GY 111 Lecture Note Series
Crystal Structure and Mineral Classes

Lecture Goals:

A) Mineral Classes
B) The silicates

Reference: Press et al. (2003), Chapter 3; Grotzinger et al. (2007) Chapter 3

A) Mineral classes

If this were a class in mineralogy, we would be spending a few weeks discussing the way minerals are classified by geologists. Since it is not, we'll spend about 15 minutes.

Most minerals are classified according to their chemical compositions, specifically the anionic components of their formulas. The one exception are native elements such as gold, silver etc. Geologists recognize 8 **classes** of minerals based upon the composition of the anion that characterizes them.

Class	Name	Anion(s)	Examples	Dominant Bond
I	**Native Elements**	none	Metals: Gold, Copper, Silver Semi-metals: Arsenic (As) Non-metals: diamond, graphite, sulfur	Metallic
II	**Sulfides**	S^-	Pyrite, Chalcopyrite, Galena	Covalent
III	**Oxides\hydroxides**	O^{2-} OH^-	hematite, magnetite, limonite	Largely Ionic
IV	**Halides**	Cl^-, Fl^-	halite, fluorite	
V	**Carbonates**	CO_3^{2-}	calcite, aragonite, malachite	
VI	**Sulfates**	SO_4^{2-}	gypsum, anhydrite	
VII	**Phosphates**	PO_4^{3-}	apatite	
VIII	**Silicates**	SiO_4^{4-}	>3000 (i.e., most minerals)	

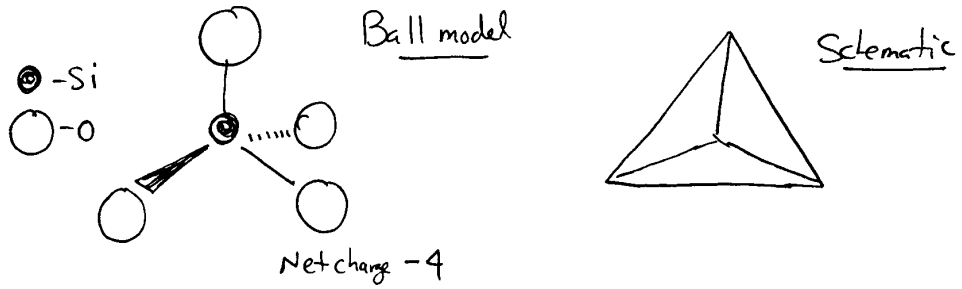
The way that minerals are classified is rather good for geologists interested in economics or, as I like to say, $$$**.** For example, many of the sulfides are valuable to our economy (hence the concept of **economic minerals**). Zinc, lead, nickel, copper molybdenum and many more metals are obtained from sulfide **ores**. Iron oxides are the principle ores for iron and steel. Gold, silver, platinum and carbon (as both diamonds and graphite) are obtained as native elements. These are not the only economic minerals. Calcite, fluorite, gypsum and dozens of others are all used by industry. In fact, you use many of them on a daily basis.

In the labs, you will see examples of many more minerals and learn more about their economic potential. Their chemical composition will give you some clues about how they are classified. See how many that you can sort out.

The silicates contain most of the minerals that have been identified. Not surprisingly then, there is a need to sub divide Class VIII into many more divisions. This will occupy the remaining time in today's class. Get ready to draw

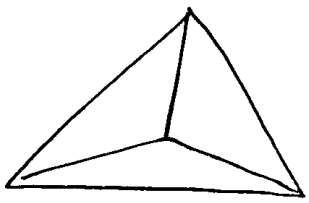
B) The Silicates:

Wow where do we start? All silicate minerals contain a basic building unit called the **silicate tetrahedron:**

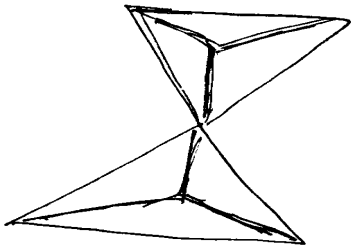


In order to simplify my drawings, I'll use the triangular symbols adjacent to the 3D tetrahedron. I'll explain more about this in class.

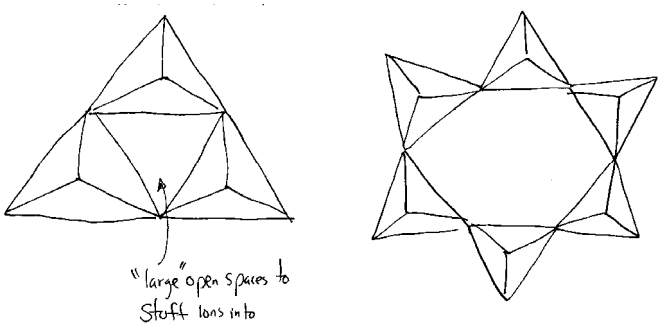
The silicates are divided up into 6 subclasses depending upon how the silicate tetrahedrons are arranged. As in our discussion about unit cells, some ions (in this case O^{2-}) are shared between tetrahedrons. The number of O^{2-} ions shared and the arrangement of the resulting structure are the factors that determine which **subclass** each silicate mineral belongs to.



1) Free silicate tetrahedra (0 shared O^{2-} ions):
Name: **Nesosilicates**
Examples: Garnet Group; e.g.; Pyrope $Mg_3Al_2Si_3O_{12}$
Olivine Group; e.g., Fayalite: Fe_2SiO_4;
Forsterite: Mg_2SiO_4



2) 1 shared O^{2-} ion:
Name: **Sorosilicates**
Examples: Epidote (you will not see this in the lab)

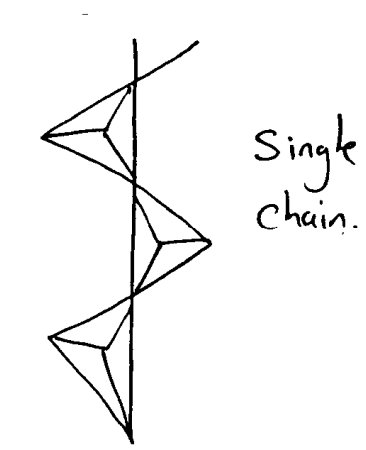


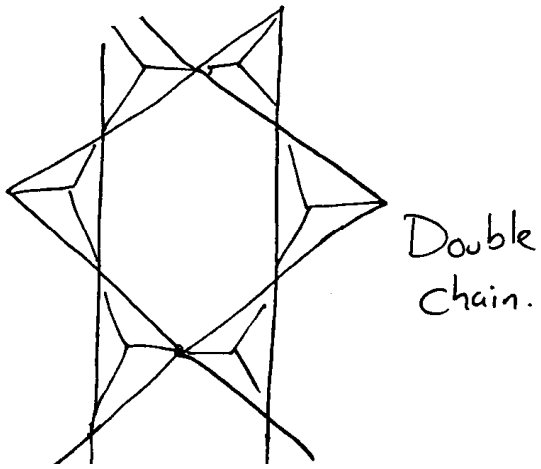
3) 2 shared O^{2-} ions
Name: **Cyclosilicates**
Examples: Beryl/emerald (you will not see this in the lab)

4) 2 or 2 1/2 shared O^{2-} ions:
Name: **Inosilicates (Chain silicates)**

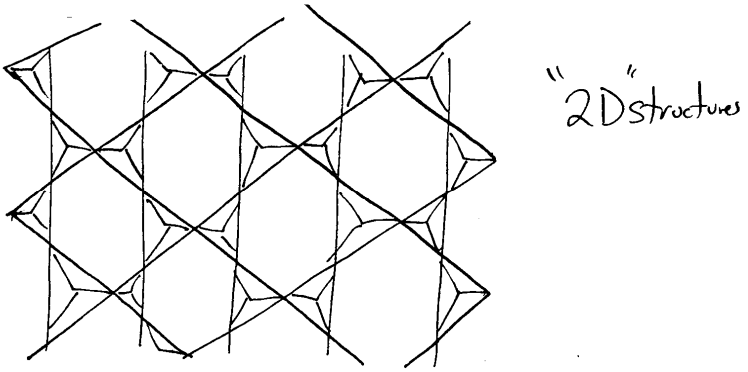
2 -shared (Pyroxene Group)
Examples: Augite

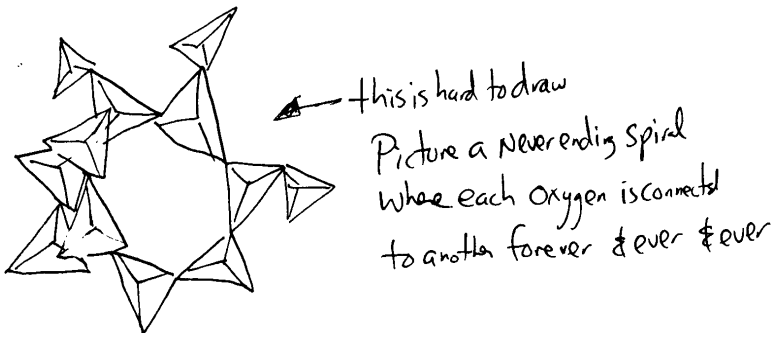
2 1/2 shared (Amphibole Group)
Hornblende





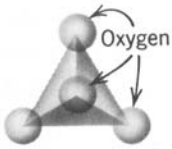
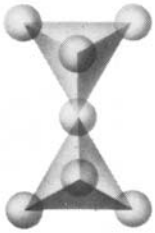
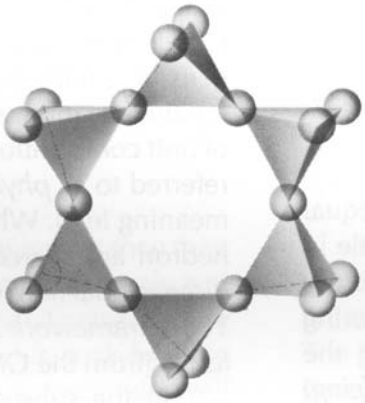
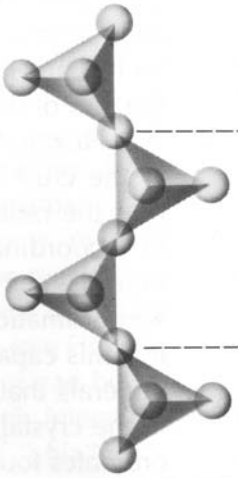
5) 3 shared O^{2-} ions:
Name: **Phyllosilicates (Sheet silicates)**
Examples: Mica Group, e.g., muscovite, biotite, chlorite;
Clay Group, e.g., kaolinite



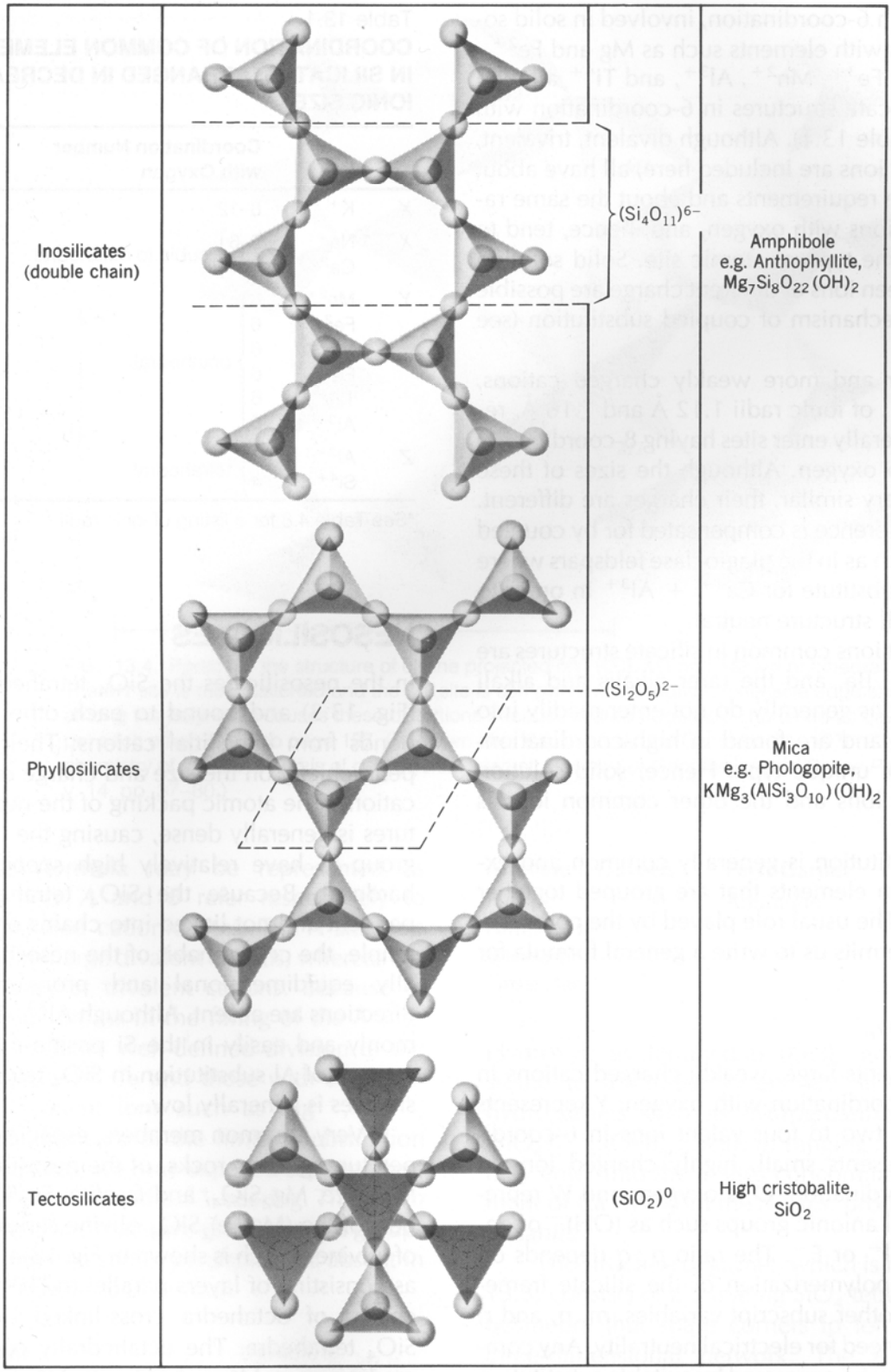


6) 4 shared O^{2-} ions (i.e., all of them):
Name: **Tectosilicates (Framework silicates)**
Examples: Quartz
Feldspars
e.g., orthoclase, Plagioclase

If my sketches do not work for you, try out these representations:

Class	Arrangement of SiO_4 tetrahedra (central Si^{4+} not shown)	Unit composition	Mineral example
Nesosilicates		$(SiO_4)^{4-}$	Olivine, $(Mg, Fe)_2SiO_4$
Sorosilicates		$(Si_2O_7)^{6-}$	Hemimorphite, $Zn_4Si_2O_7(OH)\cdot H_2O$
Cyclosilicates		$(Si_6O_{18})^{12-}$	Beryl, $Be_3Al_2Si_6O_{18}$
Inosilicates (single chain)		$(Si_2O_6)^{4-}$	Pyroxene e.g. Enstatite, $MgSiO_3$

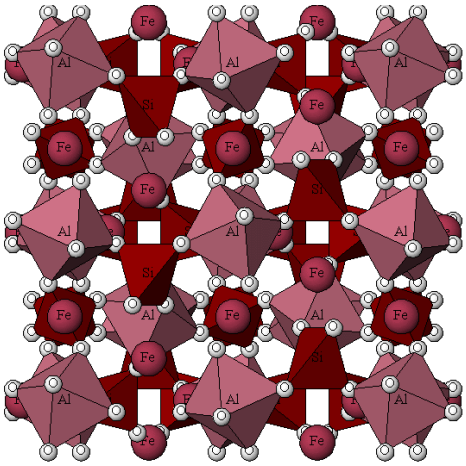
From Klein, C. and Hurlbut Jr., C.S. 1977. Manual of Mineralogy. John Wiley and Sons. 681p.

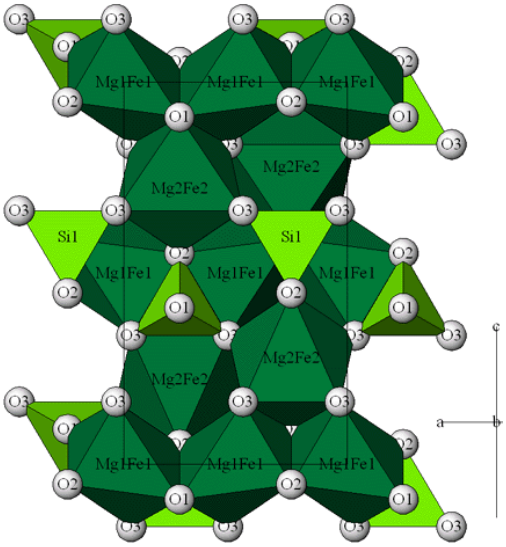


From Klein, C. and Hurlbut Jr., C.S. 1977. Manual of Mineralogy. John Wiley and Sons. 681p

Be sure to also refer to the handout (http://www.usouthal.edu/geography/haywick/PDF/silicate.pdf) that I gave you in class about silicate structures. It has a lot of formulas on it (which you do NOT have to know for GY 111), but it also shows how well the silicate minerals group together. Would you like to see some 3D images of the silicates we have discussed today; check these out:

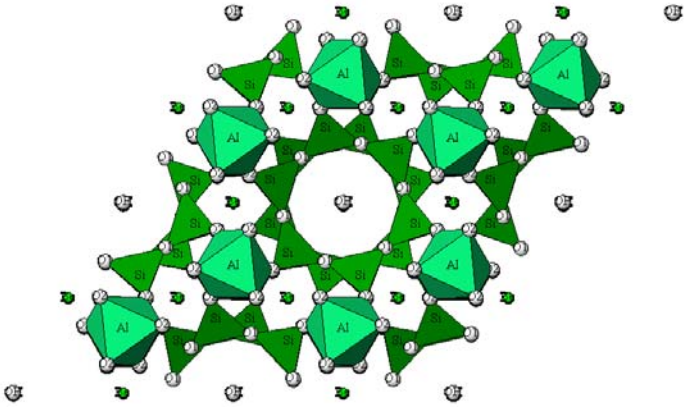
Garnet (Nesosilicate)

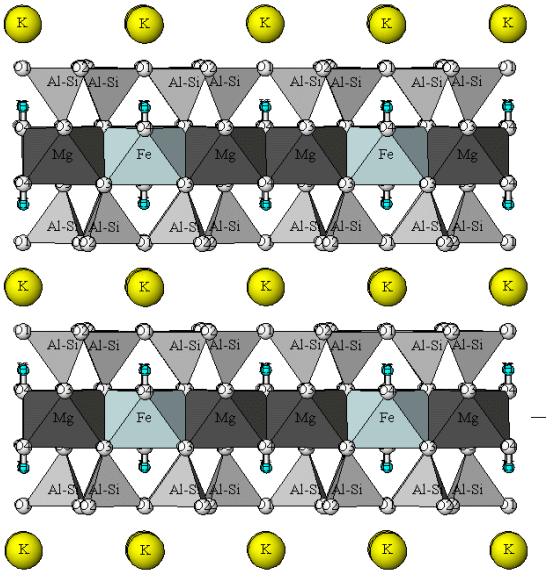




Olivine (Nesosilicate)

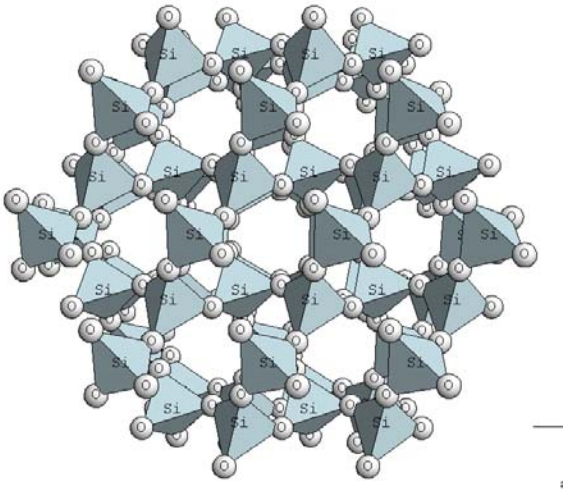
Beryl/Emerald (Cyclosilicate)





Biotite (Phyllosilicate)

Quartz (Tektosilicate)



Important terms/concepts from today's lecture
(Google any terms that you are not familiar with)

silicate tetrahedron (SiO_4^{4-})
mineral classes (native metals, sulfides, oxides/hydroxides, halides, carbonates, sulfates, phosphates, silicates)
silicate subclasses (nesosilicates, sorosilicates, cyclosilicates, inosilicates, phyllosilicates, tektosilicates)
amphibole group
pyroxene group
olivine group
plagioclase group
feldspar group