

Tectosilicates – (Framework Silicates)

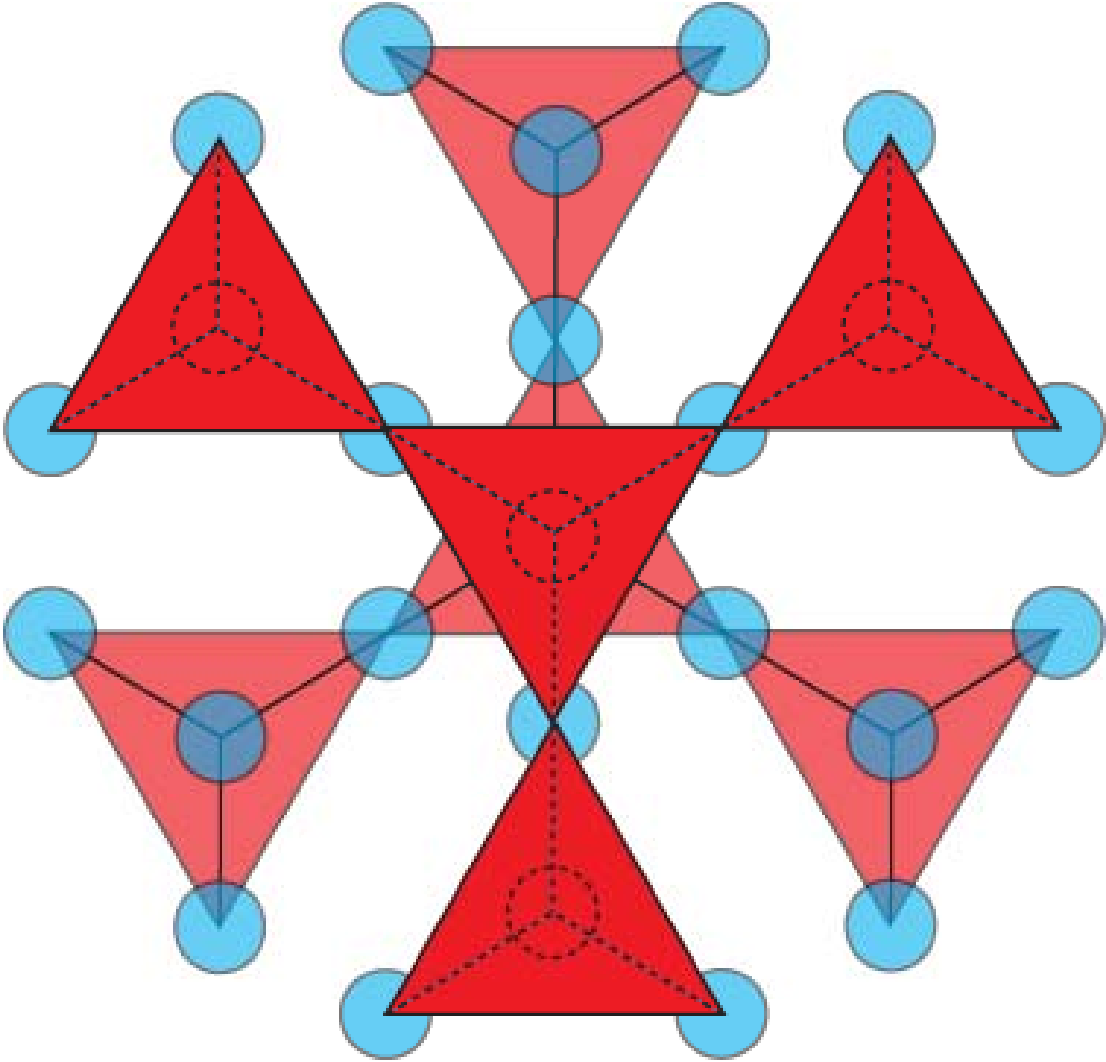
Infinite 3-dimensional network of $(\text{SiO}_4)^{4-}$
or $(\text{Si}_3\text{Al})\text{O}_8^{1-}$ - $(\text{Si}_2\text{Al}_2)\text{O}_8^{2-}$
building blocks

Such minerals account for some 64% of
the Earth's crust.

All oxygen atoms are shared between two
 SiO_4^{4-} tetrahedron.

Quartz is useful as a source of Si and for silica. It is used in
electronics as an oscillator, and is piezoelectric.

(SiO₂)
Infinite tetrahedral network



SiO₂ Group

The SiO₂ structure is electrically neutral – it does not require additional cation or anion species.

SiO₂ – quartz in its simplest form.

However, we discuss the “SiO₂ group” because there are nine SiO₂ polymorphs.

Stishovite	Tetragonal	4.35 g/cm ³
Coesite	Monoclinic	3.01
Low (α) Quartz	Hexagonal (Trigonal)	2.65
High (β) Quartz	Hexagonal (Trigonal)	2.53
Keatite	Tetragonal	2.50
Low (α) Tridymite	Mono. or Ortho.	2.26
High (β) Tridymite	Hexagonal	2.22
Low (α) Cristobalite	Tetragonal	2.32
High (β) Cristobalite	Isometric	2.20

The stable polymorph is determined by energy considerations.

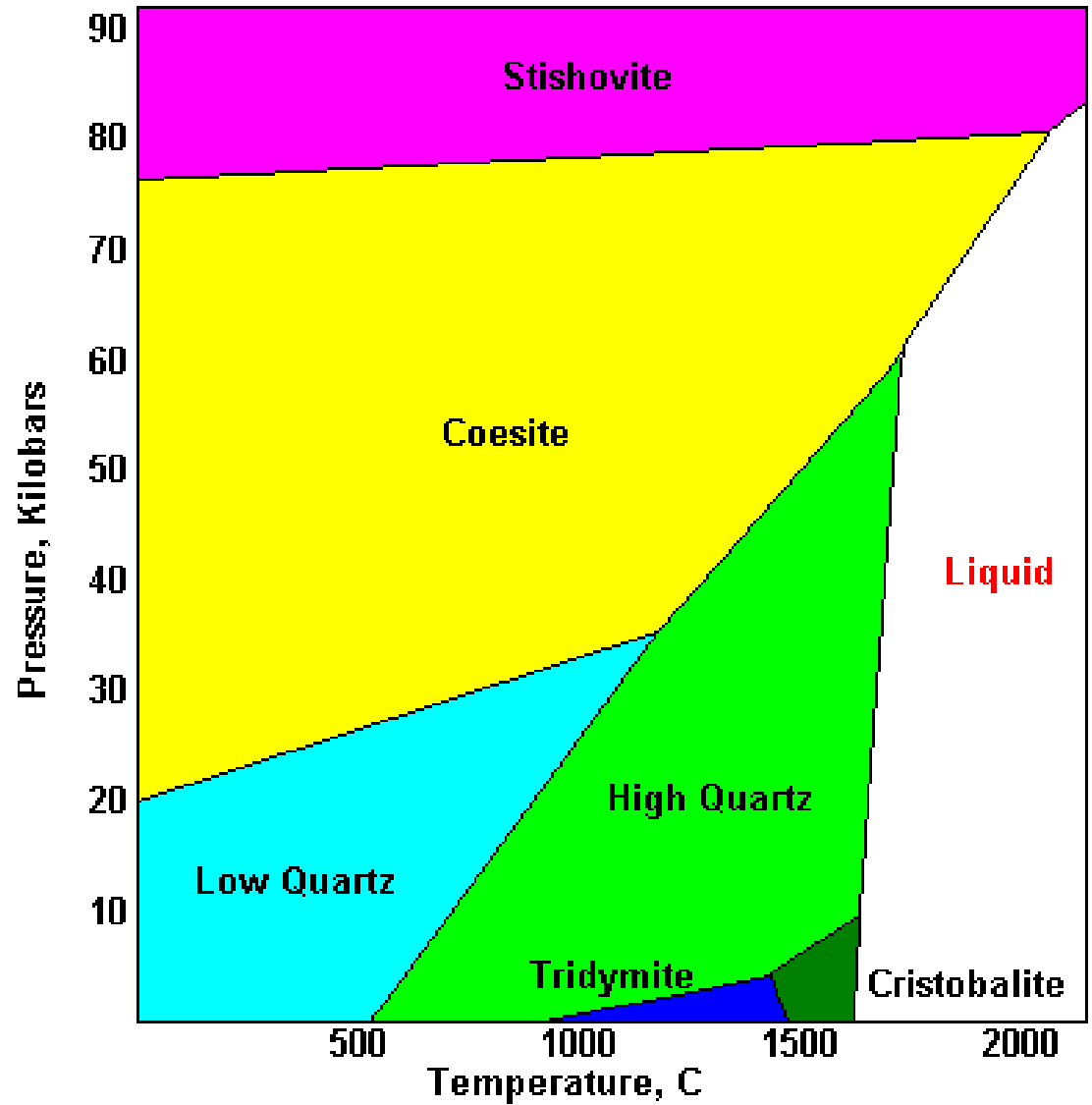
High T forms – greater lattice energy, lower D and RI.

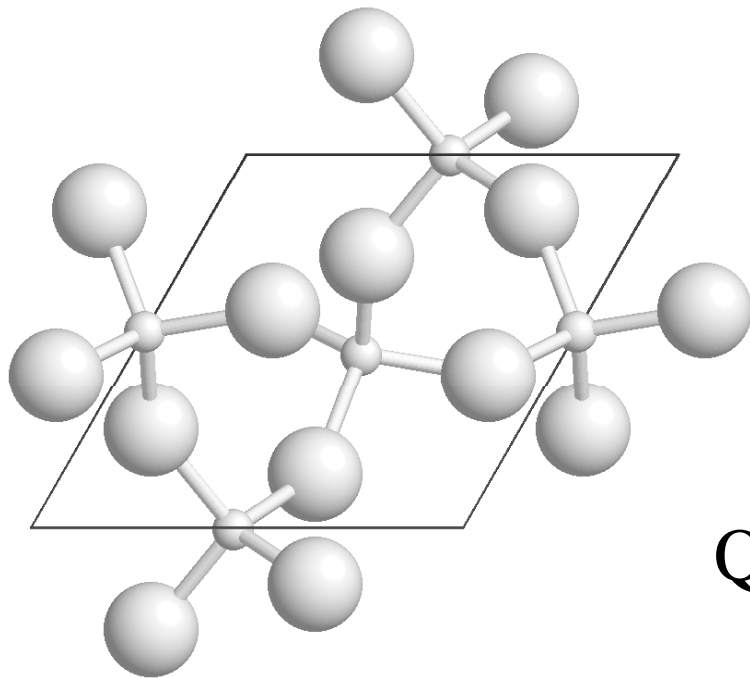
High P forms – closer packing, higher symmetry, higher D and higher RI.

Lower the T and P the lower the symmetry of the SiO_2 polymorph.

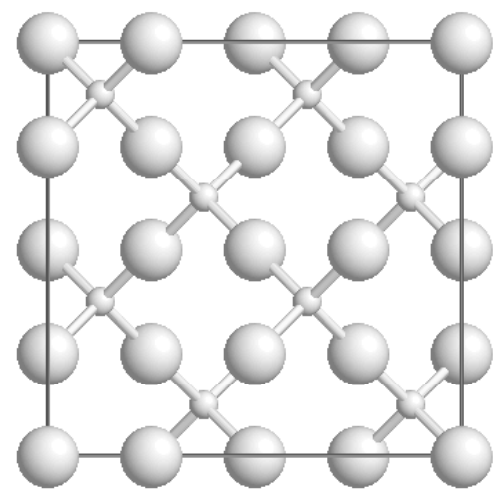
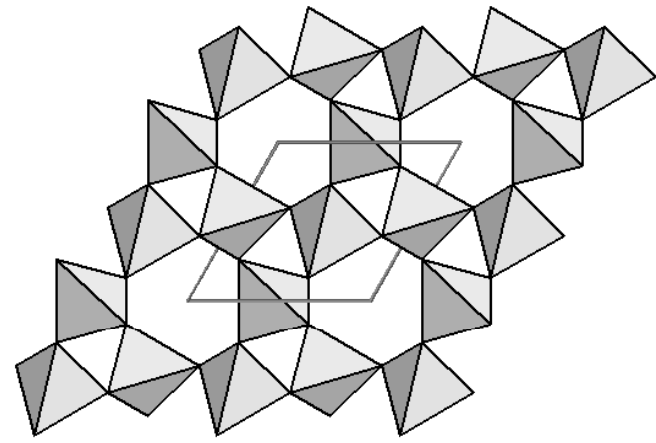
Quartz, tridymite and cristobalite are related via reconstructive inversions.

Inversions between high and low are displacive.

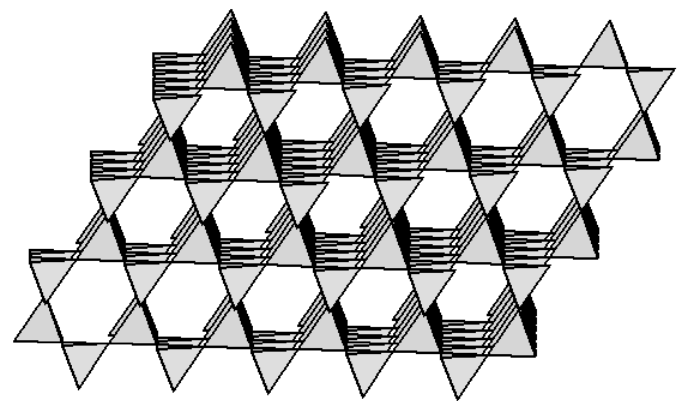


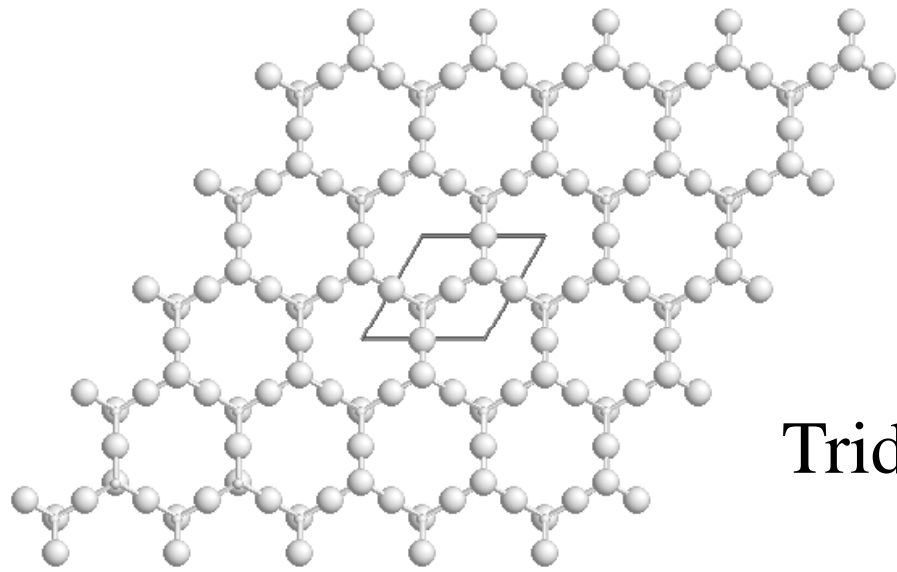


Quartz

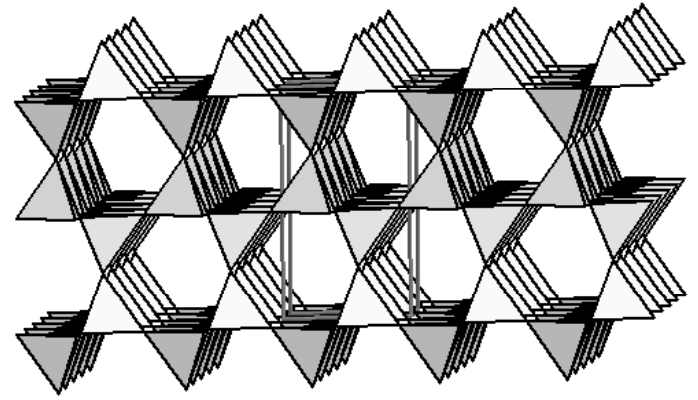


Cristobalite

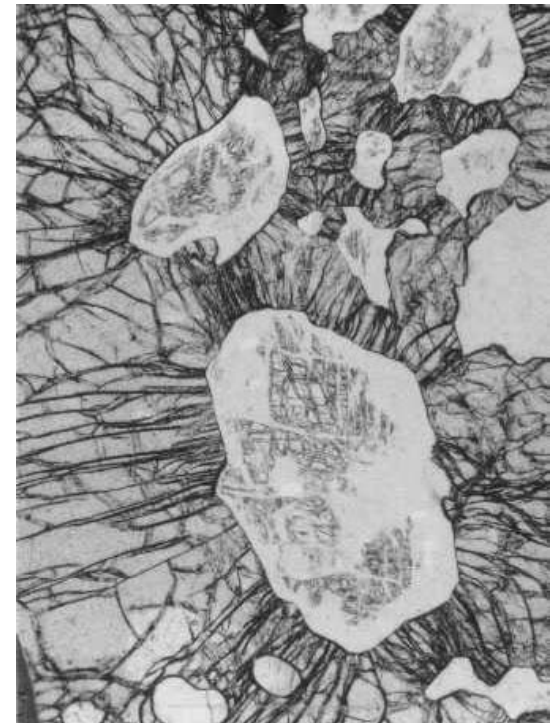
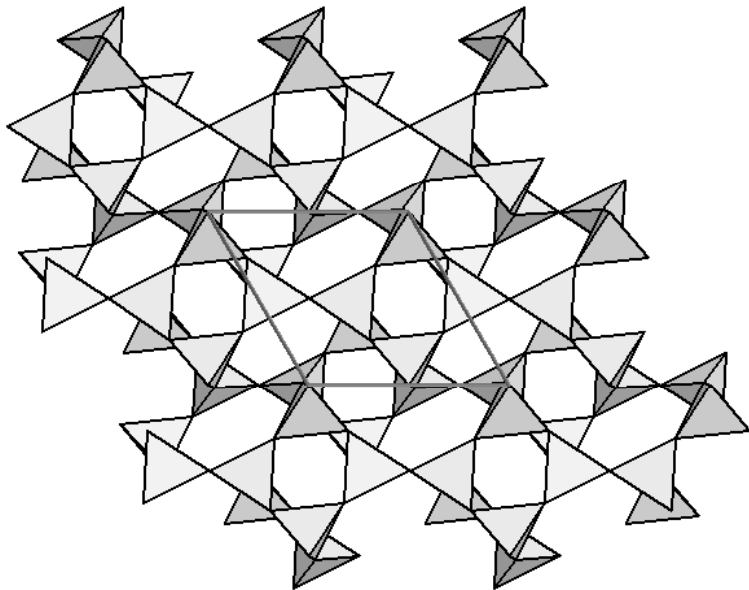




Tridymite



Coesite



Optical Properties

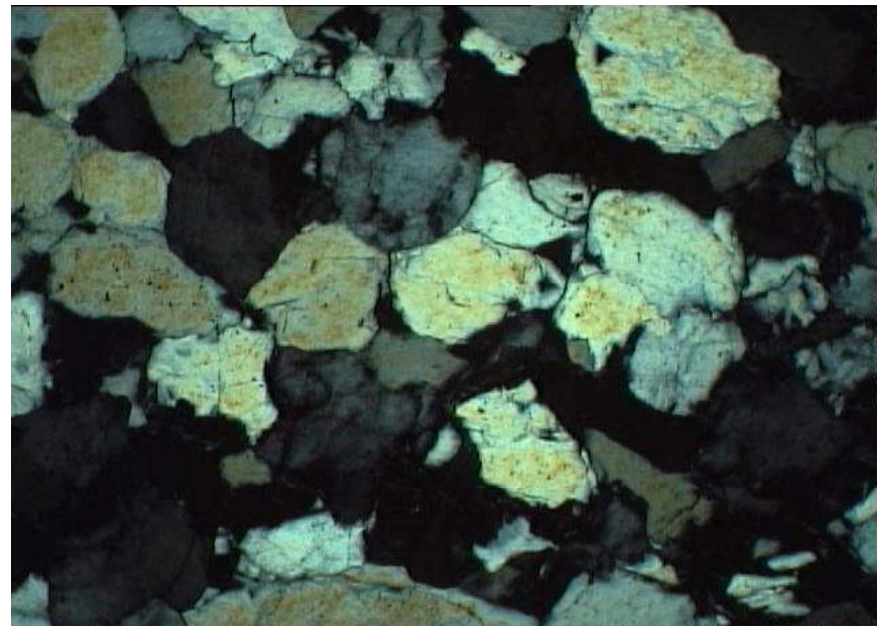
Quartz is commonly white to colourless in hand specimen and colourless in thin section.

Low relief and low 1st order birefringence – sometimes tinged yellow.

Uniaxial (Trigonal) positive and length fast.

Chemically very stable mineral, and with medium-high hardness (7) mechanically stable.

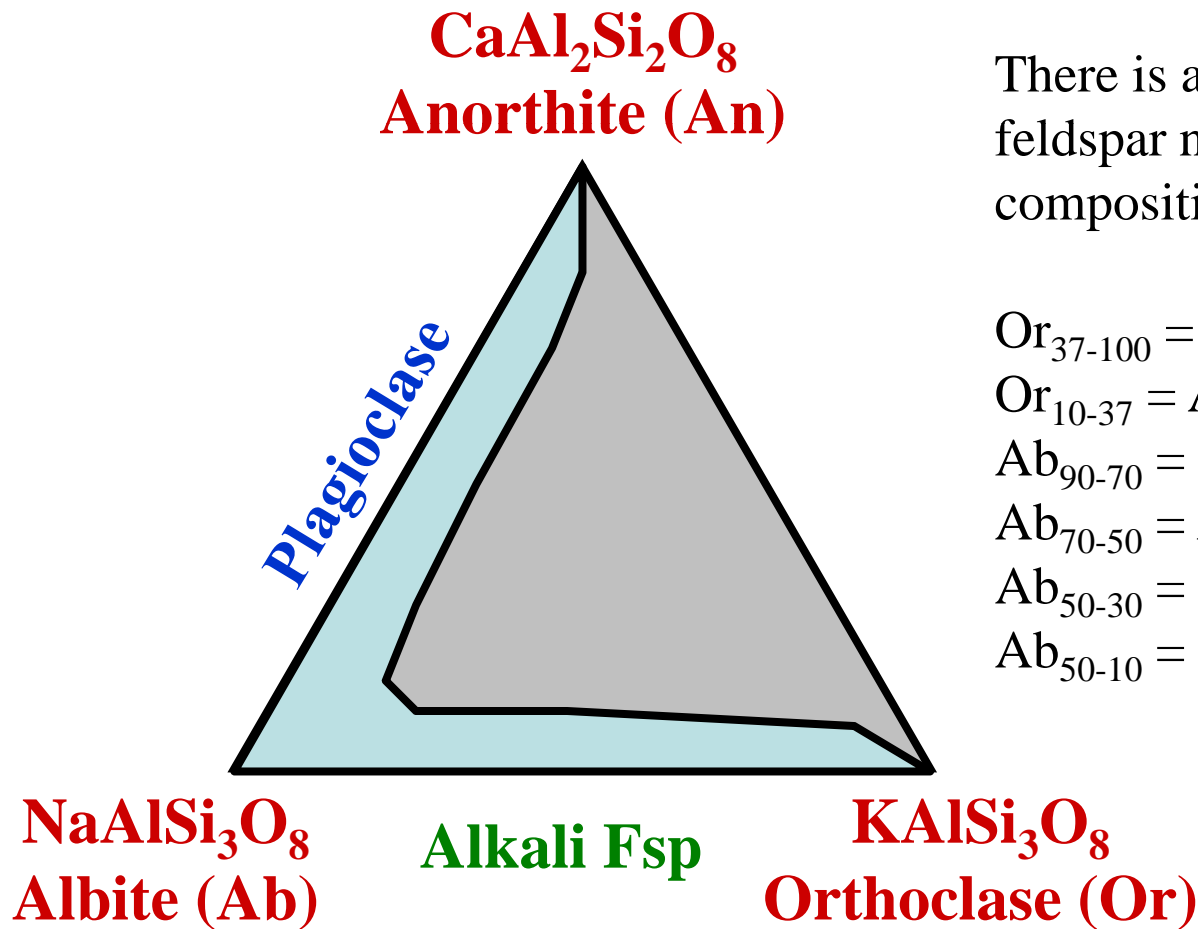
Ubiquitous in the Geological environment (12% of crust).



Feldspar Group

The feldspar group minerals are the most common silicates in the Earth's Crust.

The great majority of them can be expressed in terms to a ternary system.



There is an “old” system for feldspar nomenclature, based in composition.

Or₃₇₋₁₀₀ = Sanidine

Or₁₀₋₃₇ = Anorthoclase

Ab₉₀₋₇₀ = Oligoclase

Ab₇₀₋₅₀ = Andesine

Ab₅₀₋₃₀ = Labradorite

Ab₅₀₋₁₀ = Bytownite

Physical Properties

Feldspars show good cleavage in two directions at $\sim 90^\circ$.

Often, plagioclase is lighter, to white, in colour and the alkali feldspars often appear to have a salmon pink colour.

Hardness is around 6-7.

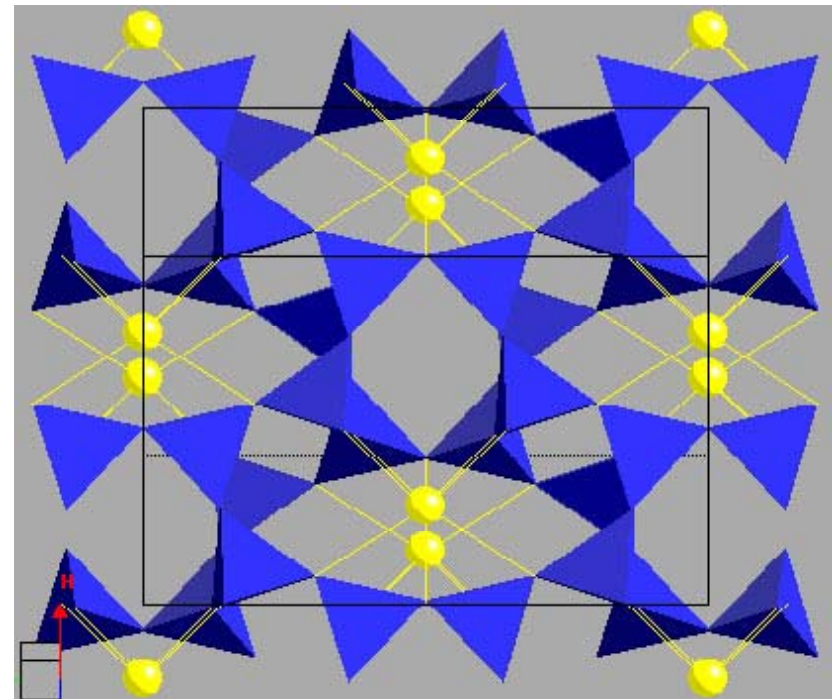
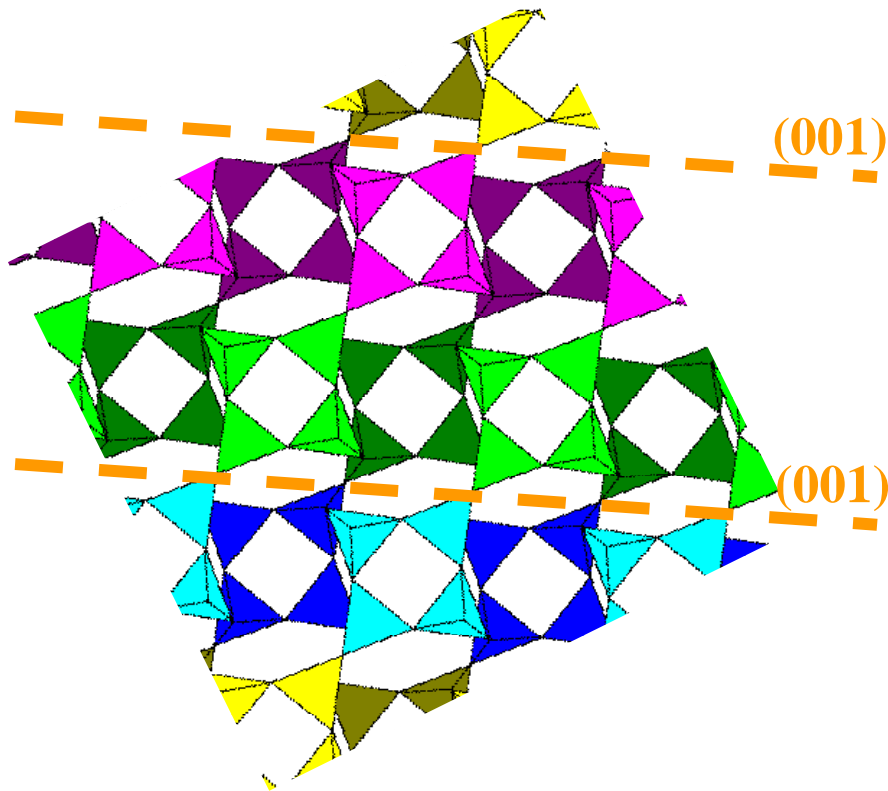
Found most intrusive igneous and many thermal and regionally metamorphosed rocks.



The structure of feldspar is similar to that of the SiO_2 polymorphs, consisting of an infinite network of inter-connected, via bridging oxygen atoms, tetrahedra.

However, in contrast to the SiO_2 group, the tetrahedra may be AlO_4 as well as SiO_4 .

Minerals are rendered electrically neutral as a result of being “stuffed” with alkali or alkali-earth element cations in available voids.



Feldspars have an idealised structural formula = $\mathbf{A(T_1T_2)O_8}$

For unambiguous feldspar characterisation, information on feldspar composition must be coupled with the “structural state” of the crystallographic lattice.

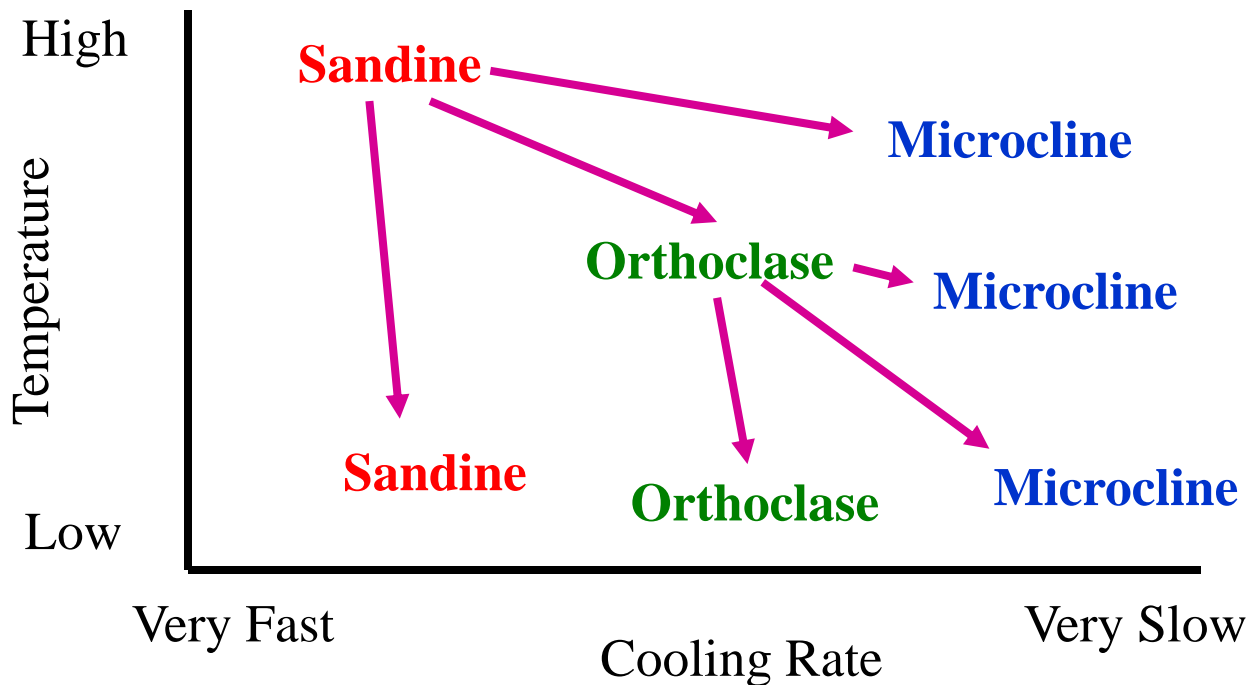
What does it mean – the structural state of the crystallographic lattice?

Alkali Feldspars (K,Na)[AlSi ₃ O ₈]		
Microcline	Low Sanidine	High Sanidine
Orthoclase	Anorthoclase	High albite
Low Albite	High Albite	
Triclinic	Triclinic	Tri/Mono- clinic
$2V = 34-103^\circ$	$0-54^\circ$	$60-50^\circ$

What does that all mean?

Feldspars are a classic example of the Al avoidance principle.

Which, itself, is measure of order in the lattice.



How does ordering vary in this diagram?

How does crystallographic structure vary with ordering?

What induces change in the structural symmetry?

Composition of Alkali Feldspars

The alkali feldspars, consist of two end-members, $\text{NaAlSi}_3\text{O}_8$ – KAlSi_3O_8 . However complete solid solution only occurs at high temperatures.

Areas of importance on this diagram include:

The Liquid Field

Liquid + Solid

Single Solid Phase

Miscibility Gap (immiscibility)

Unmixed Phases

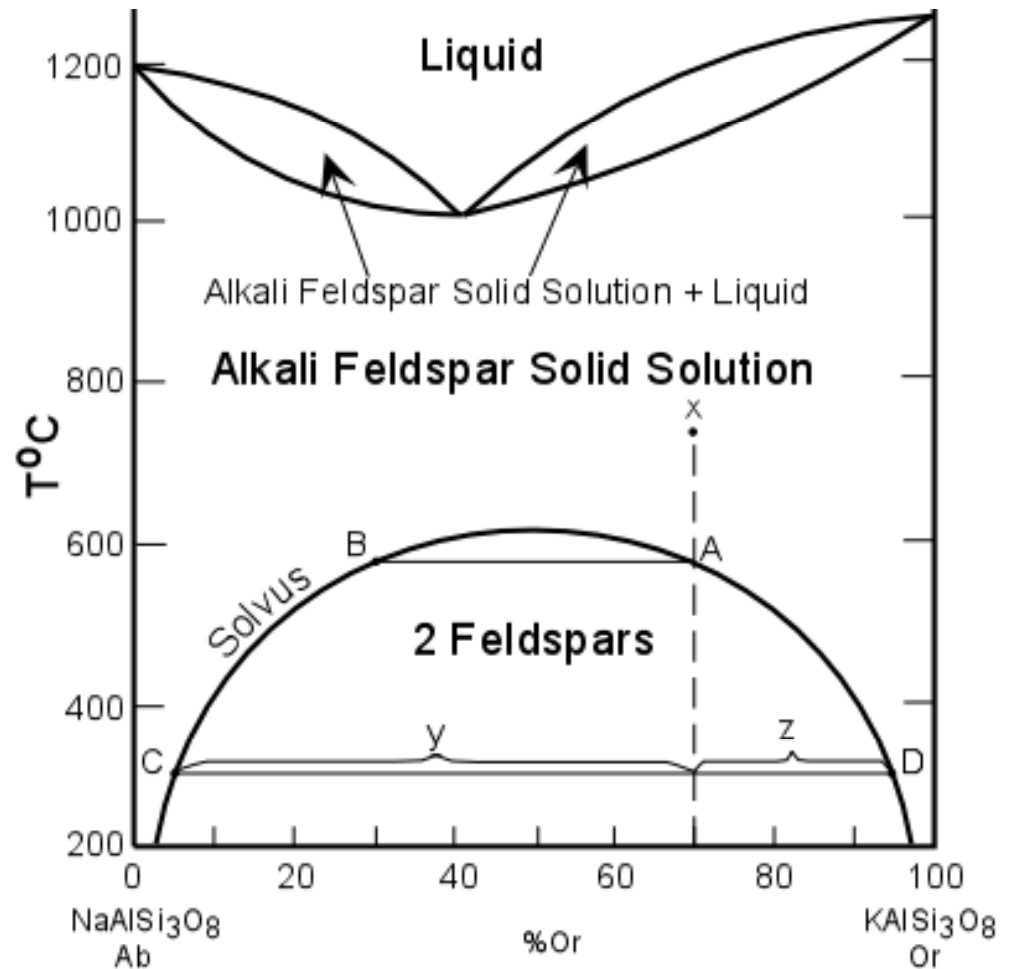
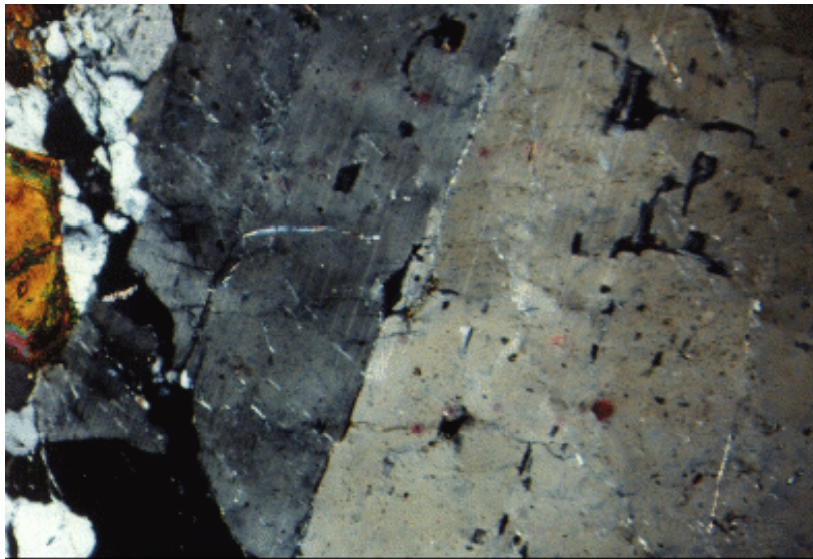


Figure 4

Fast vs Slow Cooling and Feldspar Composition

Fast cooling in the alkali feldspar system results in growth of a one phase feldspar. These feldspars are the “high” feldspars, with disordered structures.



Feldspars that grow in slow to very slow cooling systems, at low temperatures, separate into two phases: these are “low” feldspars, of albite + microcline compositions and have ordered structures.

The unmixed feldspars result in perthite (albite in orthoclase), or more rarely, antiperthite (orthoclase in albite).

Composition of Plagioclase

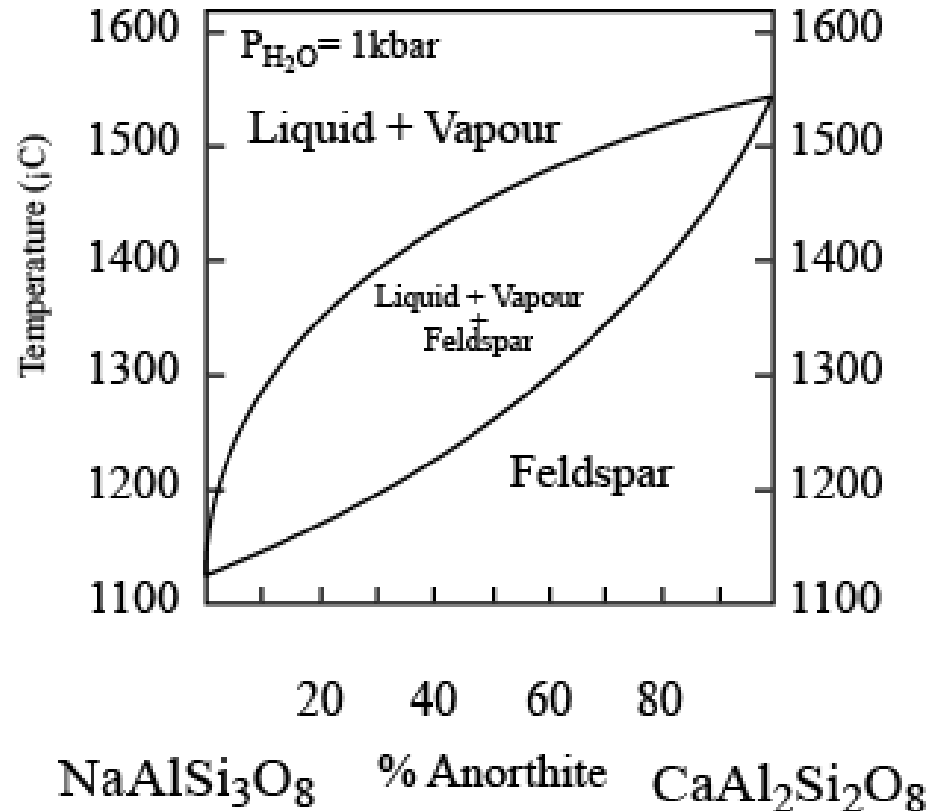
The plagioclase feldspars, consist of two end-members, $\text{NaAlSi}_3\text{O}_8$ – $\text{CaAl}_2\text{Si}_2\text{O}_8$. Complete solid solution occurs across the whole composition range.

The phase diagram, therefore, looks slightly different:

The Liquid Field

Liquid + Solid

Single Solid Phase



The consequence is that plagioclase feldspar may have a composition that lies anywhere along the solid solution.

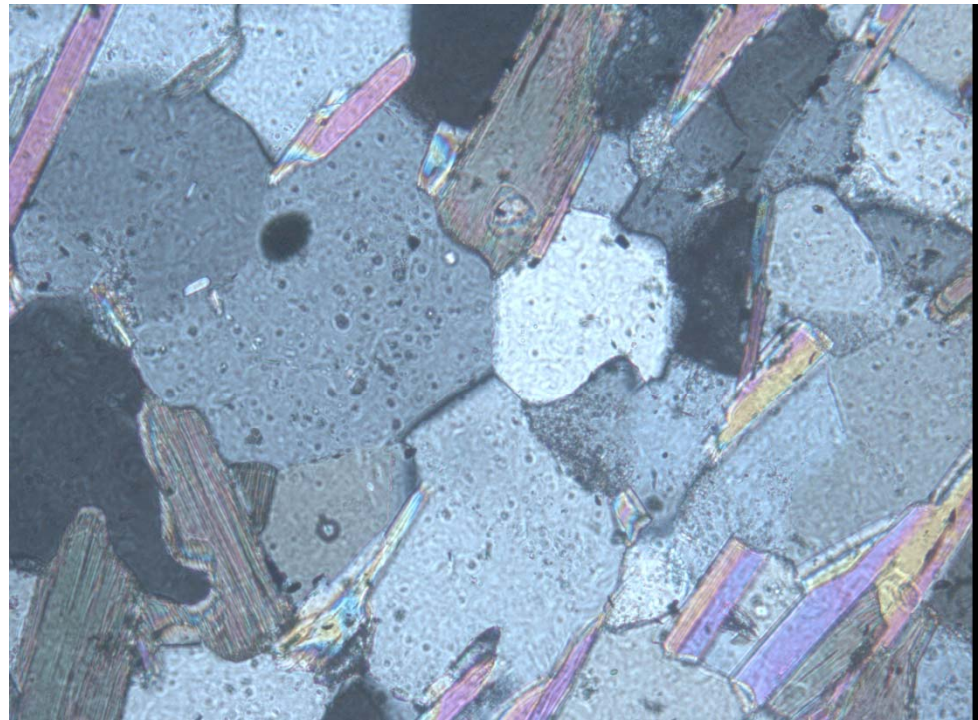
Identifying Feldspars

Both feldspar groups are biaxial (monoclinic to triclinic – high to low).

Feldspars have moderate to low relief, low birefringence (1st order greys), and may be optically +ve or –ve.

Crystals are often prismatic, but can elongate, particularly in high-strain rocks.

A poorly defined cleavage may also be seen in some grains.



Differentiating feldspars from quartz, in such examples is difficult.

Twinning

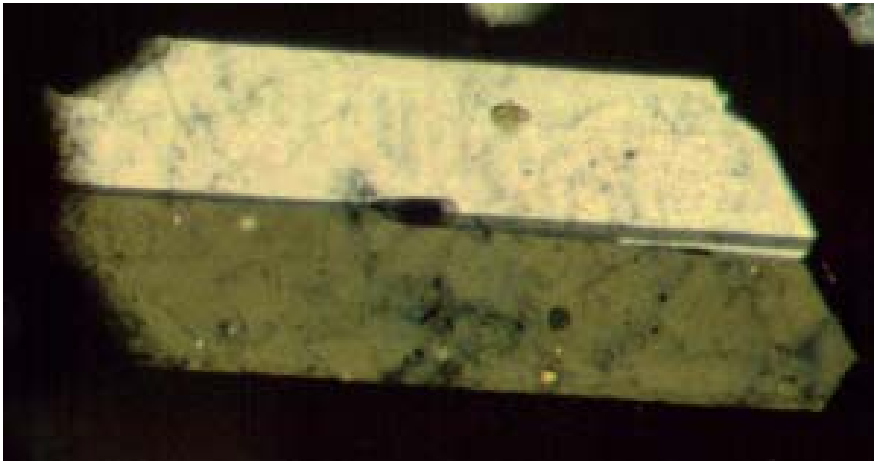
Twins result when different domains of a single crystal have different atomic orientations. The domains share atoms along a common surface.

They are observed in cross polarised light only.

Twins are NOT intergrowths – twin planes are continuous.

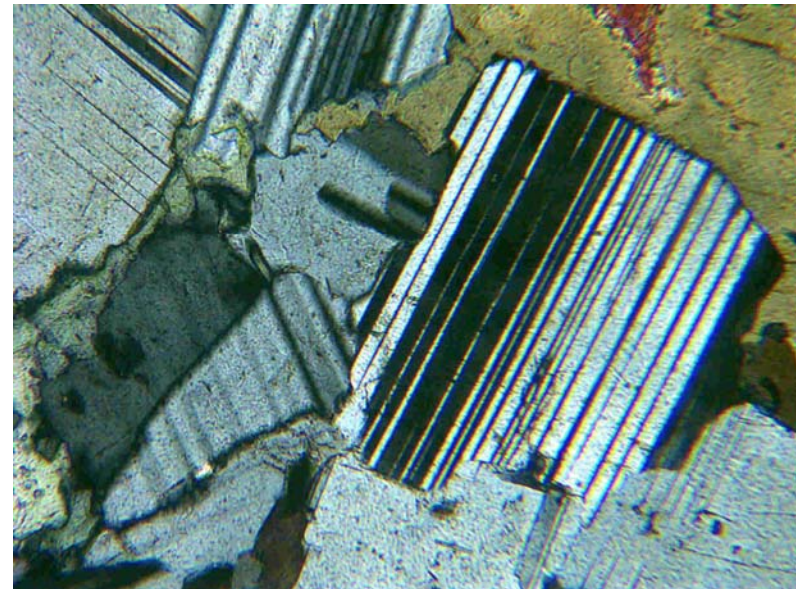
Simple Twins

2 domains with a
common plane of atoms.

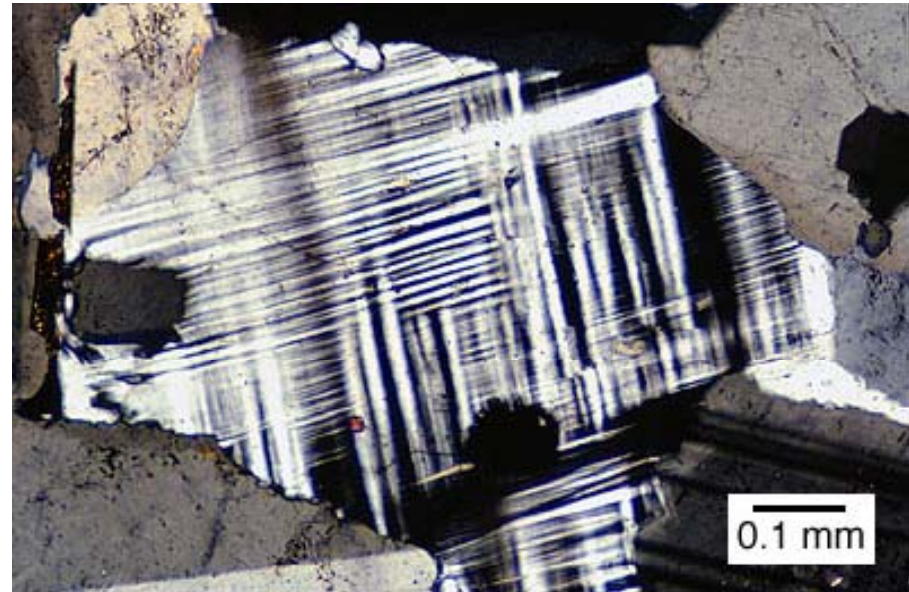


Complex Twins

>2 individual domains
(polysynthetic twinning)



A more complex polysynthetic twinning is observed in the triclinic forms of K-feldspar – so called “tartan twinning”.



The different types of twins observed in different minerals are known by their various twin laws.

K-Fsp contain simple twins related by Carlsbad, Baveno, albite or pericline laws, which are defined by orientation to crystallographic lattice.

Combining albite and pericline, results in tartan.

Twinning is not restricted to the feldspars. It is also seen in some pyroxenes, calcite, and the feldspathoids, leucite and nepheline.

Leucite and Nepheline

The feldspathoid group minerals are also anhydrous tectosilicates.

Chemically, they are similar to feldspars, but contain less SiO_2 . Subsequently they tend to form from melts rich in alkalis (Na and K), and poor in SiO_2 .

Leucite (KAlSi_2O_6) is tetragonal, with K^+ accommodated in large 12 coordinated cavities in the structure.

Nepheline ($(\text{Na,K})\text{AlSi}_3\text{O}_8$) is hexagonal.

While leucite is not particularly common, nepheline is found in many alkaline rocks. Care must be taken because its optical properties are similar to those of quartz – the one exception is that it is optically negative!

N.B. Neither mineral is ever found in the presence of quartz.