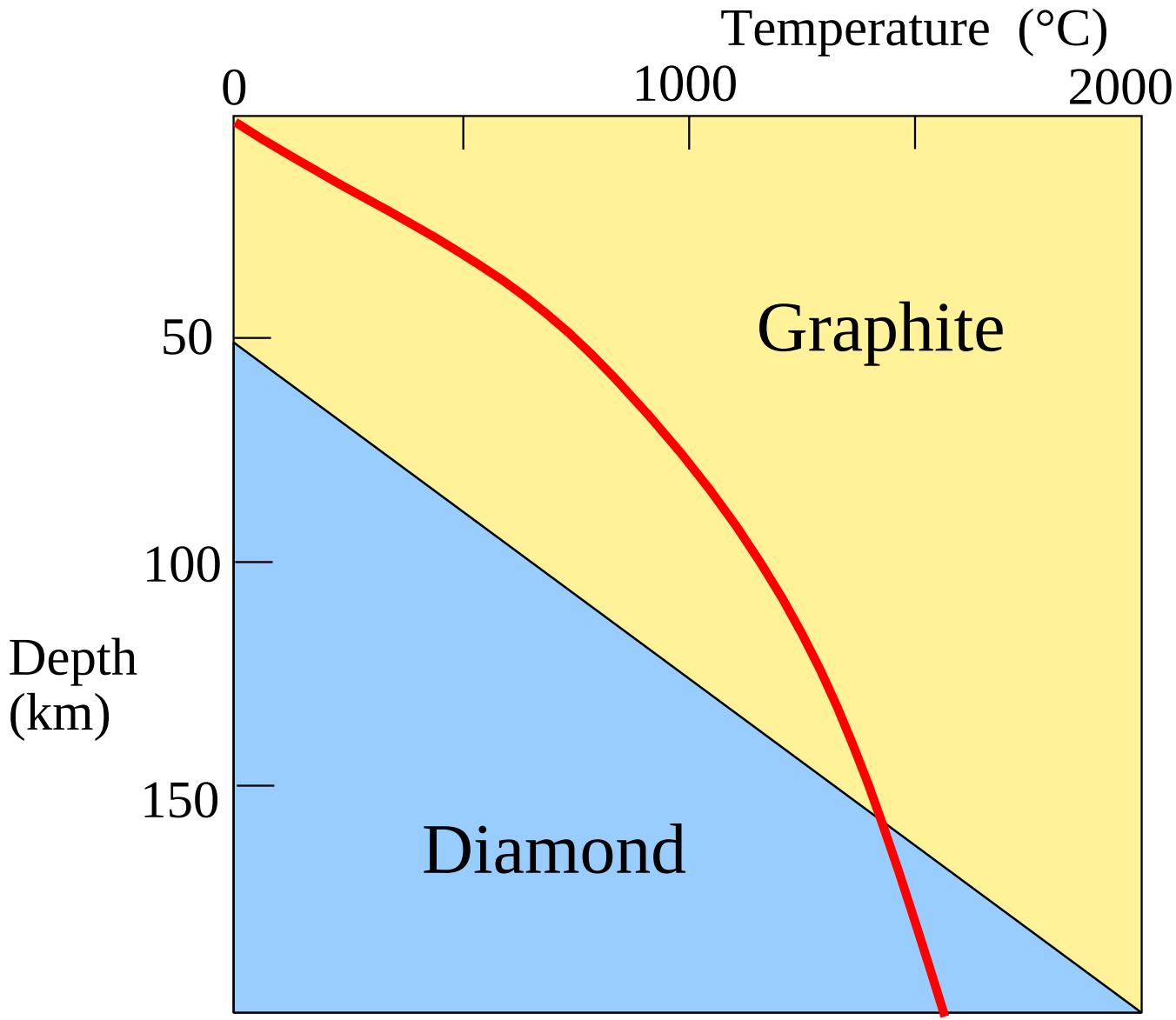
Graphite

2.1 g/cc

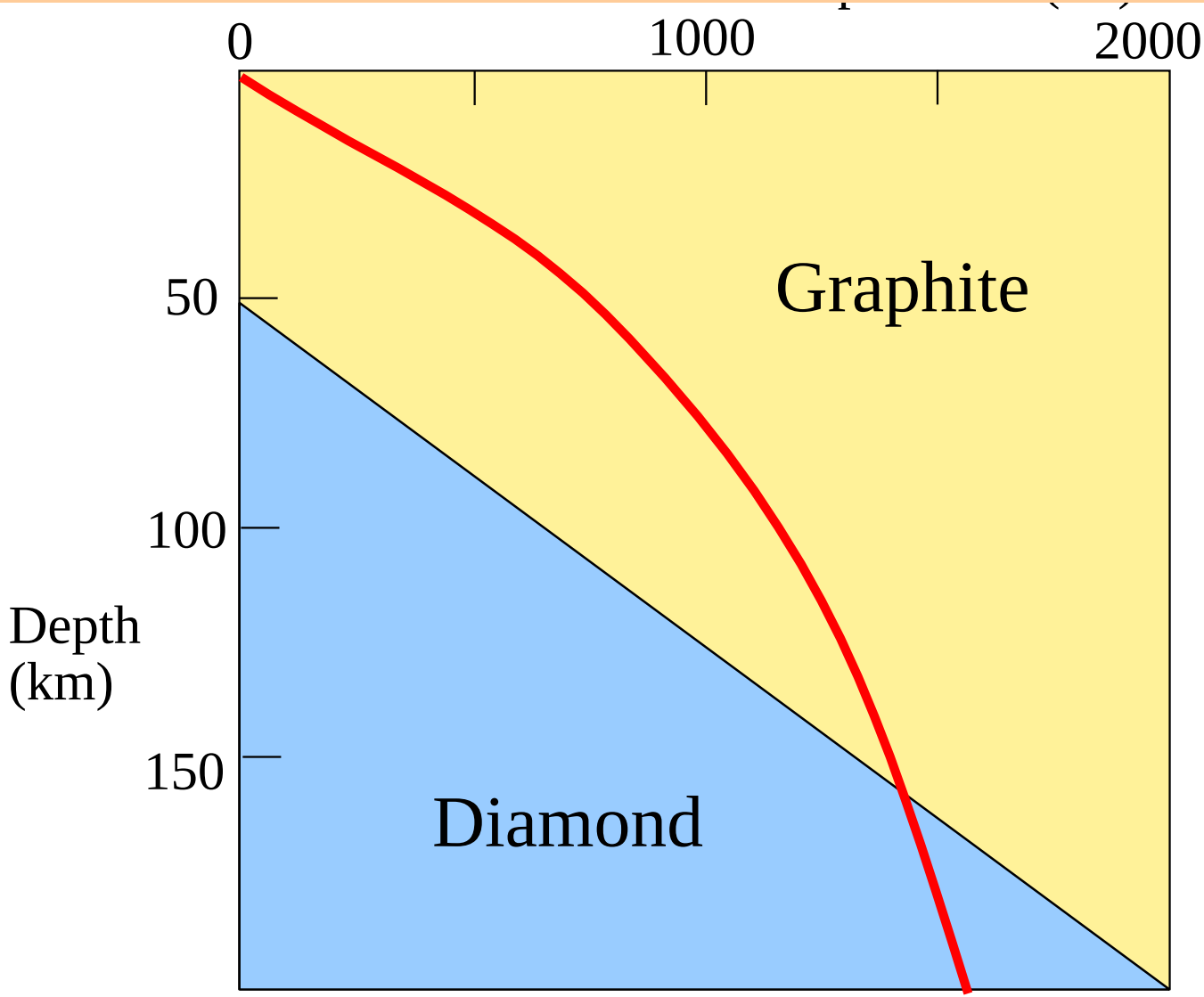


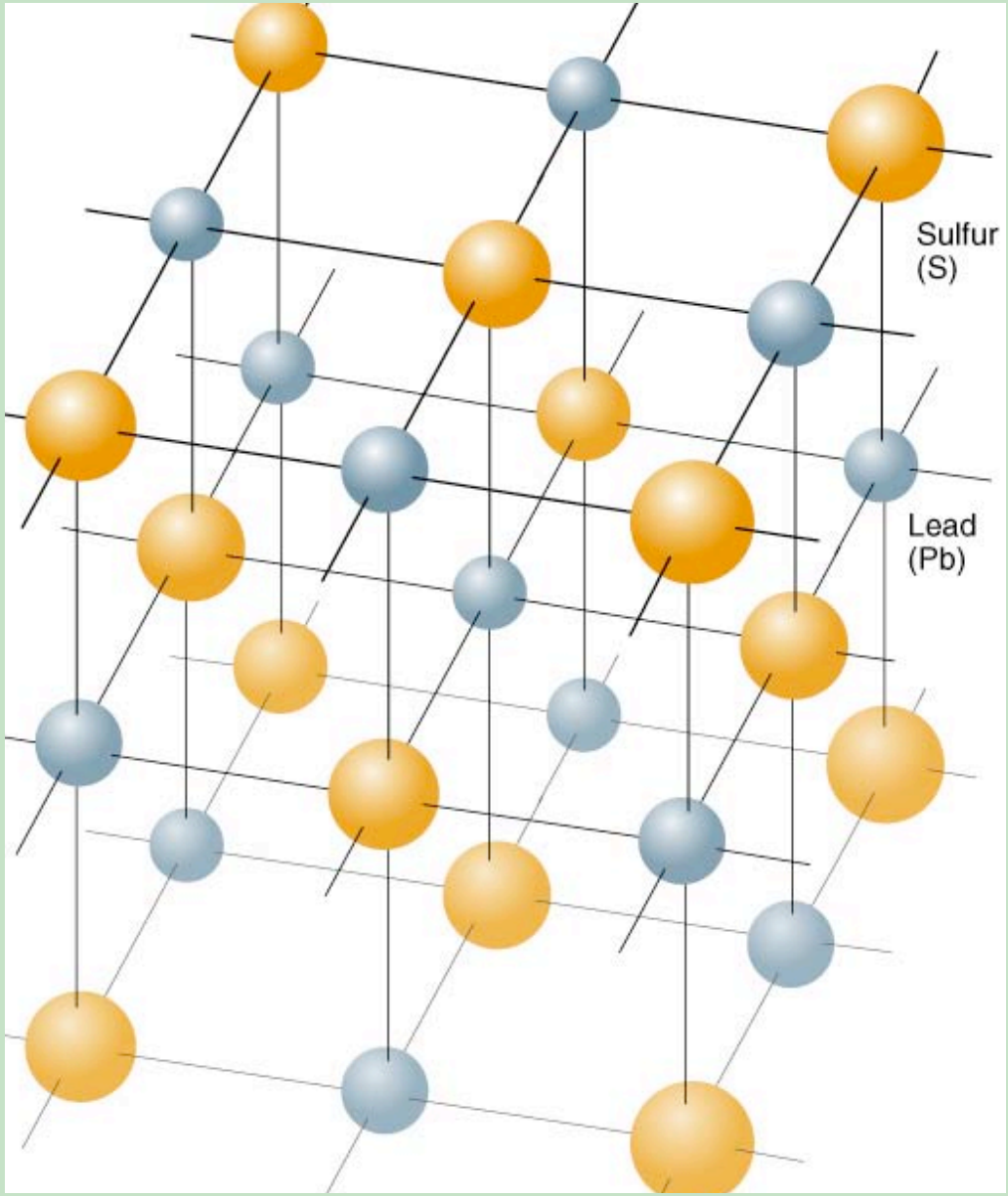
Bonding effects on Physical Properties

One Mineral or Two?



Polymorph!
same chemical comp'n, different shape

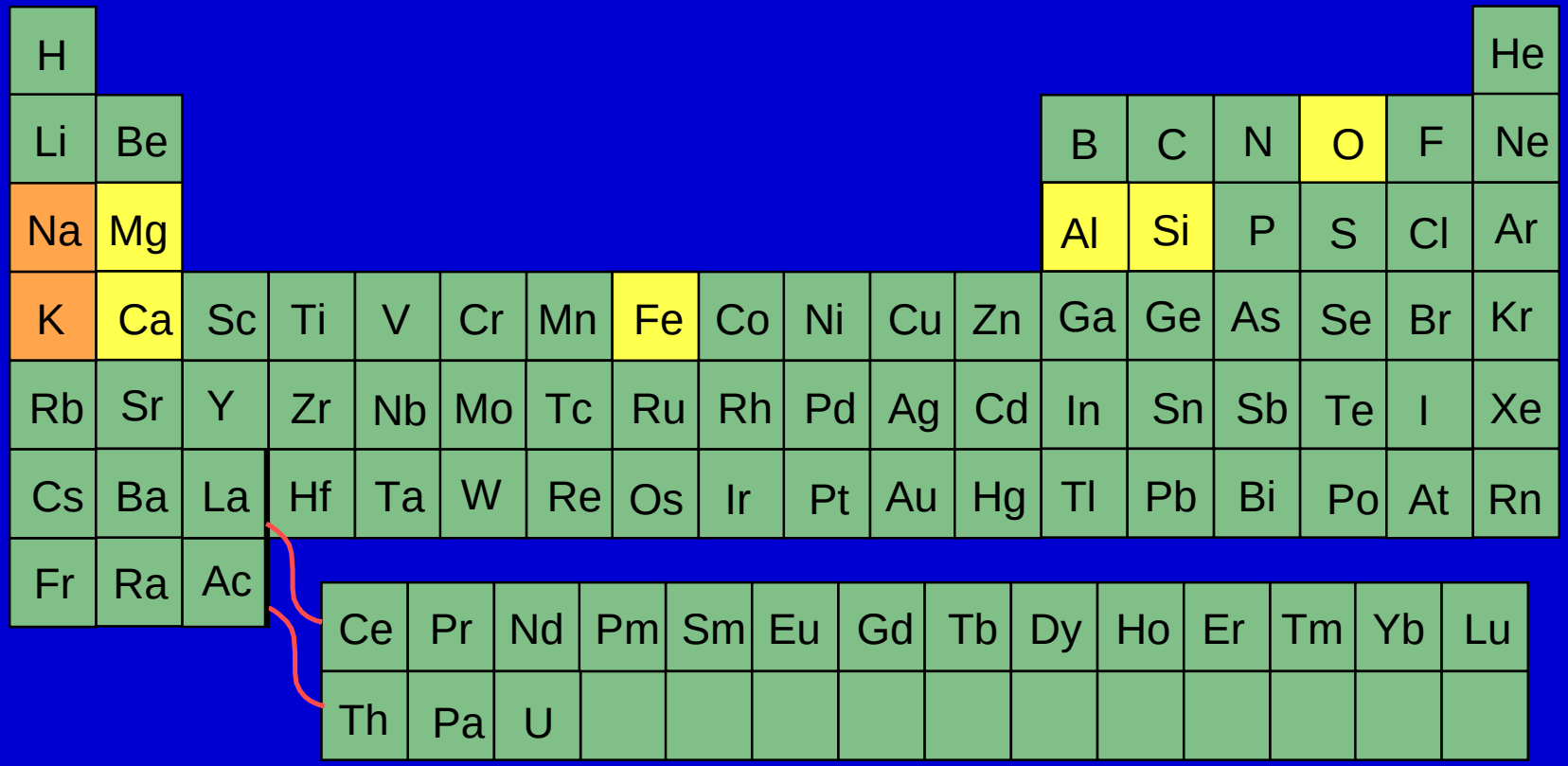




Ionic Bonding

Galena (PbS)

Periodic Table of the Elements

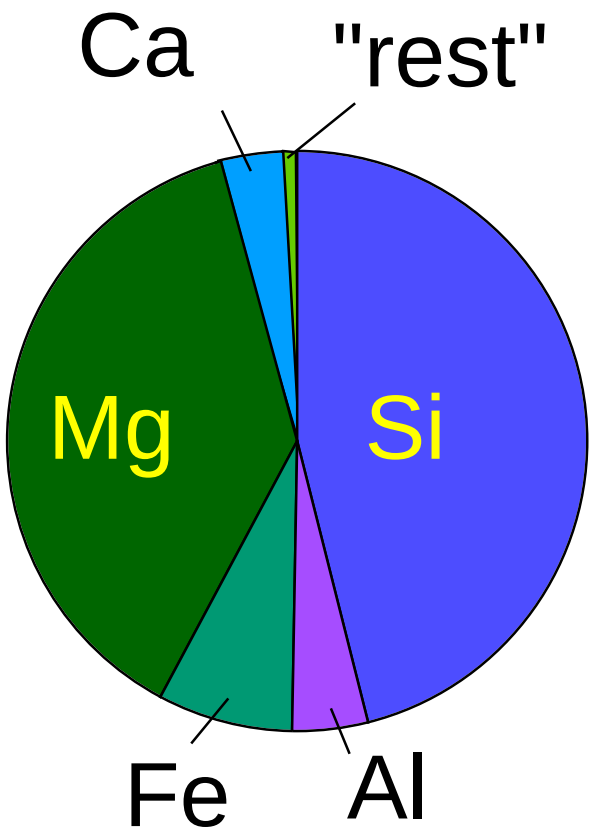


common in crust and mantle

crust

Elemental Composition of the Earth (no core)

Si - Silicon
Mg - Magnesium
Fe - Iron
Al - Aluminum
Ca - Calcium

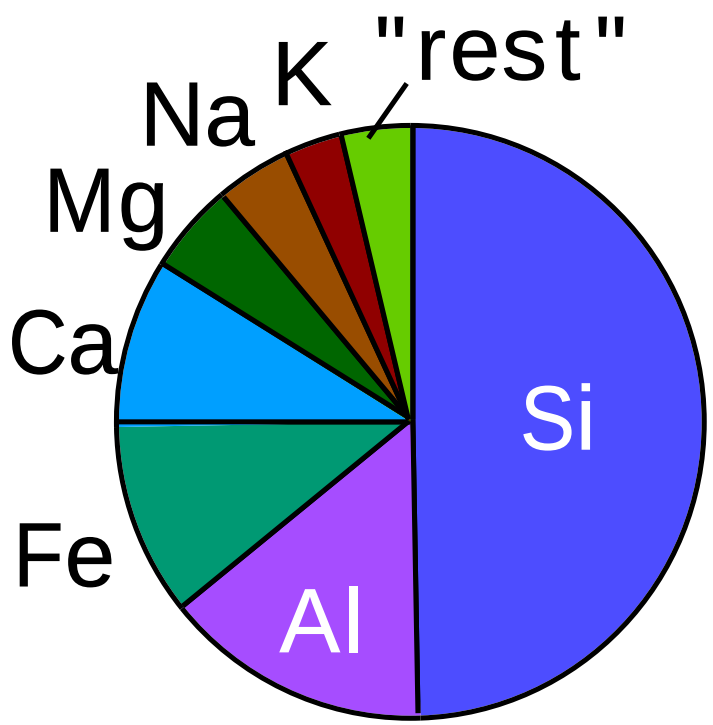


by weight

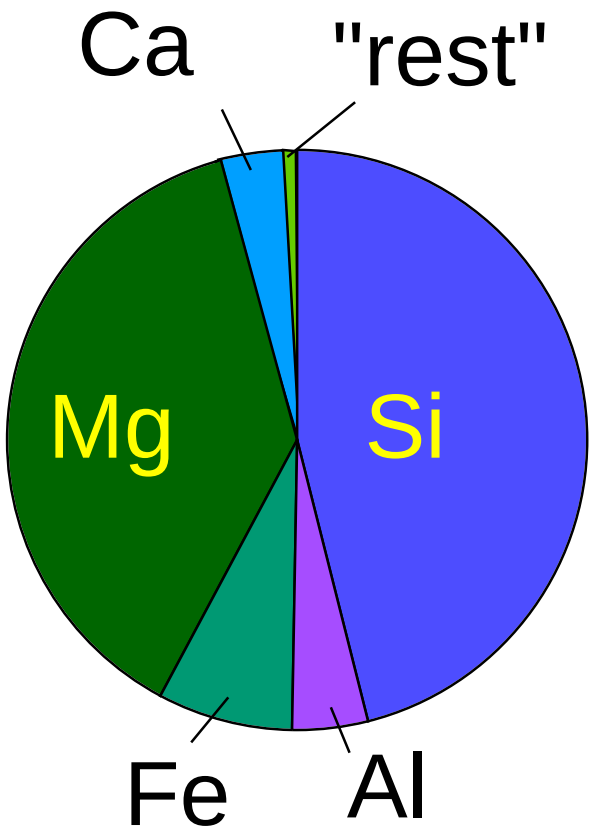
O - Oxygen not shown

Abundance of Elements

Crust



Mantle



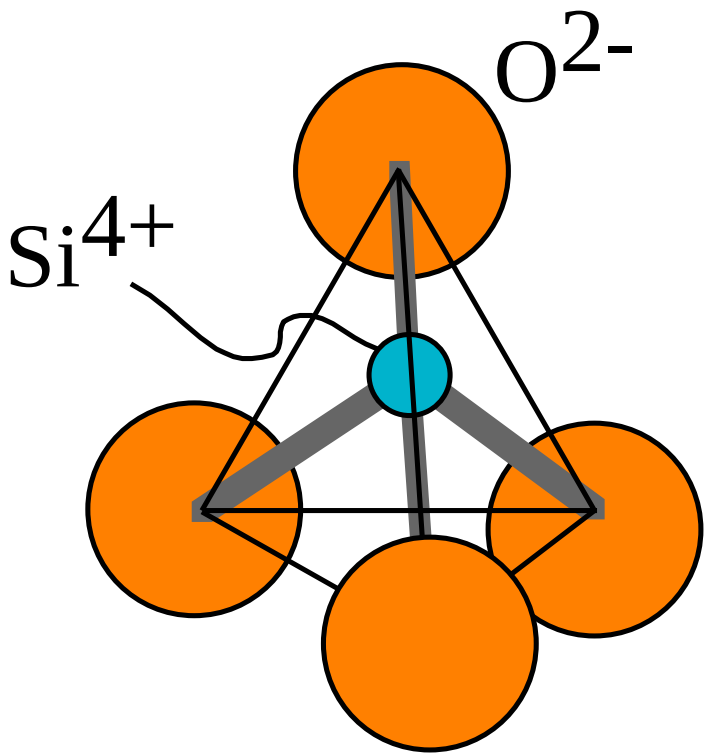
Na - sodium
K - potassium

O - Oxygen not shown

The Silicates

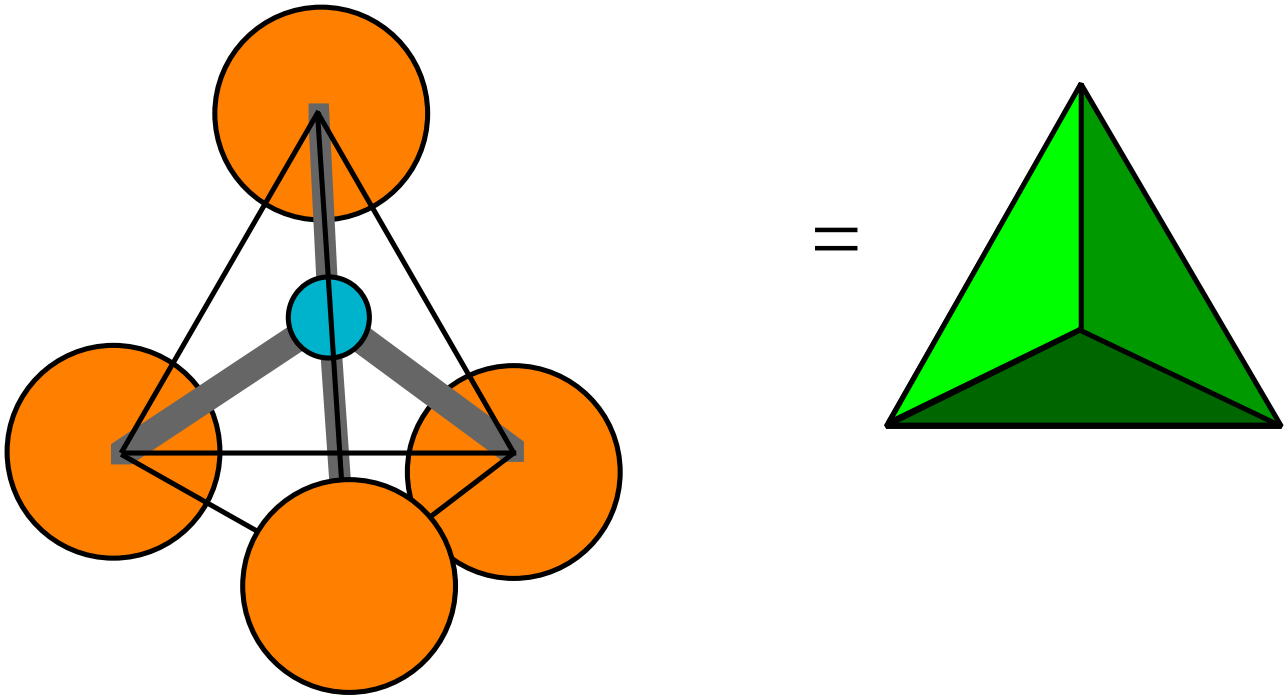
Basic Element:

Silicate Tetrahedron $(SiO_4)^{4-}$



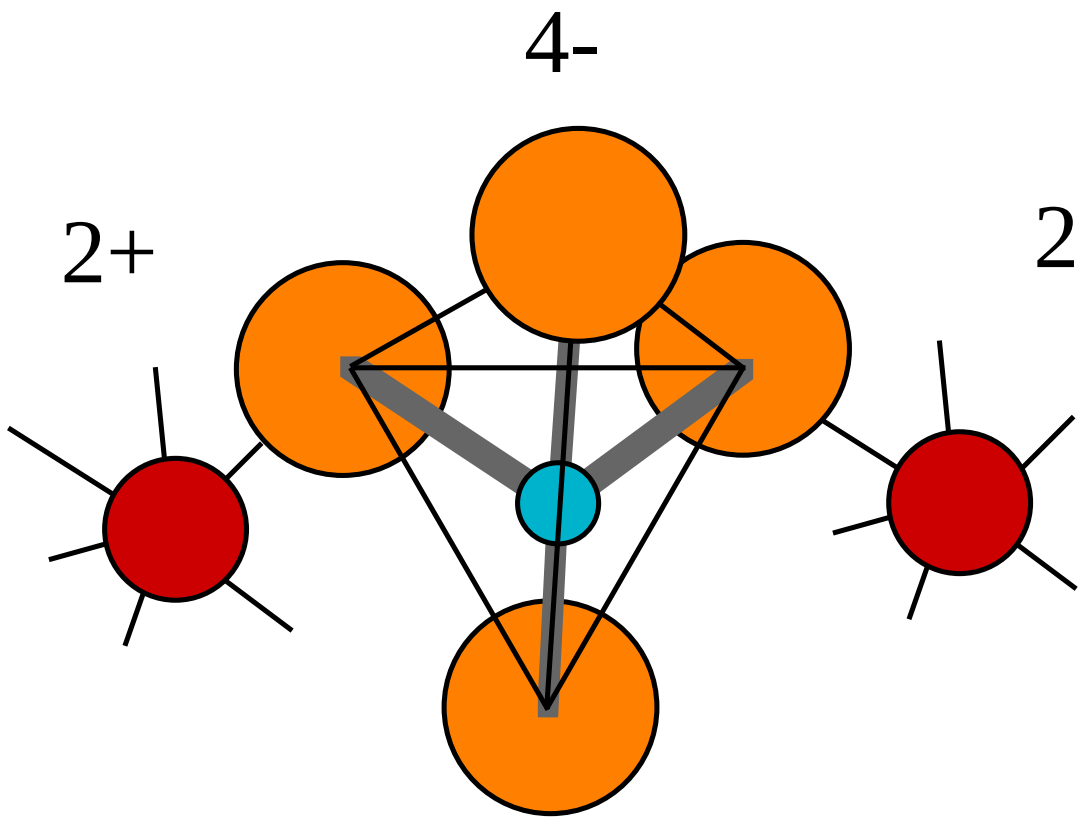
Building block of the Earth

Very strong Si-O bonds



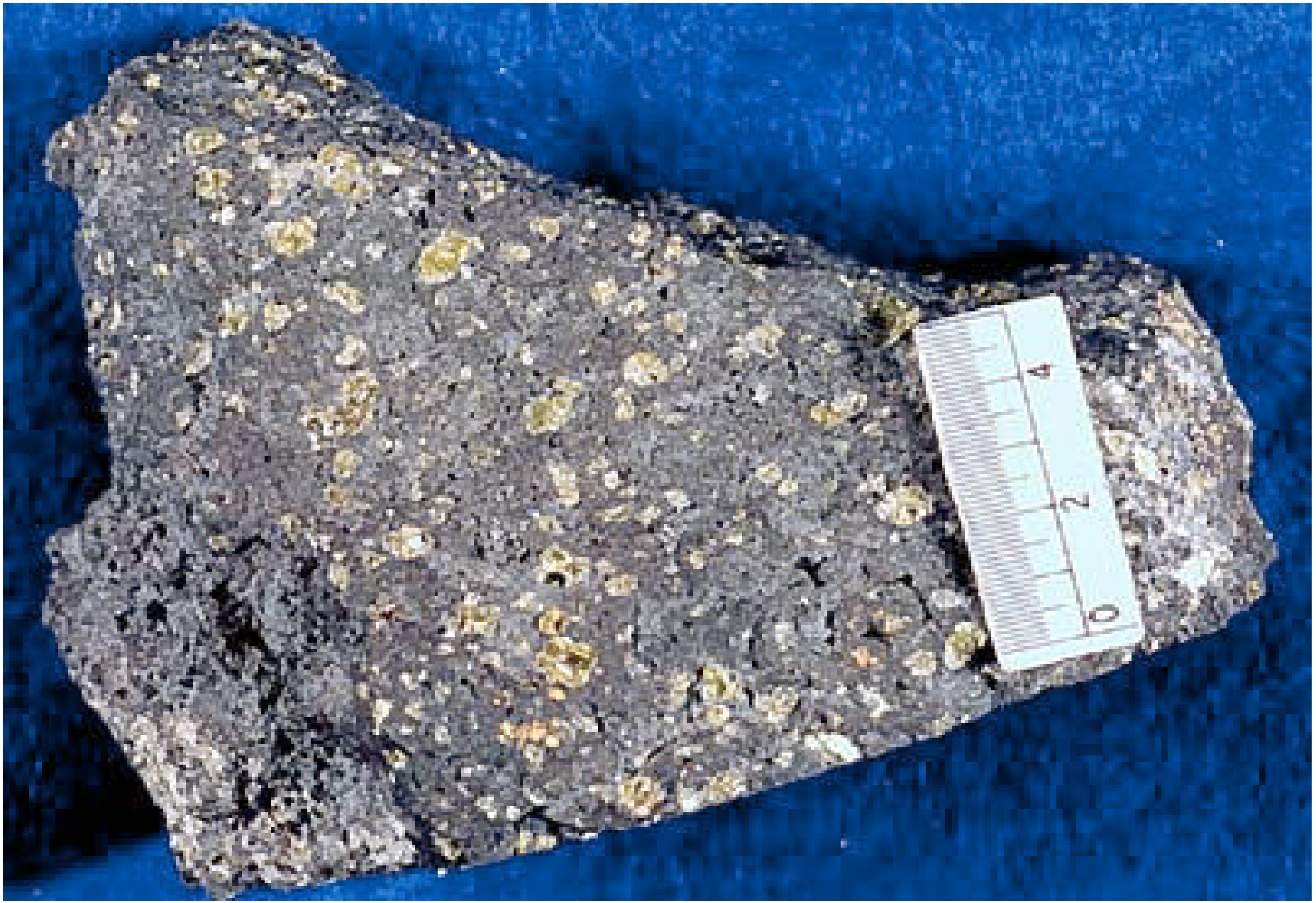
Form Minerals By:

1. Combining w/ Other Cations



Mg_2SiO_4

most important: Olivine



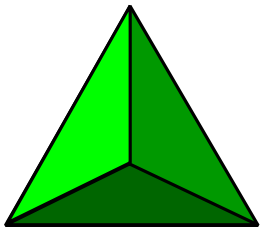
Olivine

Olivine

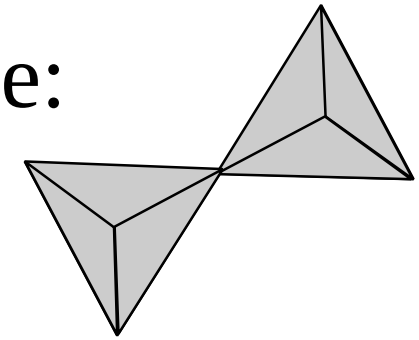
$(Mg,Fe)_2SiO_4$

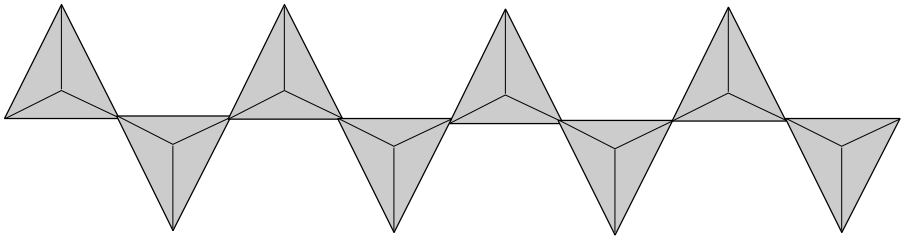
- Main mineral in upper mantle
- In igneous rox in crust
- Dense
- Green
- Gem = peridot

Single Tetrahedron



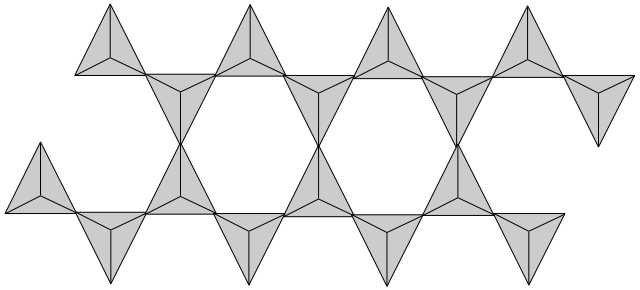
Double:

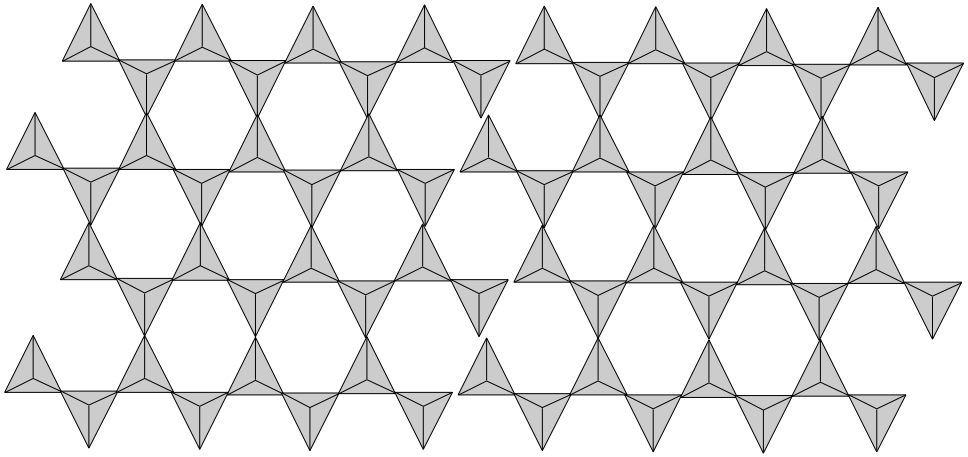




Single Chain

Double Chain





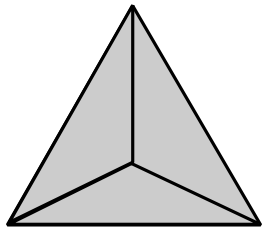
Sheet → 3D!

Most Important Silicate Minerals

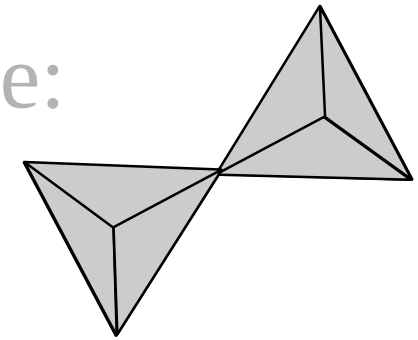
"rock-forming"

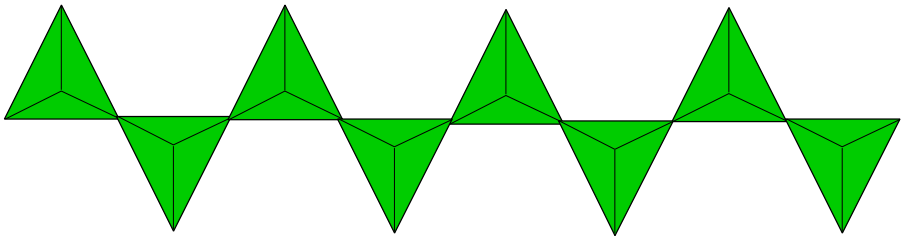
- Olivine
- Pyroxene
- Feldspar
- Quartz
- Mica
- Amphibole

Single Tetrahedron



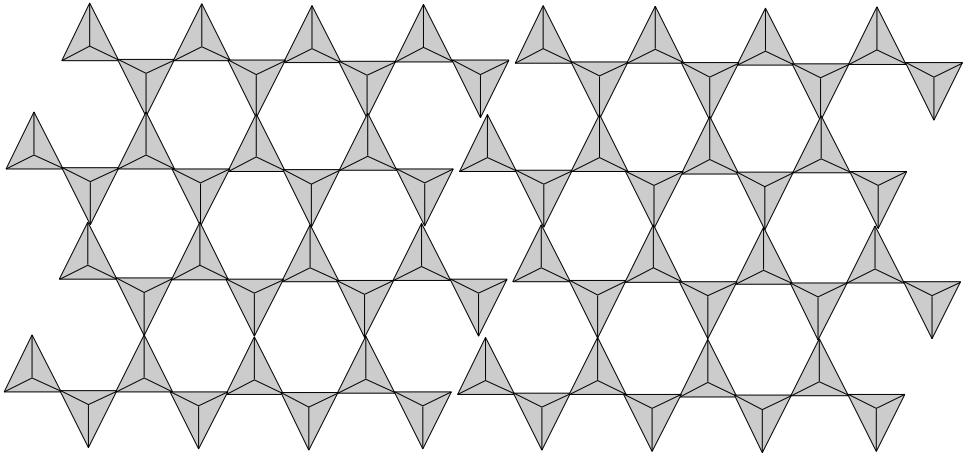
Double:

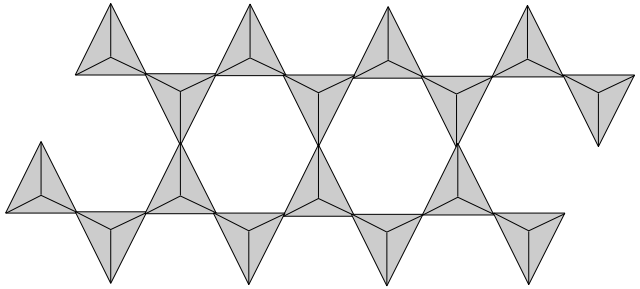




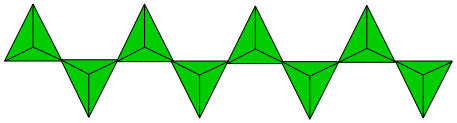
Single Chain

Double Chain



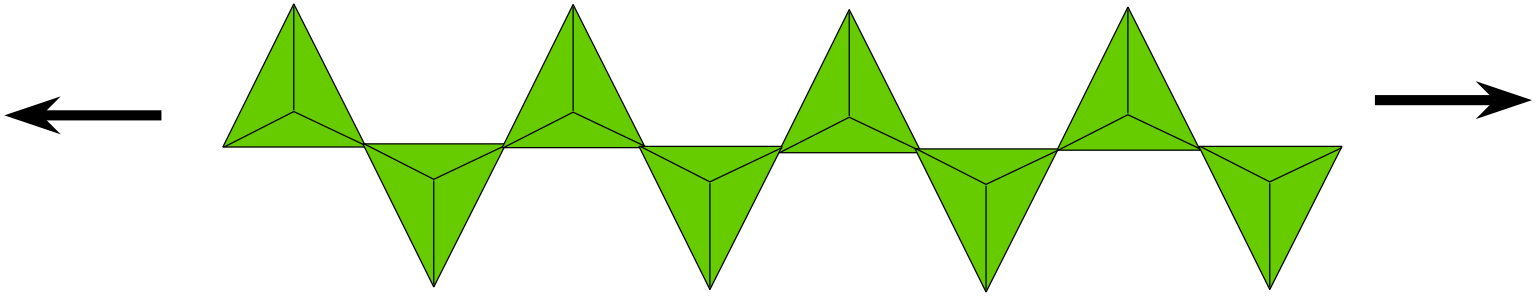


Sheet → 3D!



Pyroxenes

Single Chain silicate



Fe, Mg, Ca, Mn, Na, Al

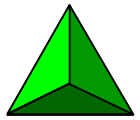
Common in mantle, oceanic crust rocks

e.g., $CaMgSi_2O_6$ = diopside

Diopside, Pyroxene

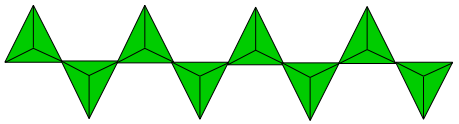
Main mantle rock: **Peridotite**

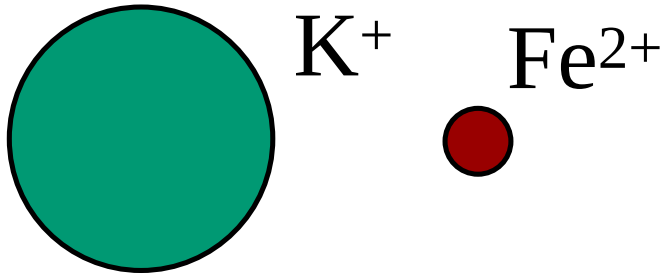
- Mostly **Olivine** (green)



- some **pyroxene**

(black, green)

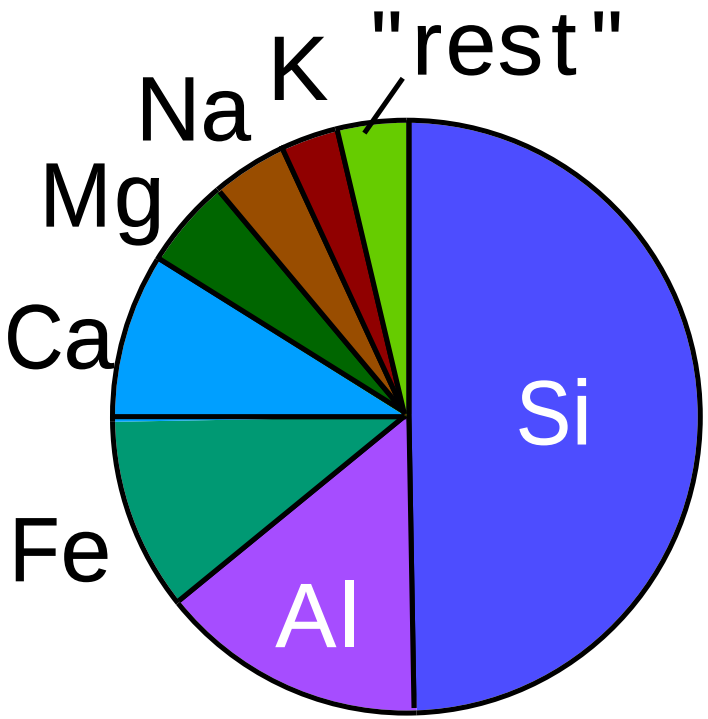




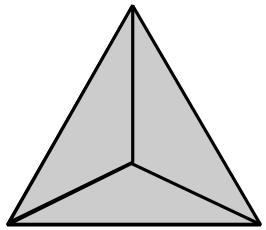
The Crust:

Need minerals that hold

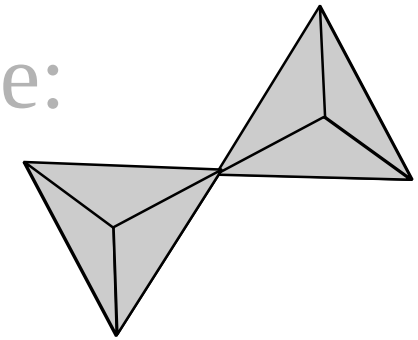
Al - Aluminum
Ca - Calcium
Na - Sodium
K - Potassium
...more Si

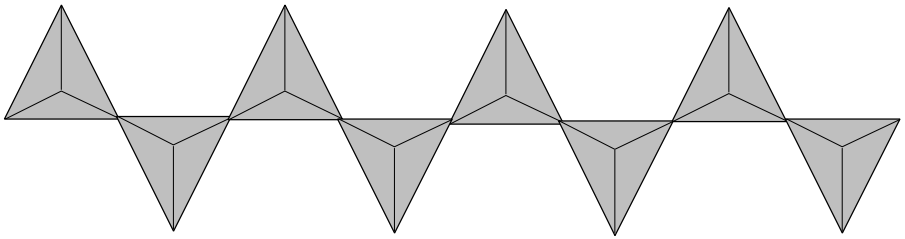


Single Tetrahedron



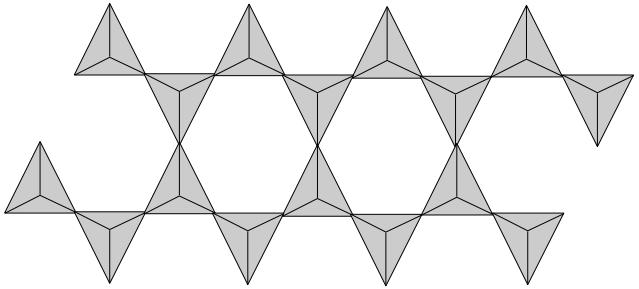
Double:

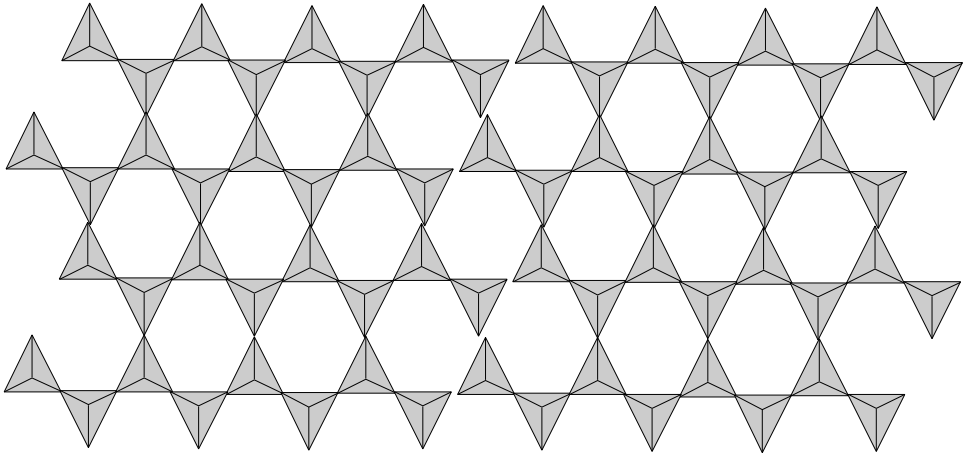




Single Chain

Double Chain





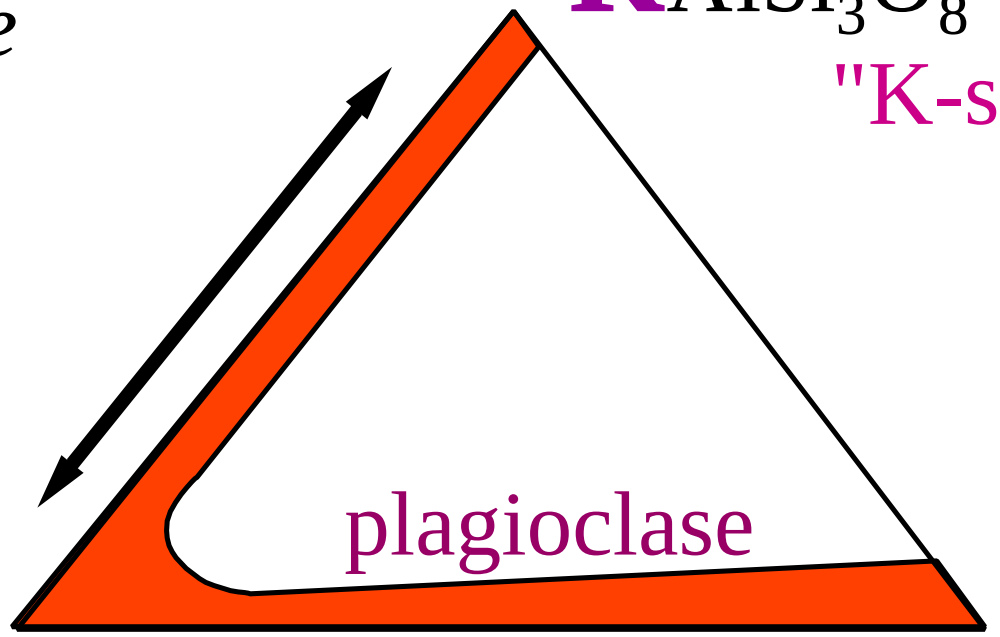
Sheet

→ 3D!

3D!

Feldspars

Holds light large cations



K$AlSi_3O_8$

"K-spar"

Na$AlSi_3O_8$

Ca$Al_2Si_2O_8$

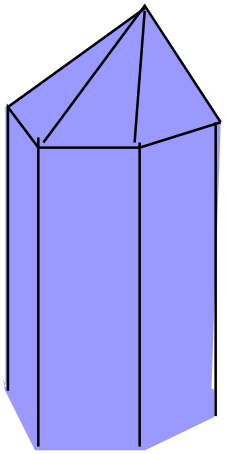
- *Makes 60% of crust*

Orthoclase K-Feldspar

3D!

Pure silica: Quartz

SiO_2

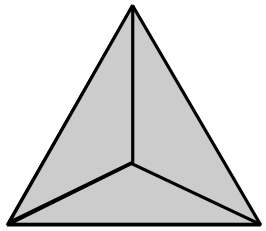


-- No cations ("pure")

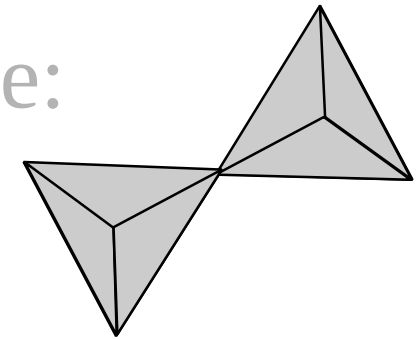
Common in continental crust

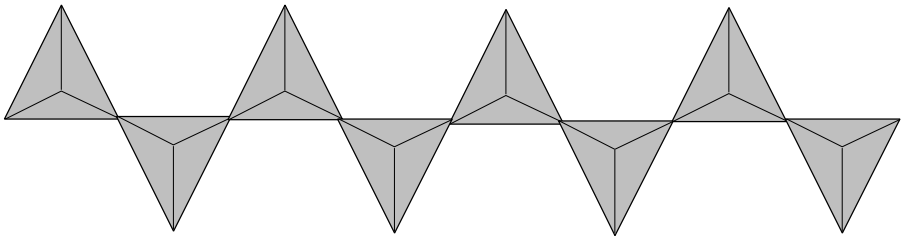
Quartz

Single Tetrahedron



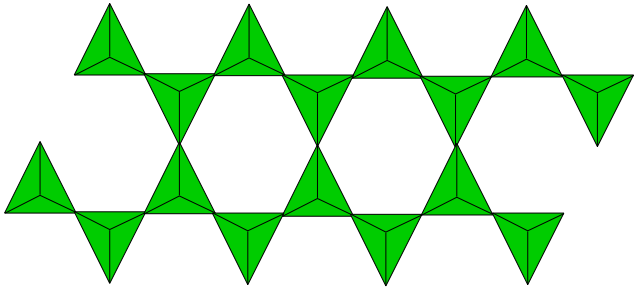
Double:

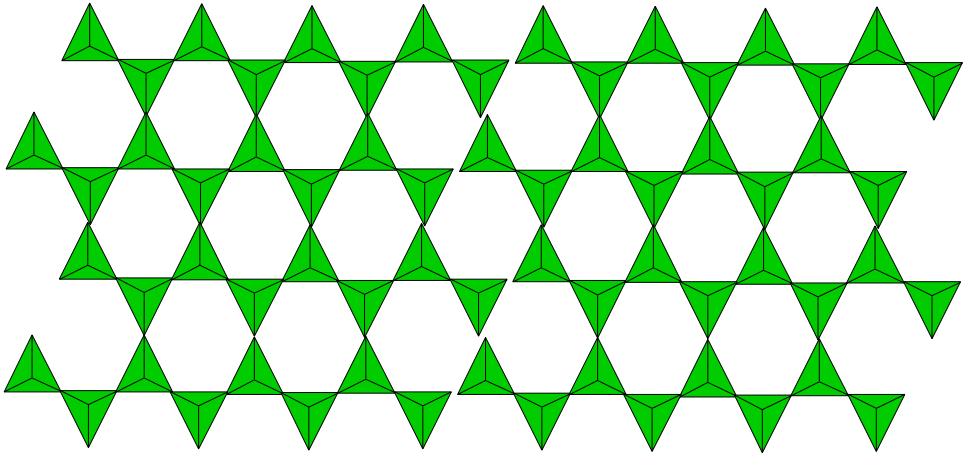




Single Chain

Double Chain



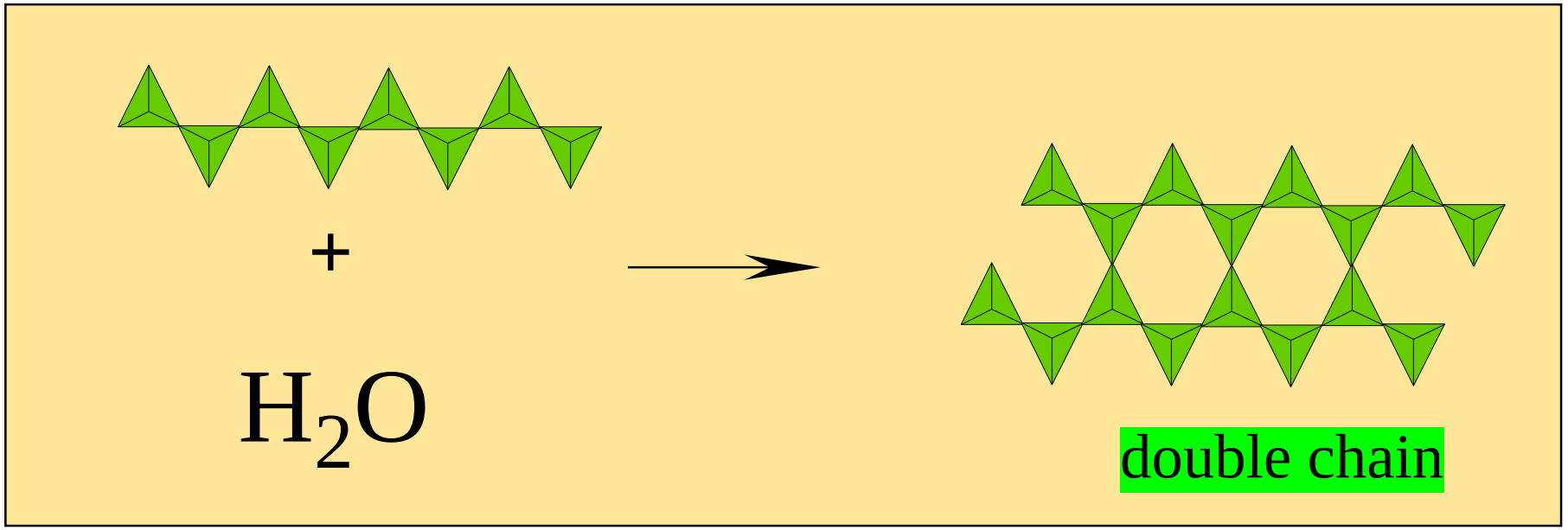


Sheet → 3D!

Just Add Water!

- *Silicates react, form more open structures*

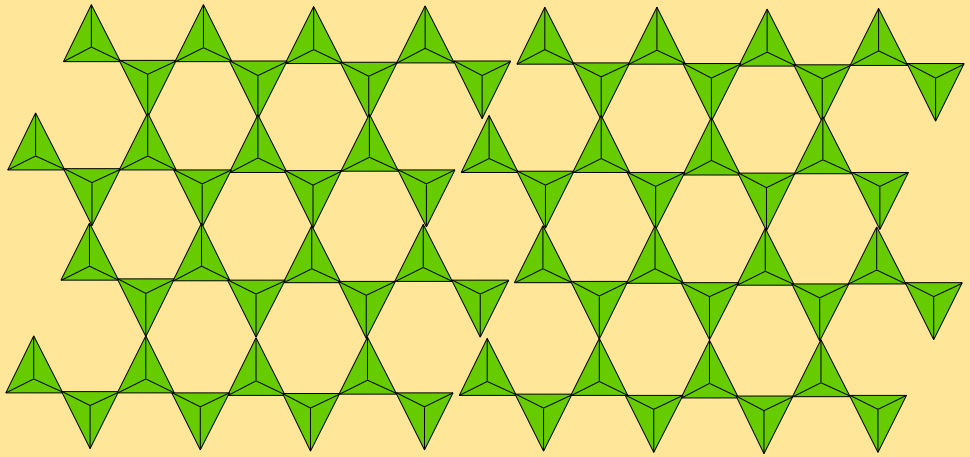
Pyroxenes + H_2O -> Amphiboles



Hornblende, Amphibole

Just Add Water!

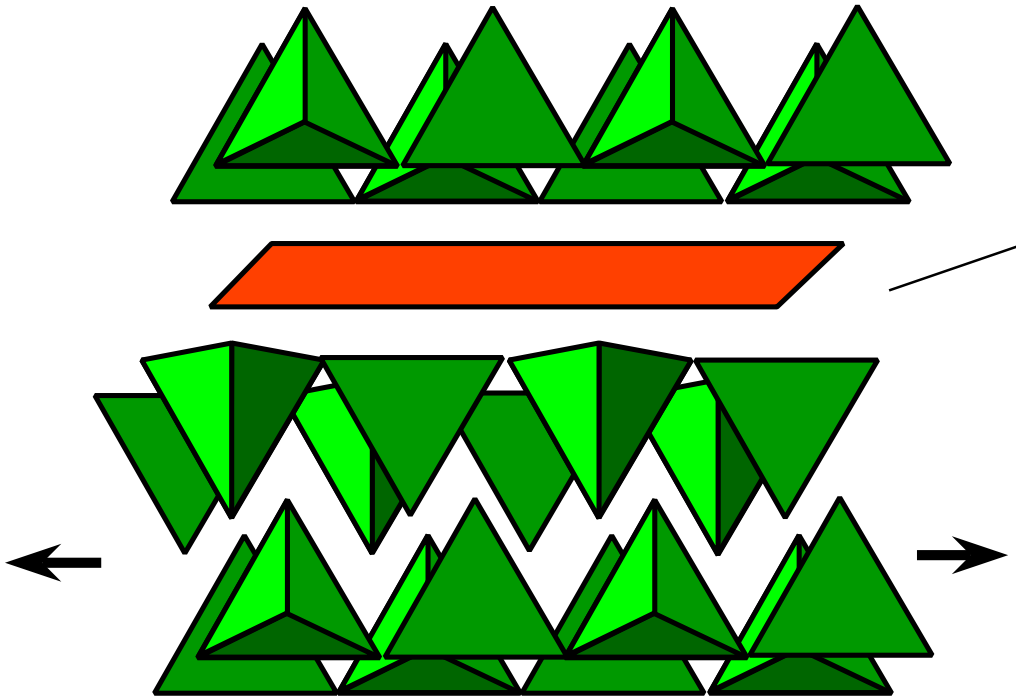
Others + H_2O -> Sheet Silicates



clays, micas, serpentines

Micas

sheet



Big gaps between sheets:

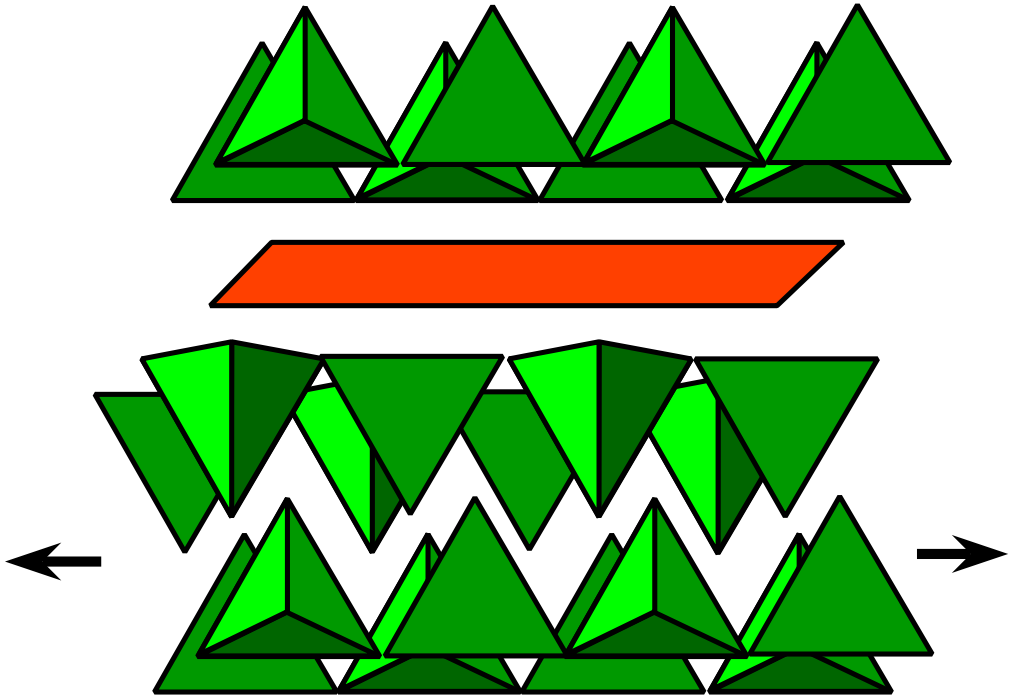
- Very weak bonds
- Holds Water

- Makes "platy" minerals

Cleavage

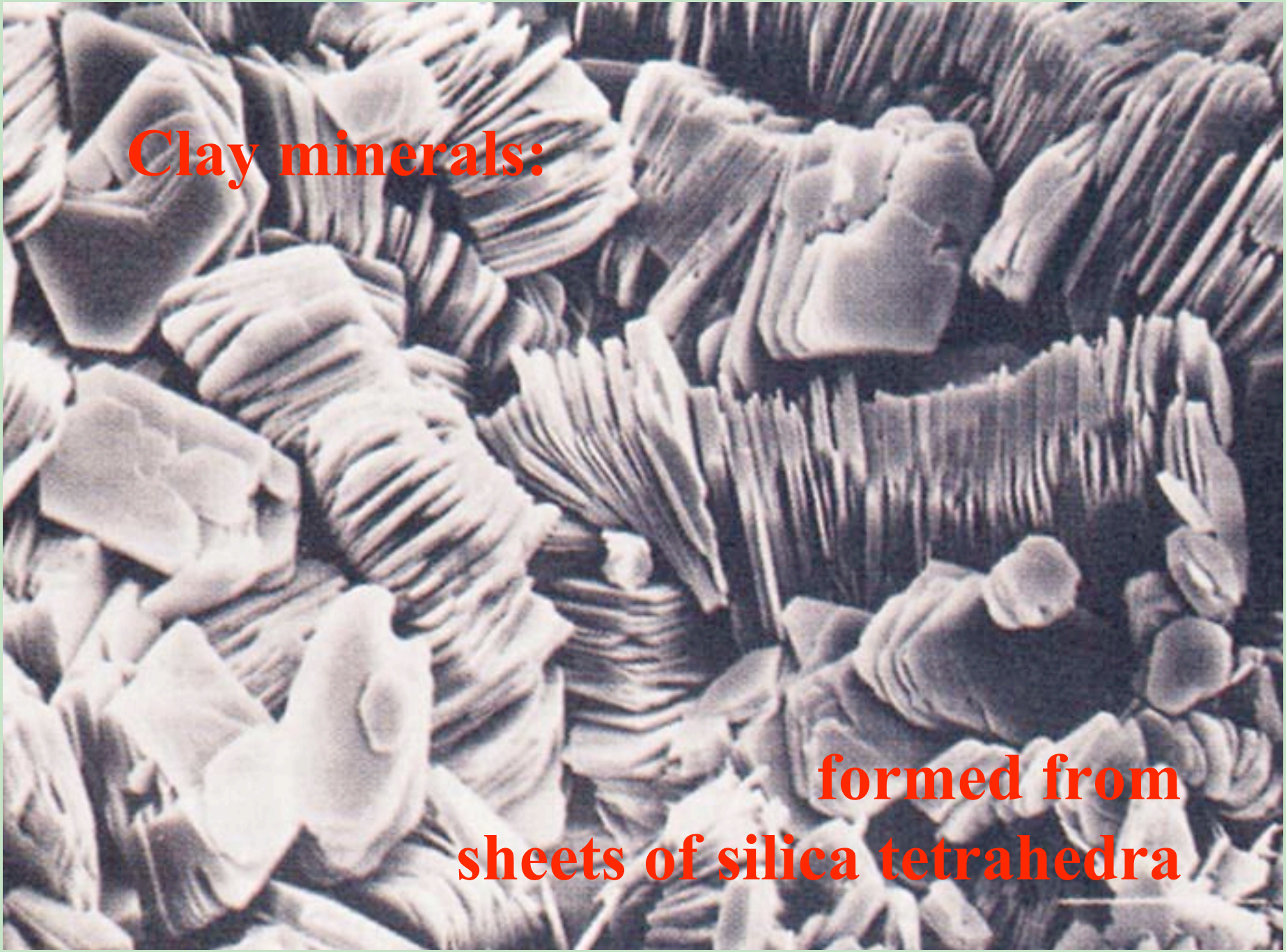
Clays

sheet



- Absorbant clays

- Common upper crust, weathering

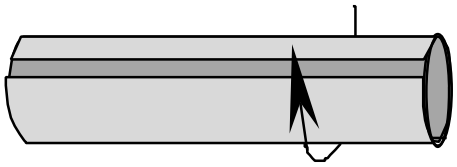

Clay minerals:
formed from
sheets of silica tetrahedra

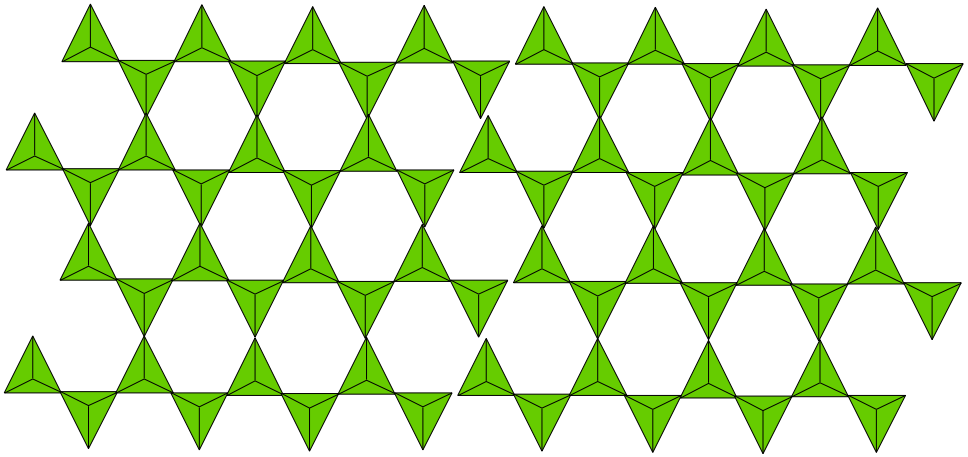
Asbestos

sheet vs. double

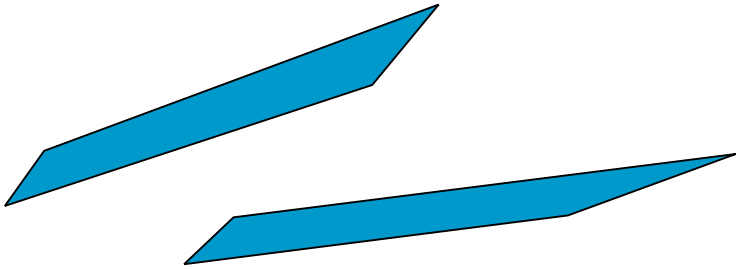
Two General Forms:

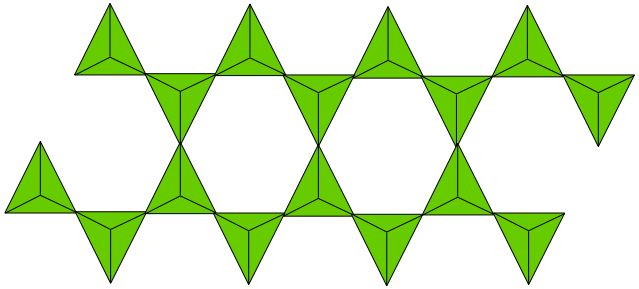
Serpentines: > 95% of all asbestos





Amphiboles: "blue asbestos"

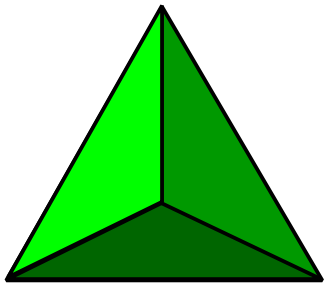


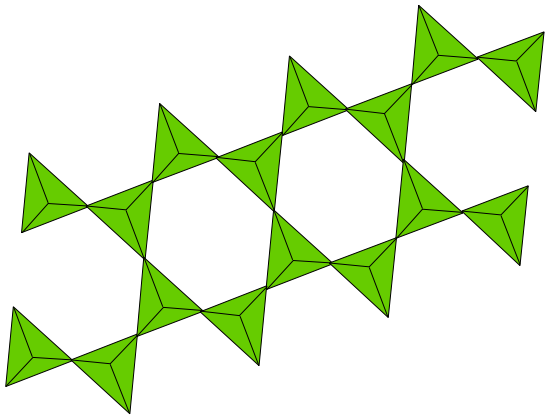


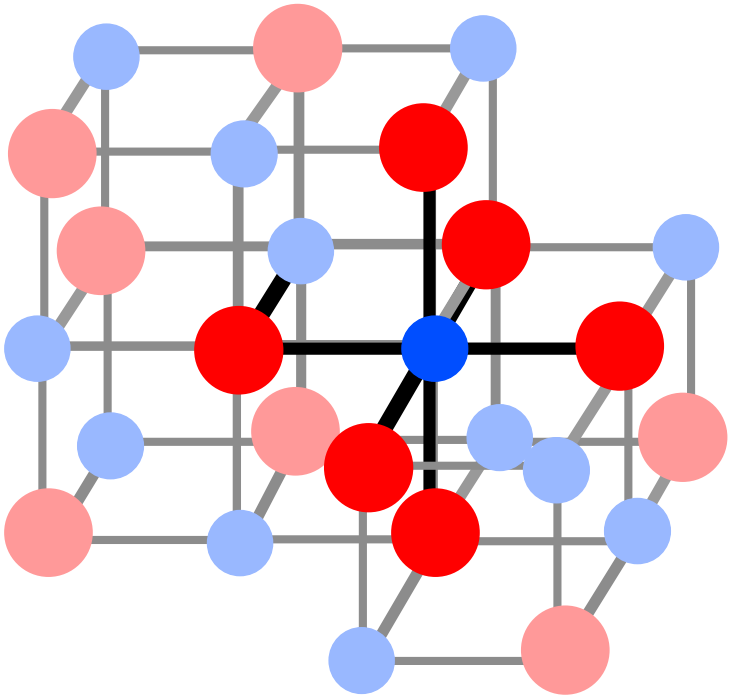
Serpentine

Theme:

Molecular structure
affects
mineral structure

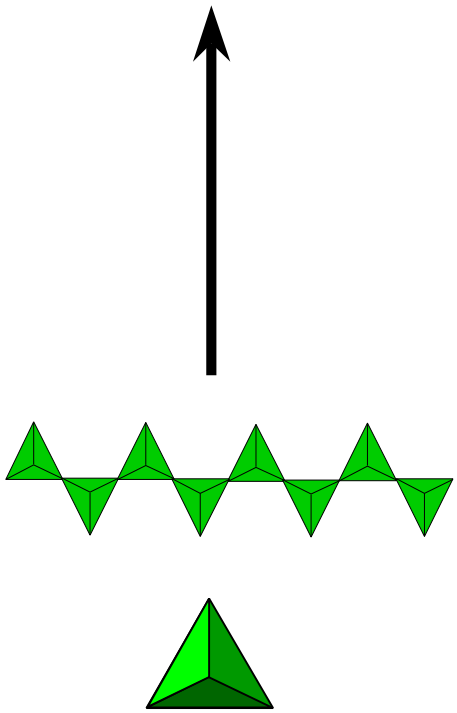






Silica tetrahedra

3D!



Light

Dense

Ions

crust

mantle

K^{1+}

Na^{1+}

Al^{3+}

Ca^{2+}

Fe^{2+}

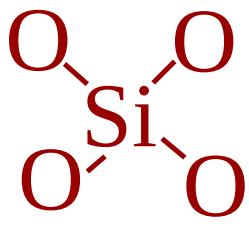
Mg^{2+}


Feldspar
Quartz
Mica
2 cm
Echantillon ENS Lyon

Major Rock-forming Minerals

-> Silicates: SiO_2 based

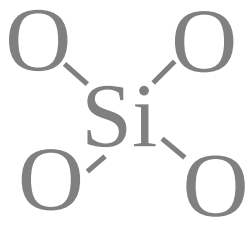
- 95% of crust, upper Mantle



Major Rock-forming Minerals

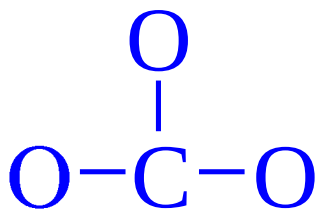
-> Silicates: SiO_2 based

- 95% of crust, upper Mantle



-> Carbonates: CO_3 based

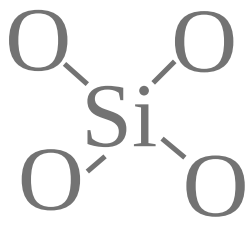
- Common near-surface (limestones,...) -- Major Carbon store



Major Rock-forming Minerals

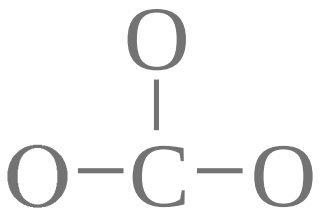
-> Silicates: SiO_2 based

- 95% of crust, upper Mantle



-> Carbonates: CO_3 based

- Common near-surface (limestones,...) -- Major Carbon store



-> Others

Oxides (various settings)

Sulfides, Sulfates (S = sulfur)

Rock Types

- All rocks are organized according to genesis (igneous, sedimentary or metamorphic), composition and texture
- Igneous
  - Mafic (silica poor) to felsic (silica rich)
  - Aphanitic (finely crystalline) to phaneritic (coarsely crystalline)
- Sedimentary
  - Clastic
  - Chemical and/or biochemical
- Metamorphic
  - Protolith (what was it before being heated and/or deformed?)
  - Contact (heating) vs. regional metamorphism (heating and deforming)