Igneous Minerals

Quartz

Orthoclase

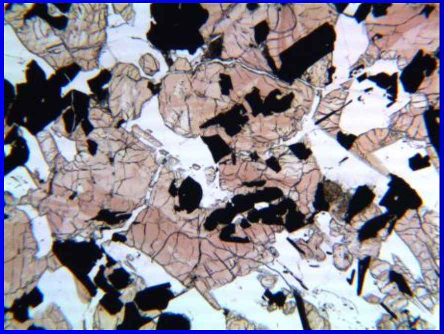
Plagioclase

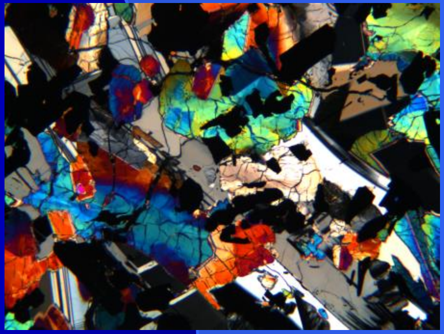
Mica

Amphibole

Pyroxene

Olivine





Silica and oxygen are the two most abundant elements in the Earth's crust (and mantle). They combine to form the silica tetrahedron which is the basic building block of the silicate minerals. The silicate minerals comprise 92% of the Earth's crust.

Table 7.1 The eight most common elements in the Earth's crust.

	Weight[a] percentage	Atom[b] percentage	Ionic radius[c] (Å)	Volume[d] percentage
O	46.60	62.55	1.26	~86
Si	27.72	21.22	0.40[IV]	
Al	8.13	6.47	0.53[IV]	
Fe	5.00	1.92	0.92[VI]	~14
Ca	3.63	1.94	1.14[VI]	in total
Na	2.83	2.64	1.32[VIII]	
K	2.59	1.42	1.65[VIII]	
Mg	2.09	1.84	0.86[VI]	
	98.59	100.00		

[a] Data from Mason and Moore, 1982.
[b] Values obtained by dividing the numbers in the first column by the appropriate atomic weights, then normalized to 100.
[c] Radii taken from Table 4.4.
[d] These values fluctuate somewhat depending on the radii used in the calculation of the ionic volume ($V = \frac{4}{3}\pi r^3$).

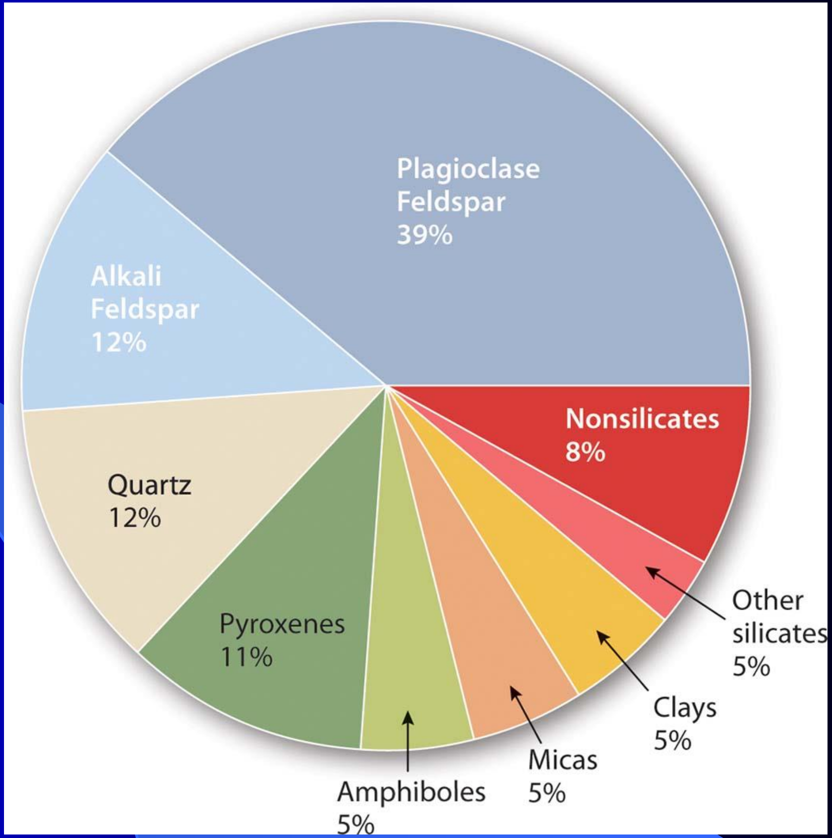
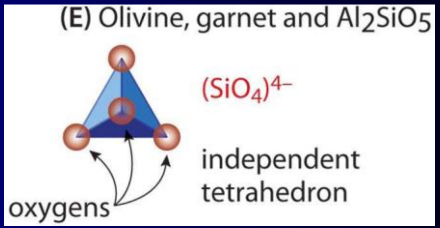
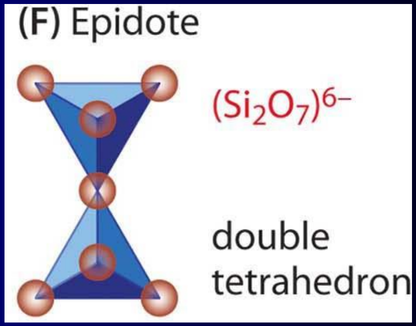
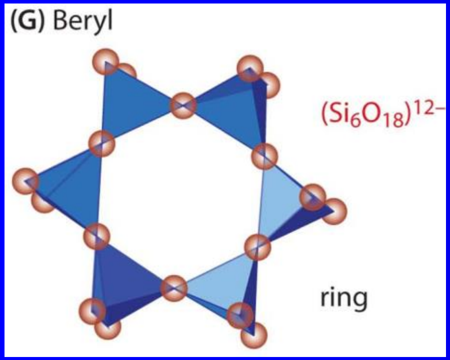


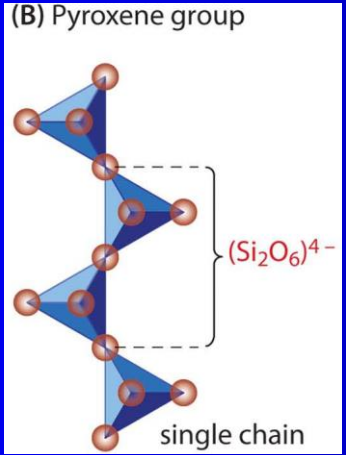
Table 7-4. Properties of the silicate crystal classes

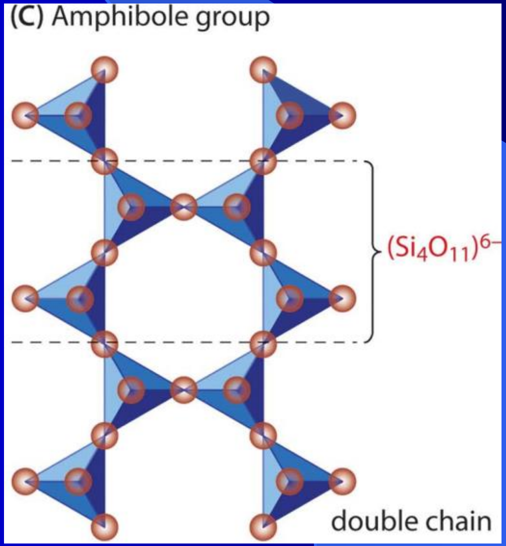
Class	Tetrahedral arrangement	# shared corners	Chemical unit	Si:O	Example
Nesosilicate	Independent tetrahedra	0	SiO_4^{4-}	1:4	Olivine
Sorosilicate	Two tetrahedra sharing a corner	1	$Si_2O_7^{6-}$	1:3.5	Melilite
Cyclosilicate	Three or more tetrahedra sharing two corners, forming a ring	2	SiO_3^{3-}	1:3	Beryl
Inosilicate	Single chain of tetrahedra sharing two corners	2	SiO_3^{3-}	1:3	Augite
	Double chain of tetrahedra alternately sharing two or three corners	2.5	$Si_4O_{11}^{6-}$	1:2.75	Hornblende
Phyllosilicate	Sheet of tetrahedra sharing three corners	3	$Si_2O_5^{2-}$	1:2.5	Kaolinite
Tektosilicate	Framework of tetrahedra sharing all four corners	4	SiO_2	1:2	K-feldspar

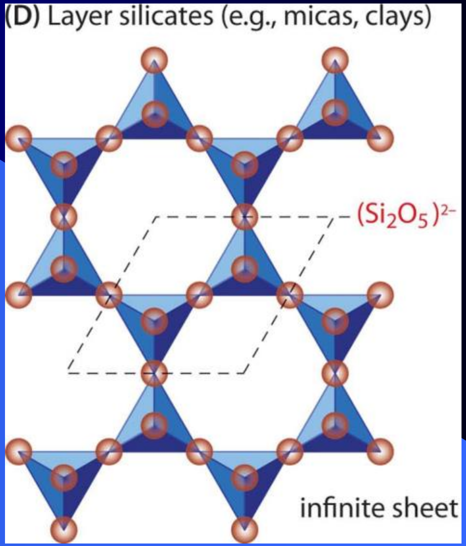






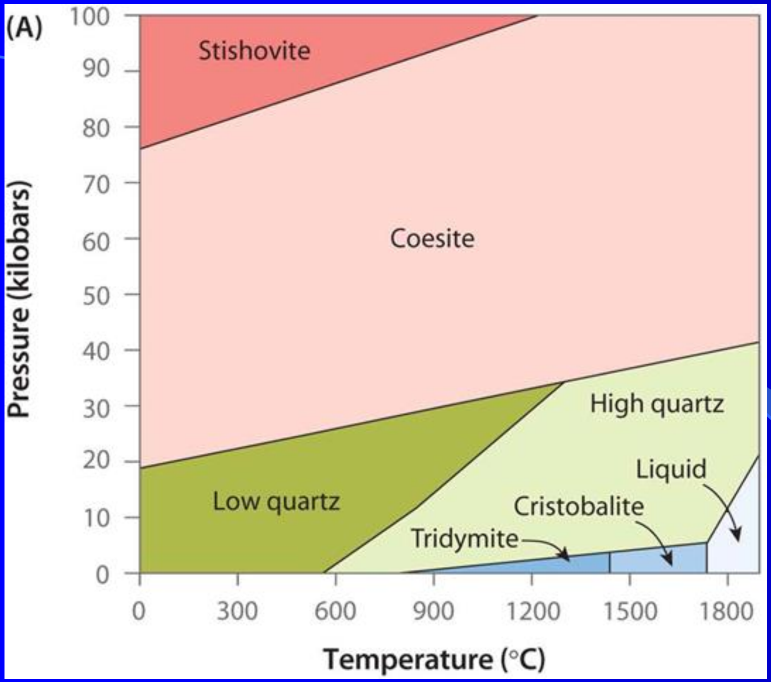


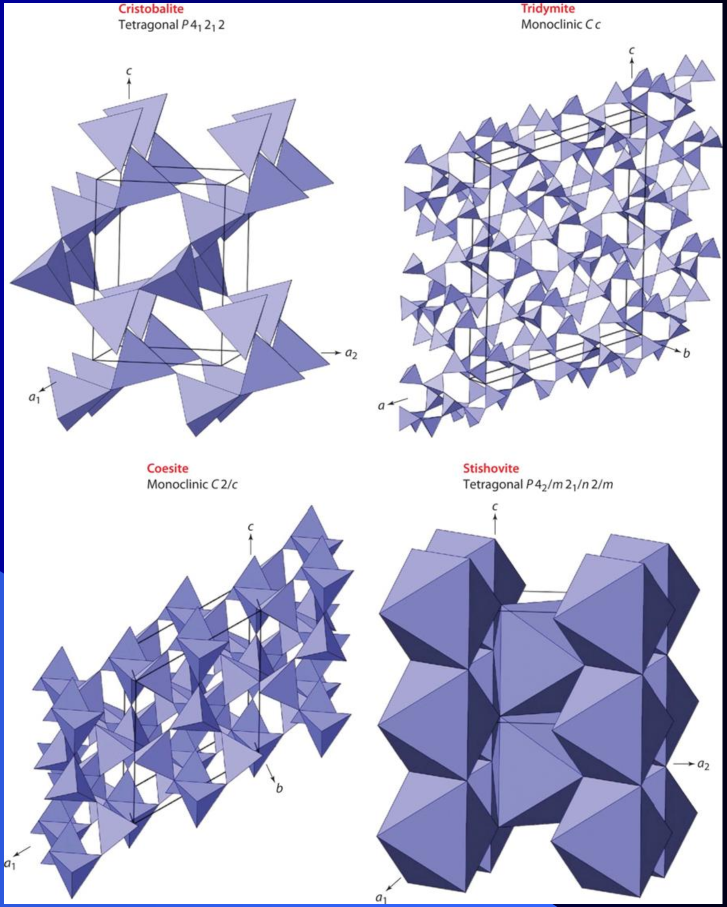


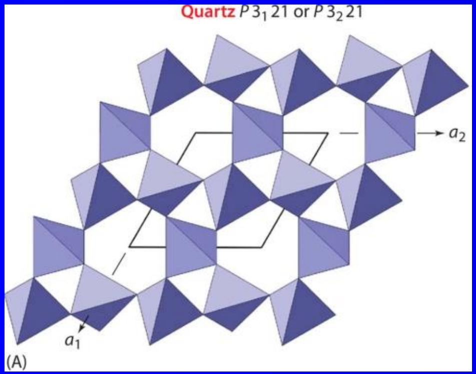


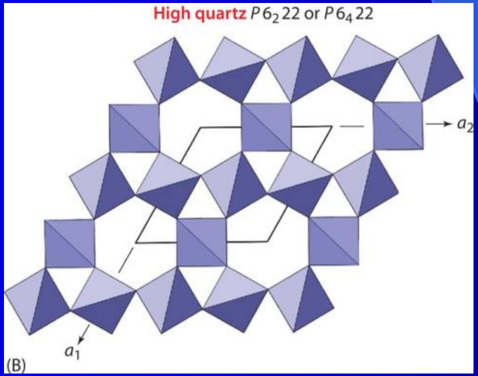
Quartz – SiO_2

P-T conditions and polymorphs







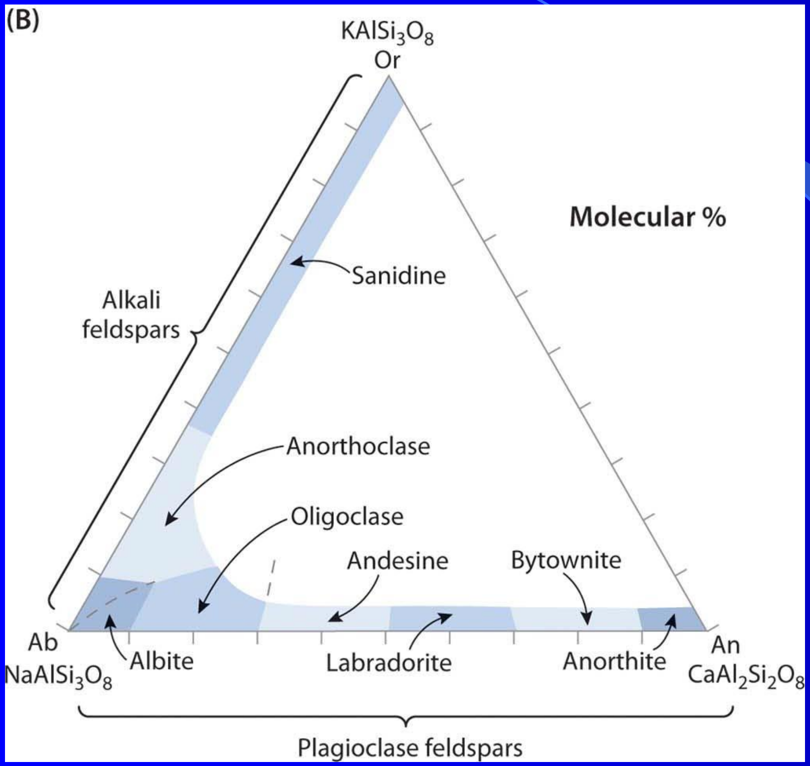


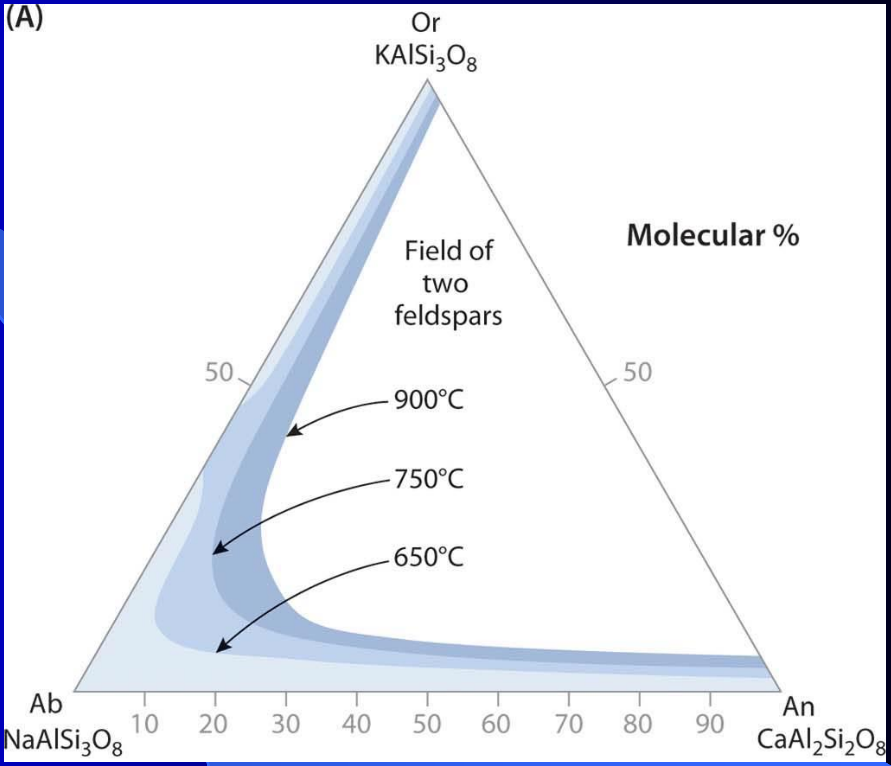
Feldspars

K-feldspar ($KAlSi_3O_8$)

Plagioclase ($NaAlSi_3O_8 \leftrightarrow CaAl_2Si_2O_8$)

Coupled substitution: CaAl ↔ NaSi





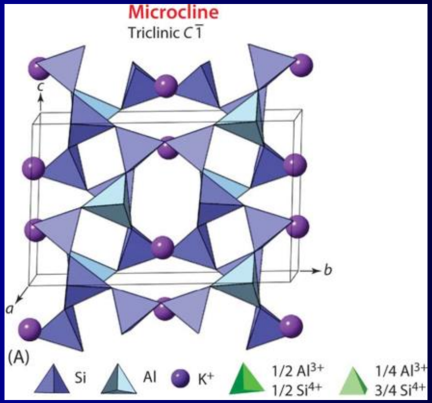
$KAlSi_3O_8$ polymorphs:

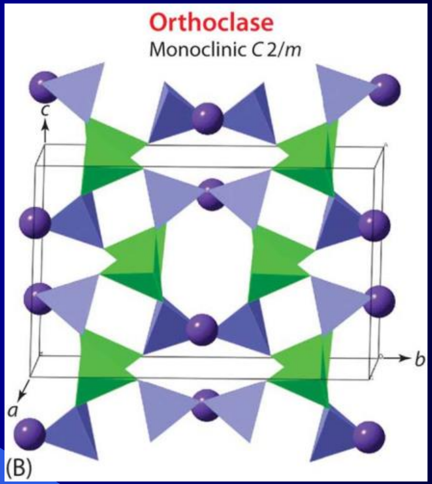
The distinction between the polymorphs is based on the ordering of Al in the tetrahedral sites.

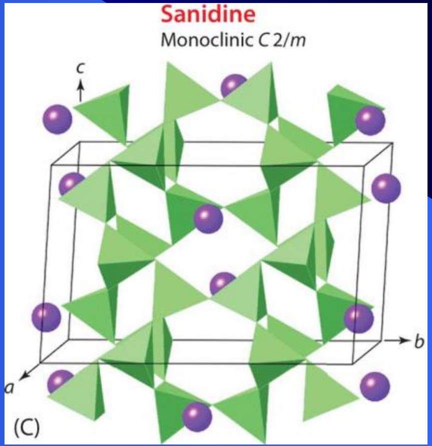
- Microcline – low T polymorph – one in every four tetrahedral sites is filled with an Al. Total order

- Orthoclase – moderate T polymorph – Al is distributed over two equivalent tetrahedral sites. Partially ordered

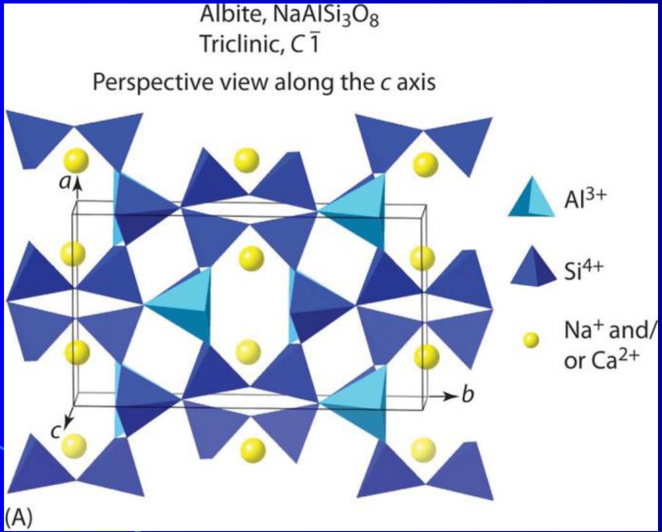
- Sanidine – high T polymorph – equal probability of finding Al in any of the four tetrahedral sites. Completely disordered.

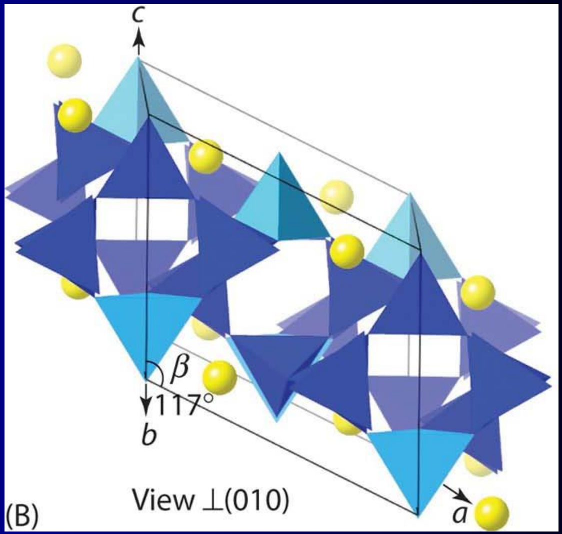


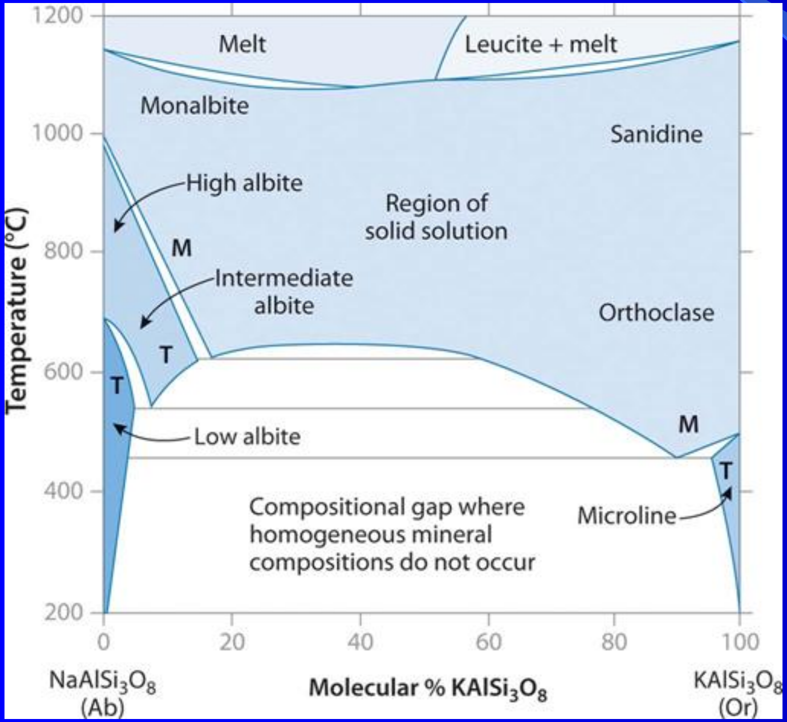


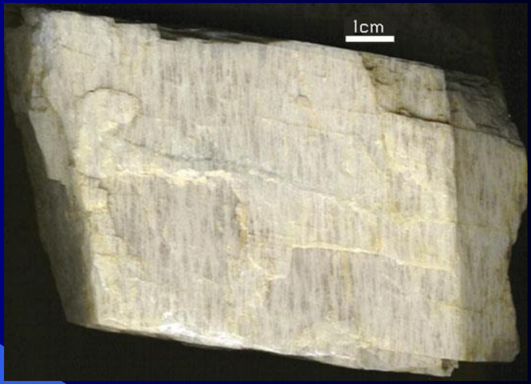


Plagioclase structure









Perthite – albite exsolved from microcline or orthoclase.

Antiperthite – orthoclase exsolved from albite.

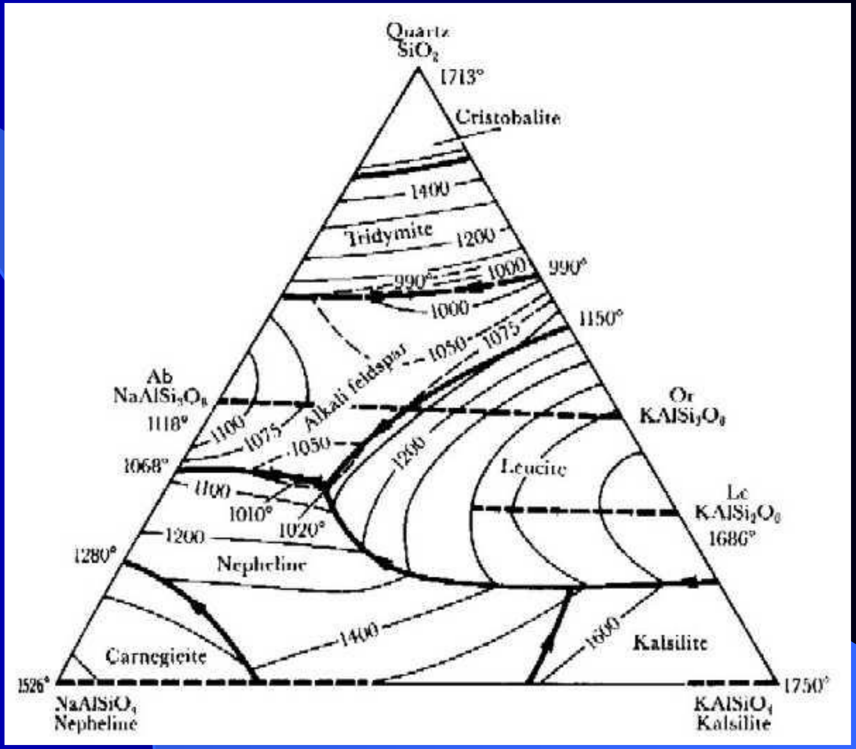
Feldspathoids

- Leucite – $KAlSi_2O_6$
- Nepheline – $(Na,K)AlSiO_4$
- Sodalite – $Na_4Al_3Si_3O_{12}Cl$

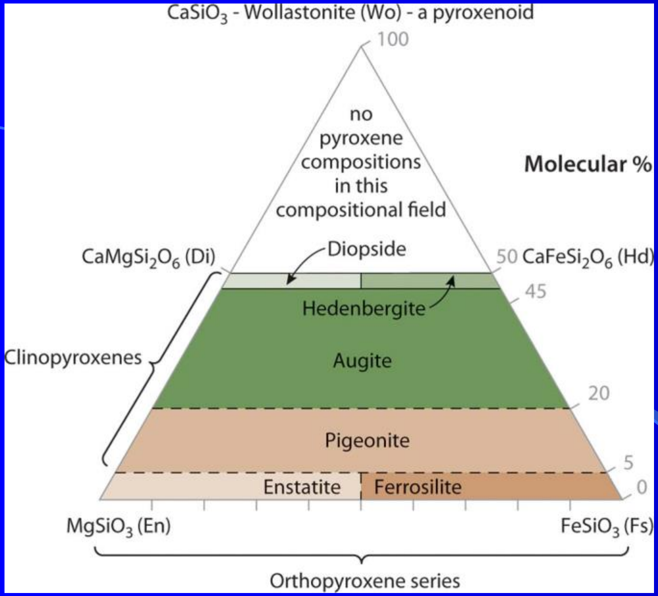
Feldspathoids are found in silica undersaturated igneous rocks. Silica deficient relative to the feldspars.

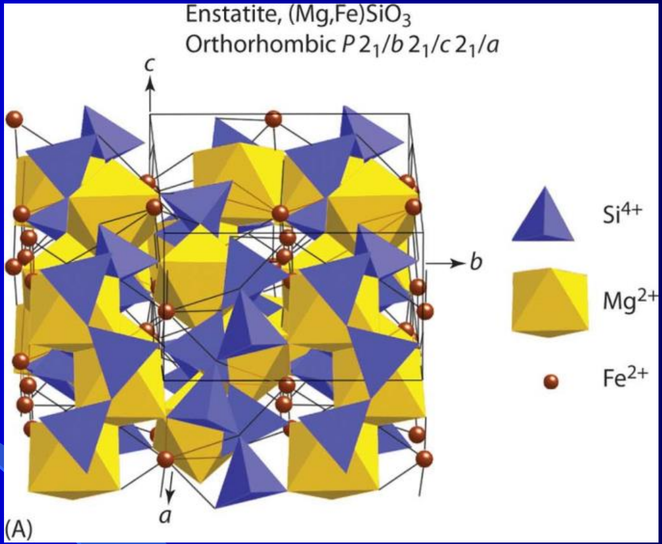
For example:

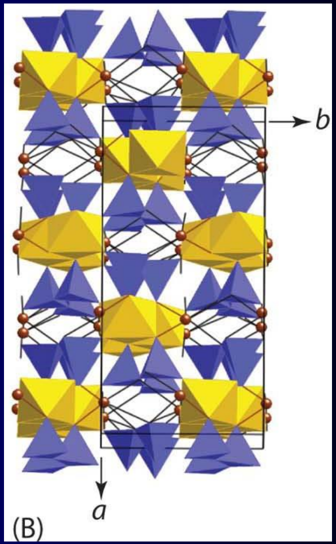
$KAlSi_2O_6 + SiO_2 = KAlSi_3O_8$

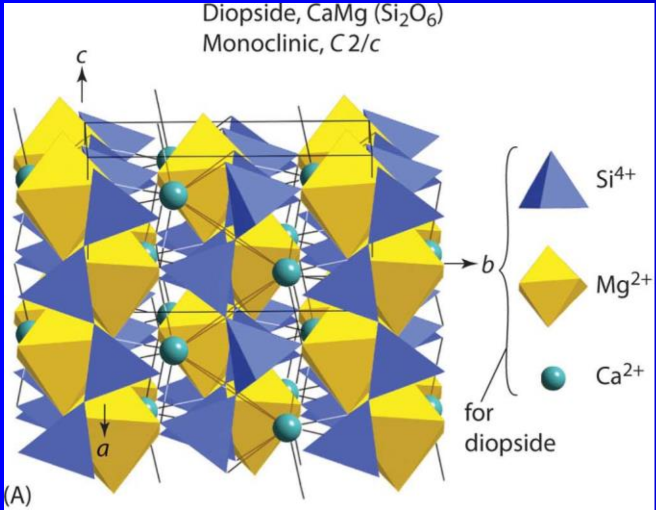


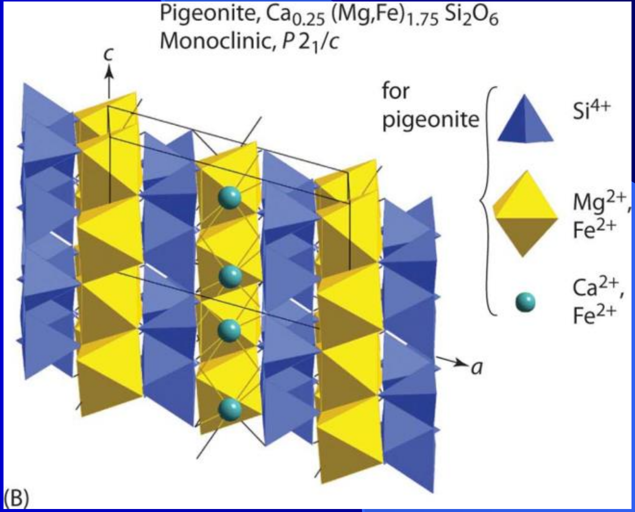
Single chain silicates - Pyroxenes



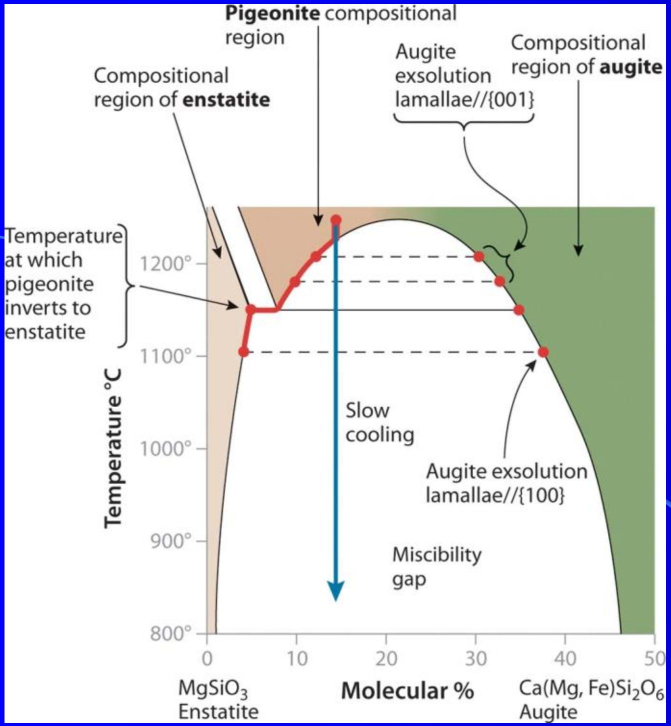


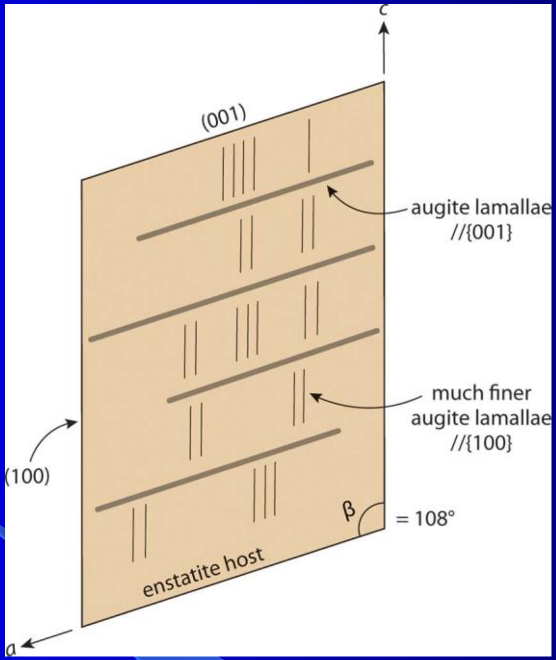






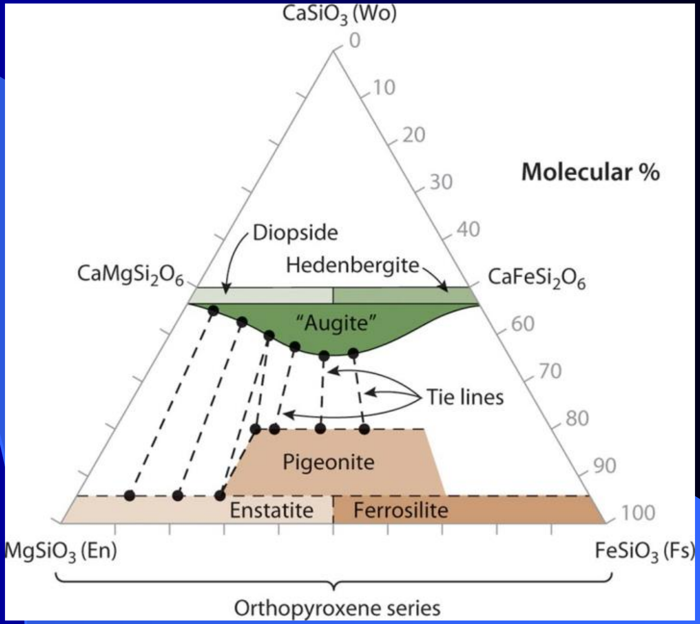
Enstatite: $MgSiO_3$ – $(Mg,Fe)SiO_3$
Pigeonite: $Ca_{0.25}(Mg,Fe)_{1.75}SiO_6$
Augite: $(Ca,Na)(Mg,Fe,Al)(Si,Al)O_2O_6$
Aegirine: $NaFe^{3+}Si_2O_6$



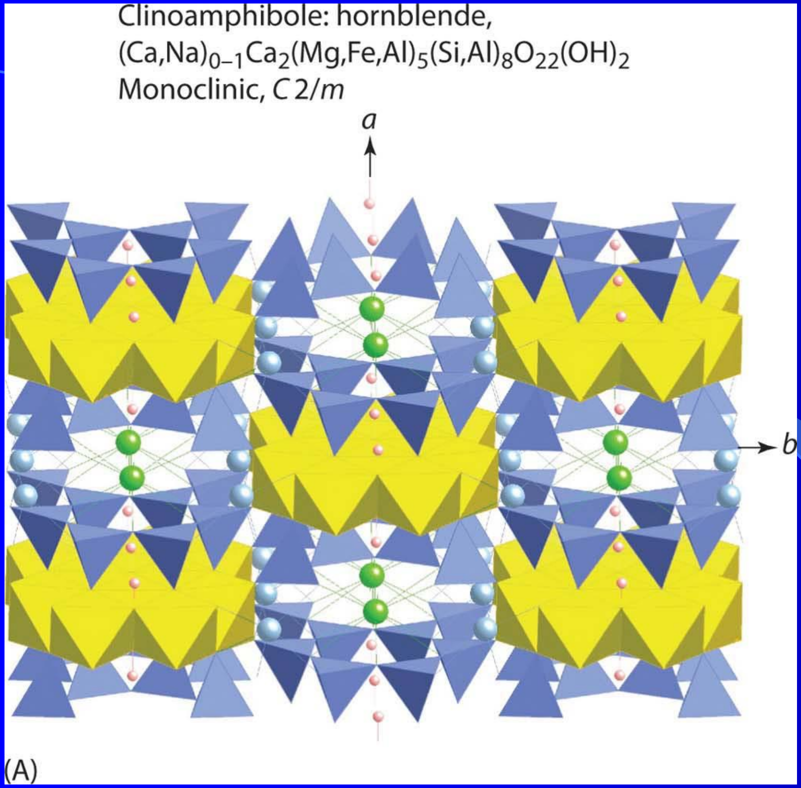


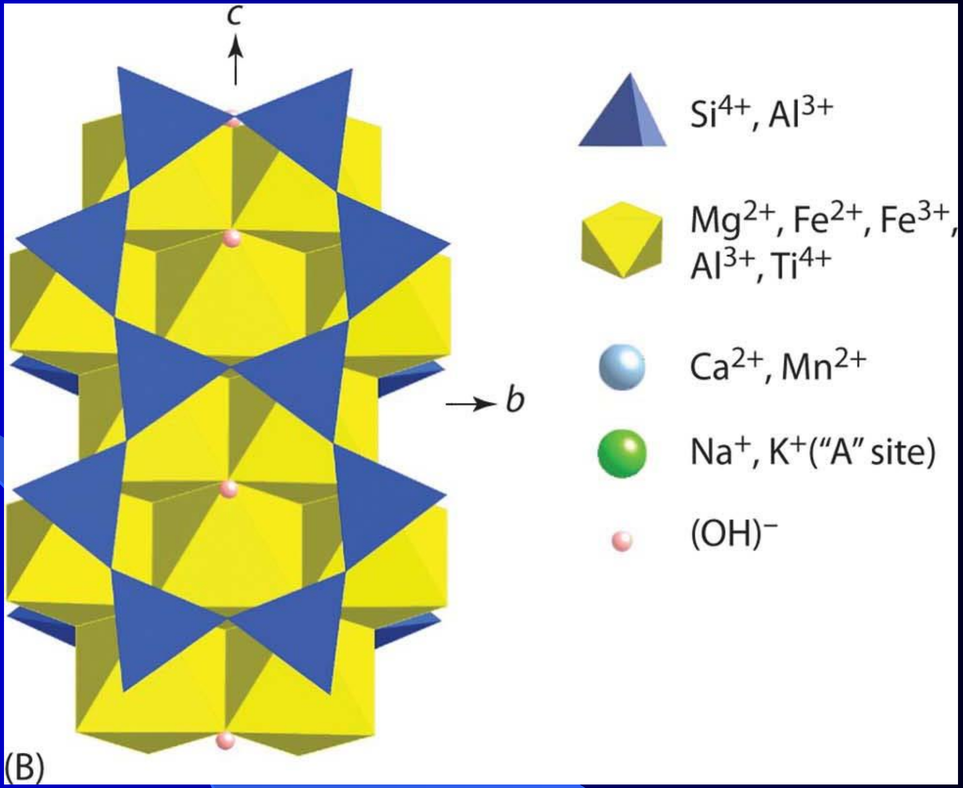
Exsolution of augite lamallae in enstatite host. Enstatite is orthorhombic but orientation of lamallae indicate that the original grain was pigeonite (monoclinic).

Alkali olivine basalts – one Ca-pyroxene. Tholeiites – two pyroxenes, one Ca-rich and the other Ca-poor. Composition of co-existing pyroxenes.



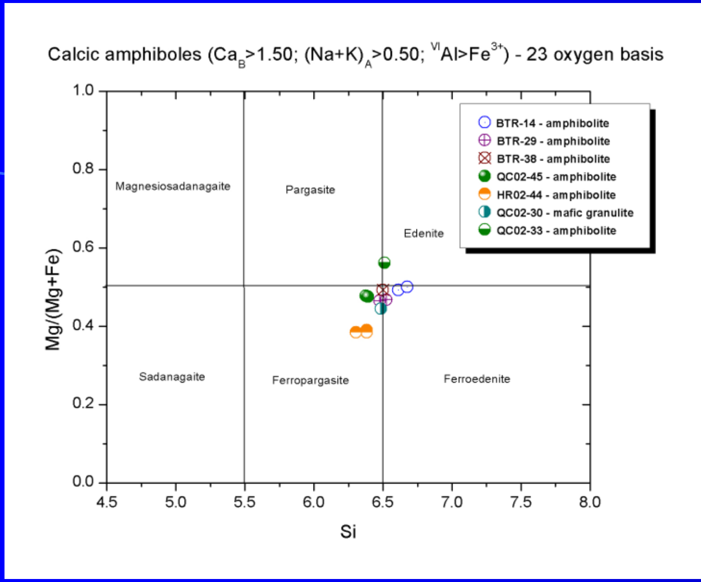
Double chain silicates - Amphiboles

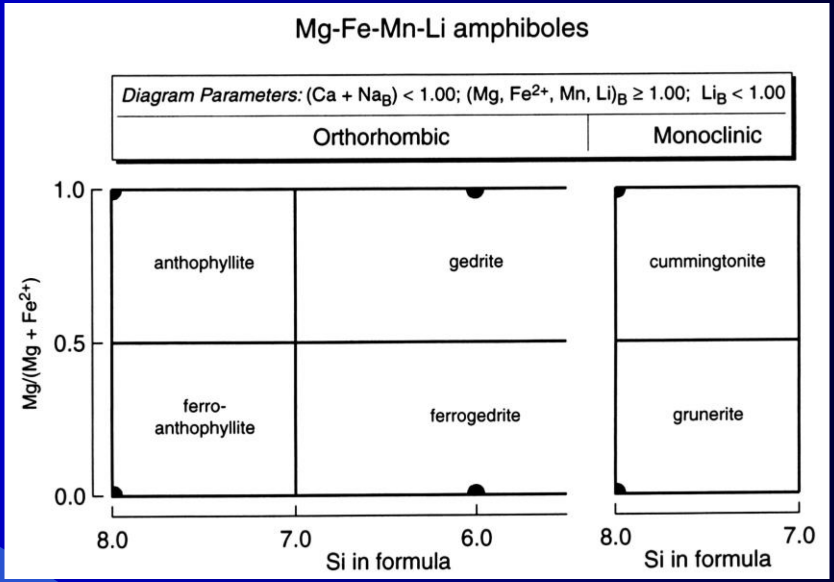


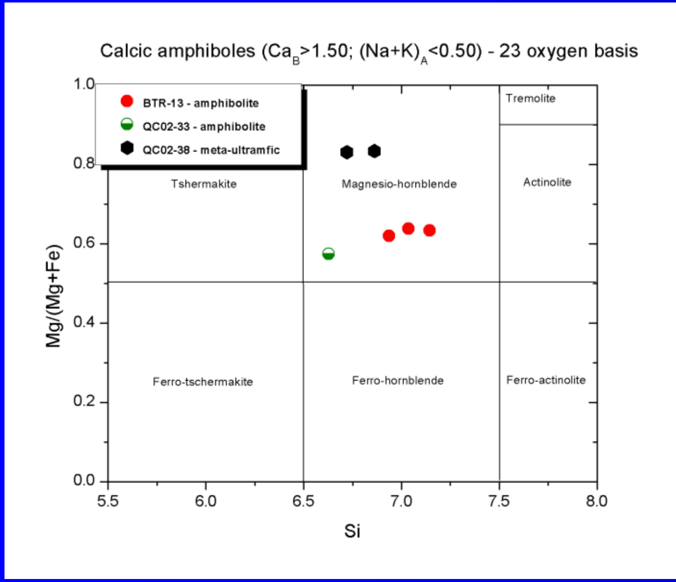


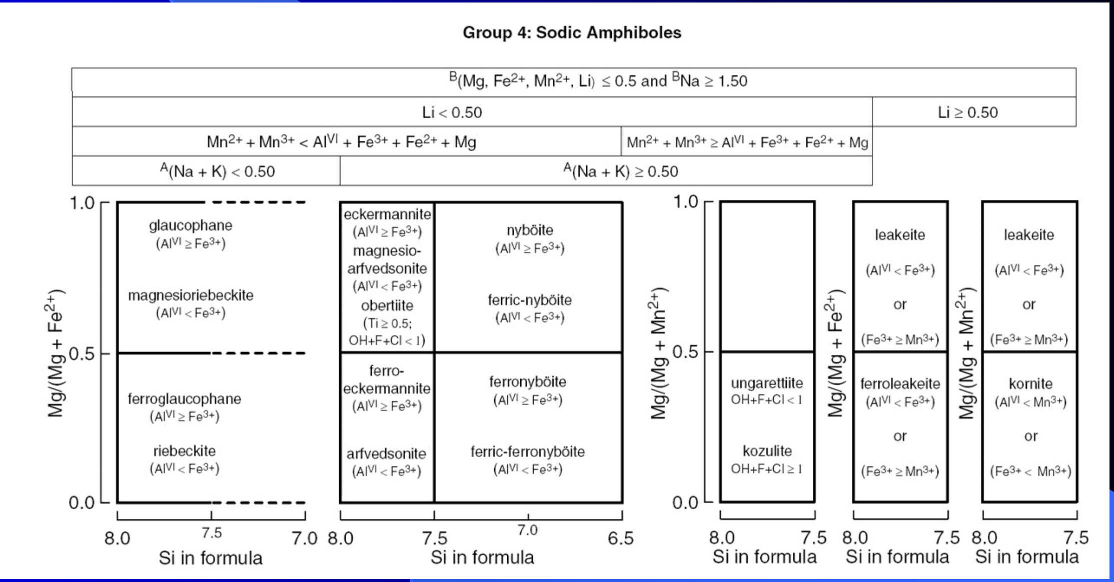
Hornblende: $(Na,K)_{0\text{-}1}Ca_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}(OH)_2$

Amphibole Classification

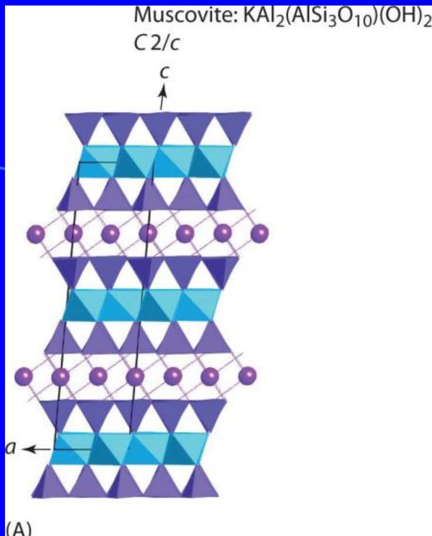


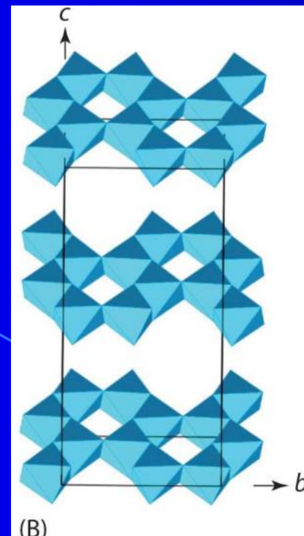


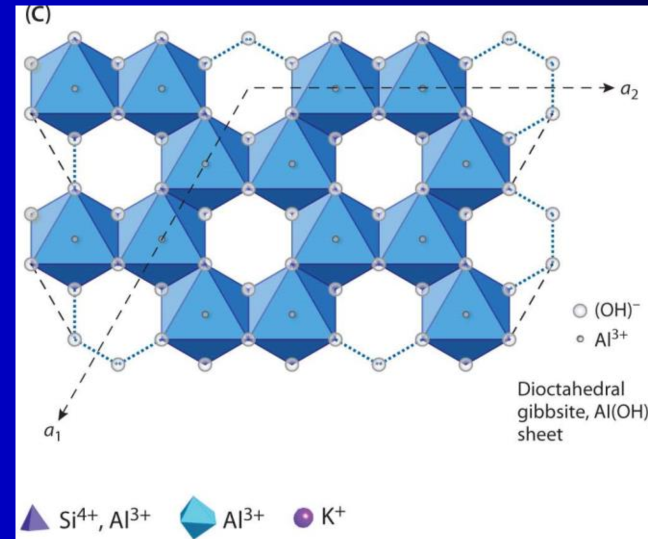




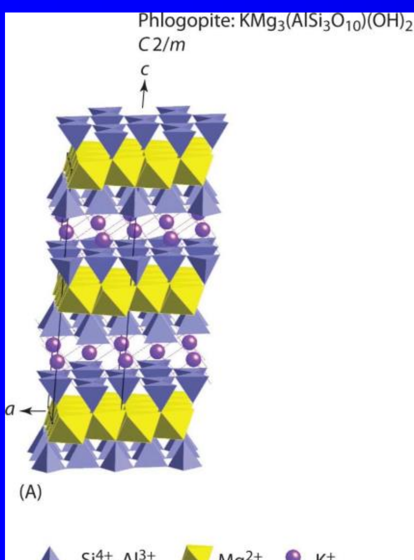
Sheet Silicates - micas

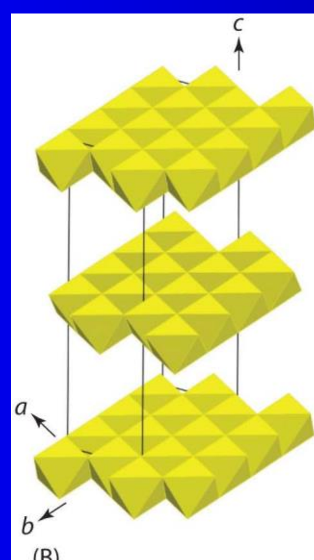


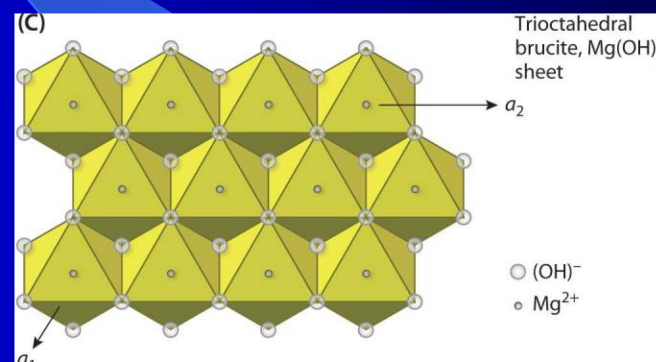




Biotite: $K(Mg, Fe)_3AlSi_3O_{10}(OH)_2$



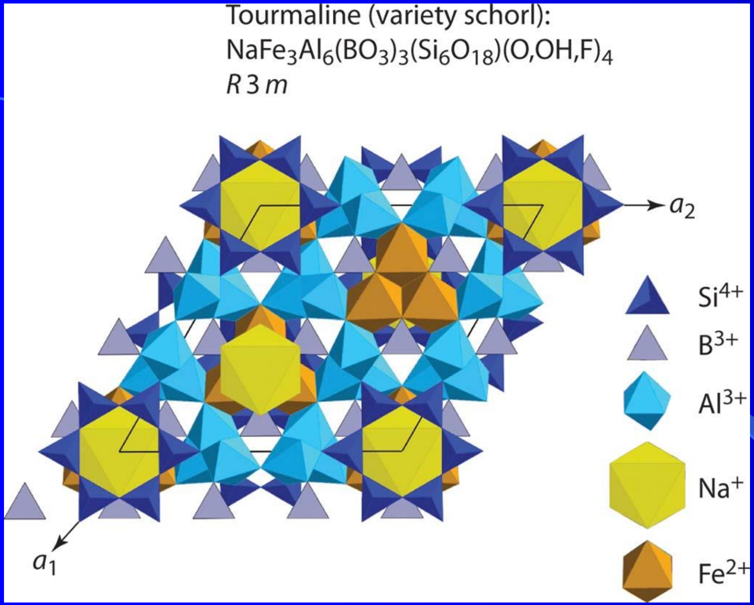




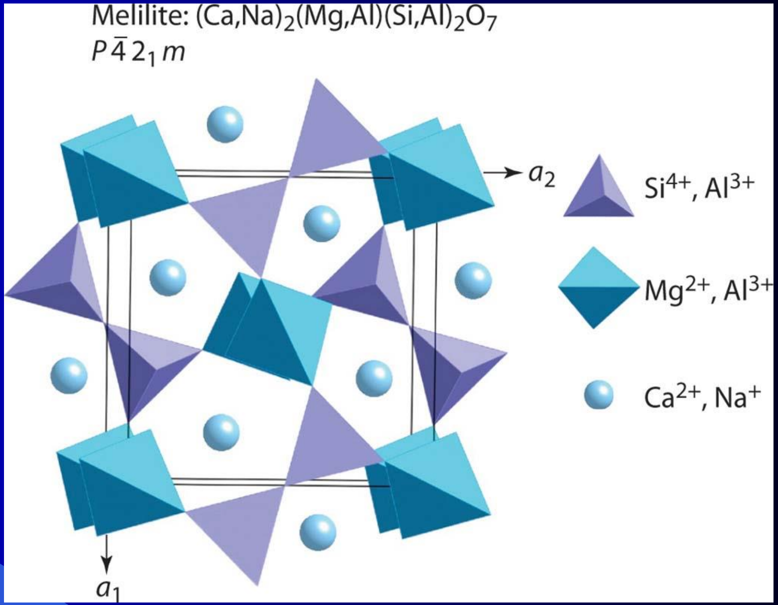
Dioctahedral gibbsite – $Al(OH)_3$

Trioctahedral brucite – $Mg(OH)_2$

Cyclosilicate

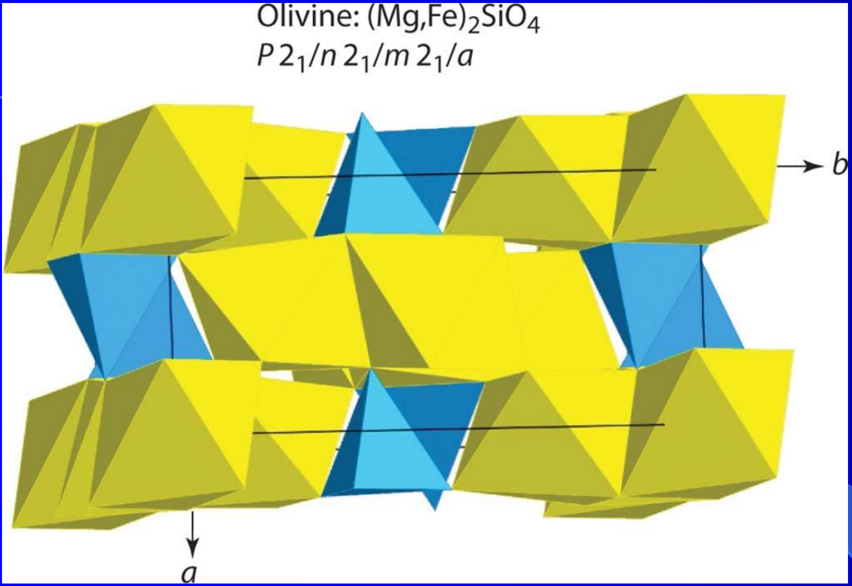


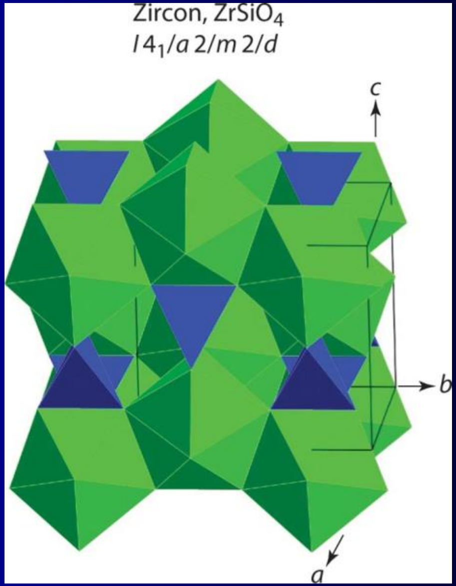
Sorosilicate



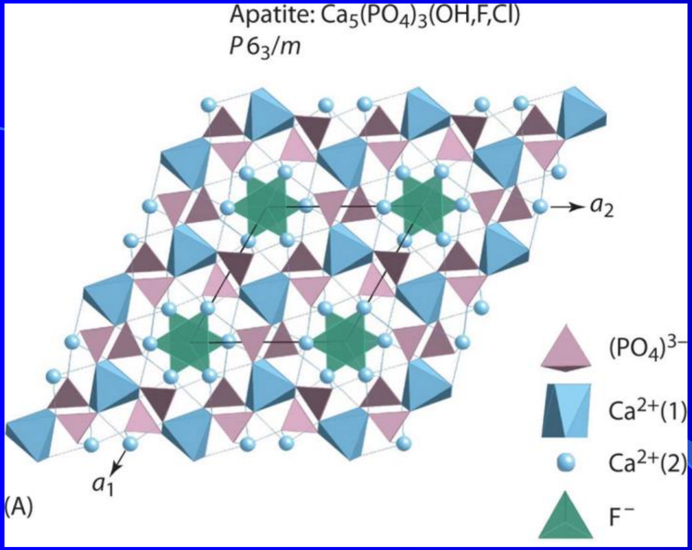
Gehlenite $[Ca_2Al(Al, Si)_2Si_7]$ → Akermanite $[Ca_2MgSi_2O_7]$

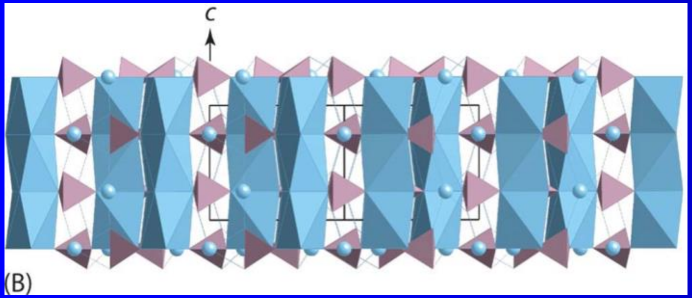
Nesosilicates





Apatite





Chlorapatite – Cl

Fluorapatite – F

Hydroxyapatite - OH

Other Minerals

Mineral	**Formula**
Oxides	
Chromite	$FeCr_2O_4$
Hematite	Fe_2O_3
Magnetite	Fe_3O_4
Ilmenite	$FeTiO_3$
Rutile	TiO_2
Sulfides	
Pyrite	FeS_2
Pyrrhotite	$Fe_{1-x}S$
Chalcopyrite	$CuFeS_2$