Tectosilicate minerals

SiO_2 group

Feldspar group

Feldspathoid group

Zeolite group

Tectosilicate

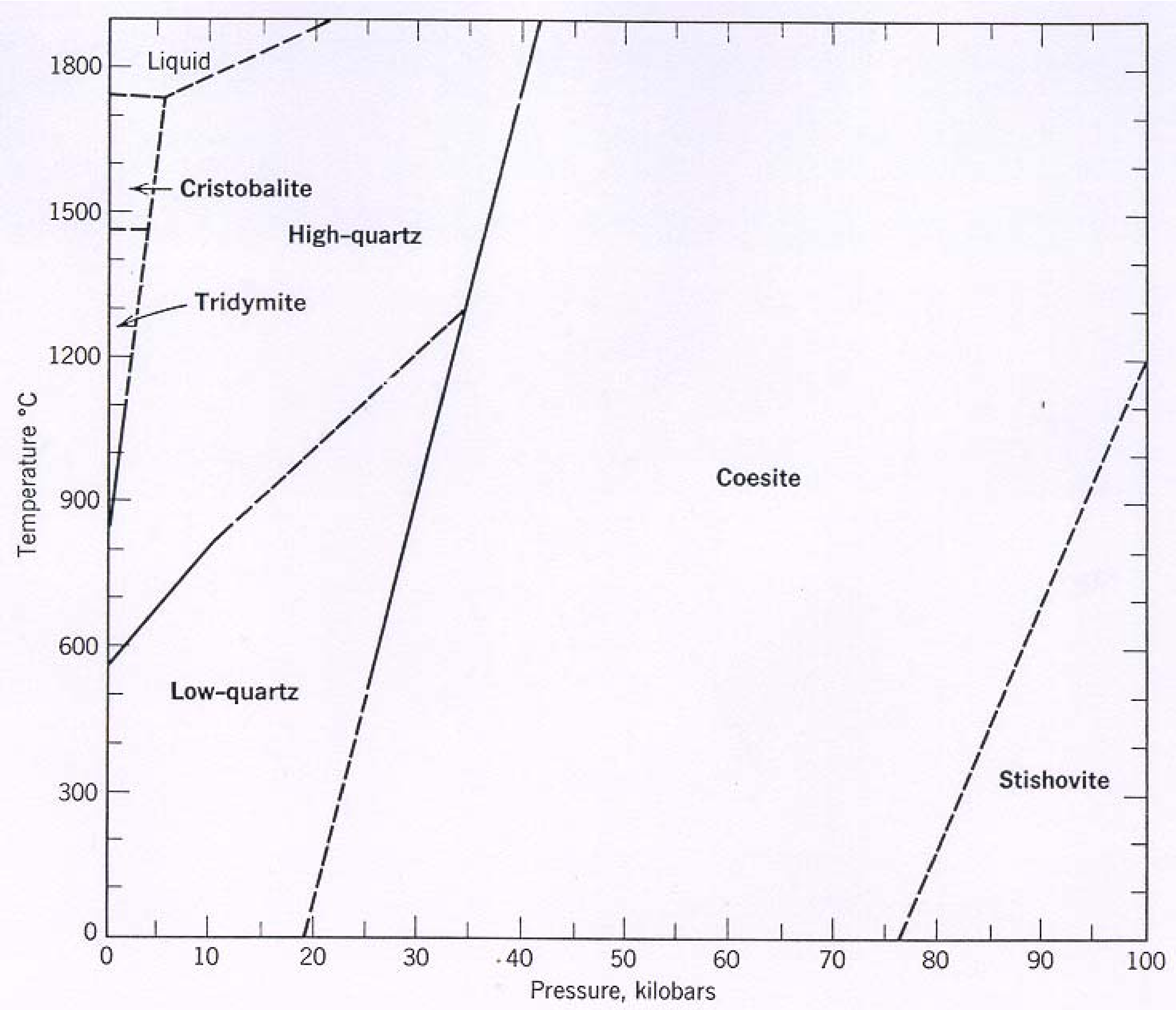
- Si:O ratio is 1:2; three-dimensional framework of SiO_2 tetrahedra linked togethe ➔ results in stable, strongly bonded structure
- ~ 64% of rocky crust is made of tectosilicate minerals

Name	Symmetry	Space Group	Specific Gravity	Refractive Index (Mean)
Stishovite*	Tetragonal	$P4_2/mnm$	4.35	1.81
Coesite	Monoclinic	$C2/c$	3.01	1.59
Low (α) quartz	Hexagonal	$P3_221$ (or $P3_121$)	2.65	1.55
High (β) quartz	Hexagonal	$P6_222$ (or $P6_422$)	2.53	1.54
Keatite (synth.)	Tetragonal	$P4_12_12$ (or $P4_32_12$)	2.50	1.52
Low (α) tridymite	Monoclinic or Orthorhombic	$C2/c$ (or Cc) $C222_1$	2.26	1.47
High (β) tridymite	Hexagonal	$P6_3/mmc$	2.22	1.47
Low (α) cristobalite	Tetragonal	$P4_12_12$ (or $P4_32_12$)	2.32	1.48
High (β) cristobalite	Isometric	$Fd3m$	2.20	1.48

*Only polymorph with Si in octahedral coordination with oxygen.

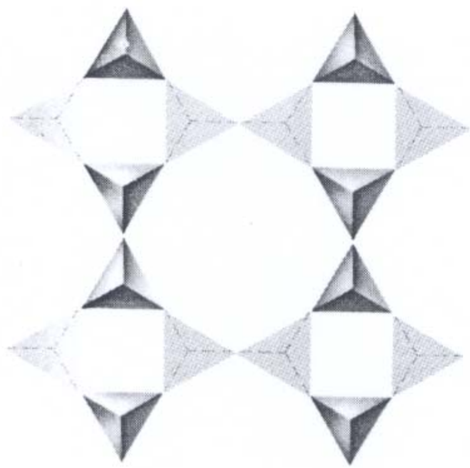
High *T* Polymorph	Minimum Crystallization *T* for Stable Form at 1 Atmosphere *P*	Inversion to Low *T* Form at 1 Atmosphere *P*
High cristobalite	1470°C	~268°C
High tridymite	870°C	~120°–140°C
High quartz	574°C	573°C

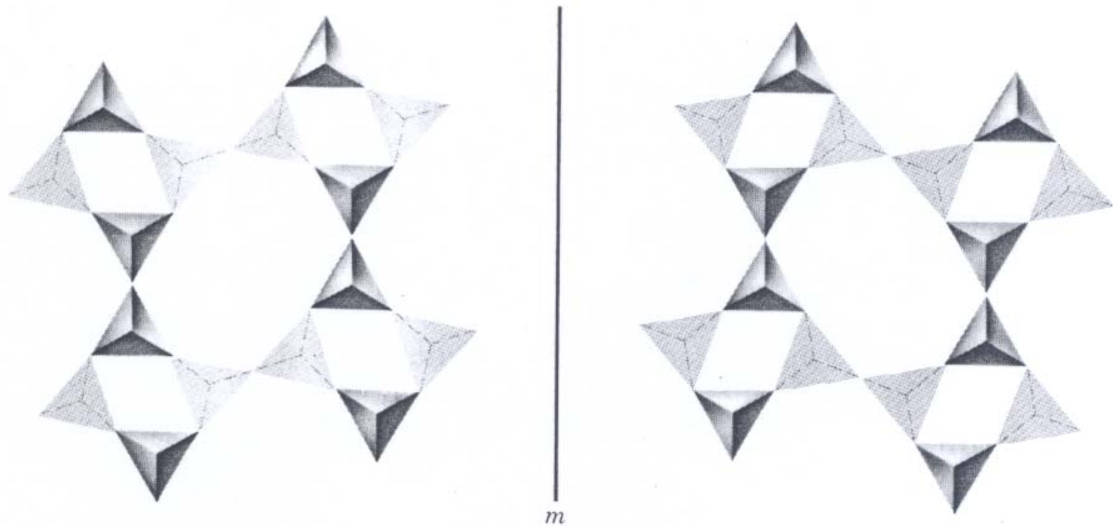
Stability relations of SiO_2 polymorphs

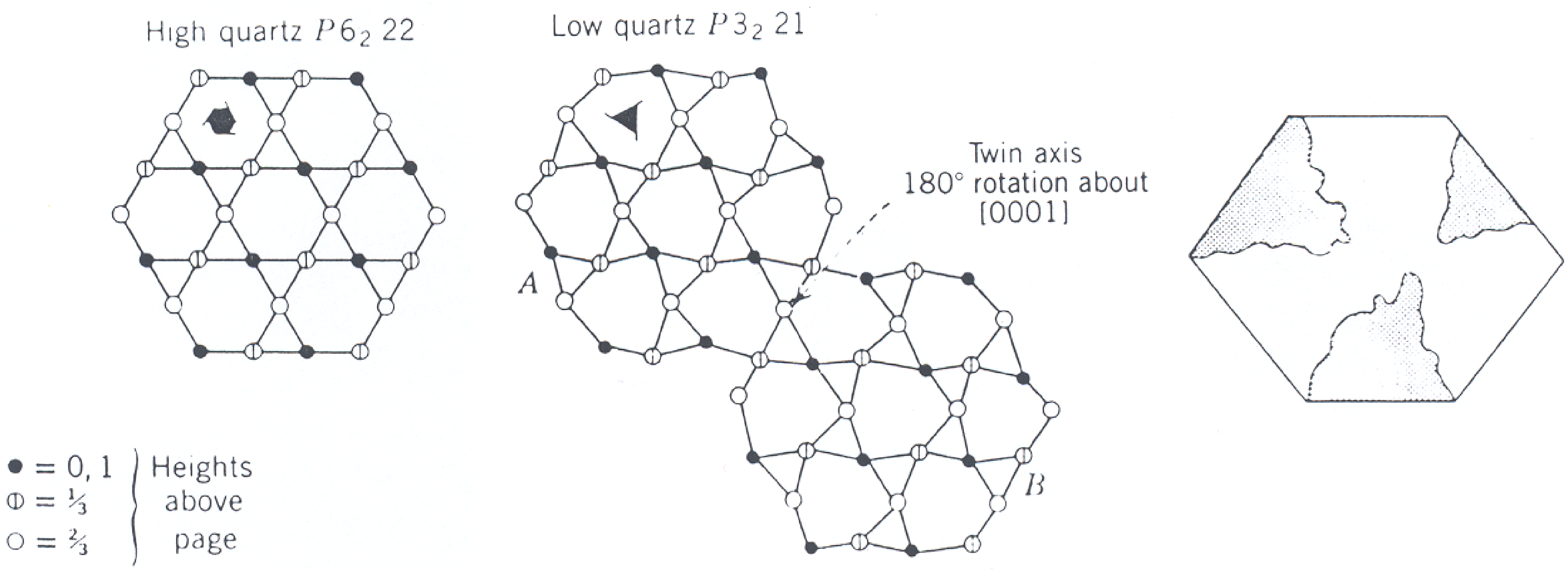


SiO_2 group

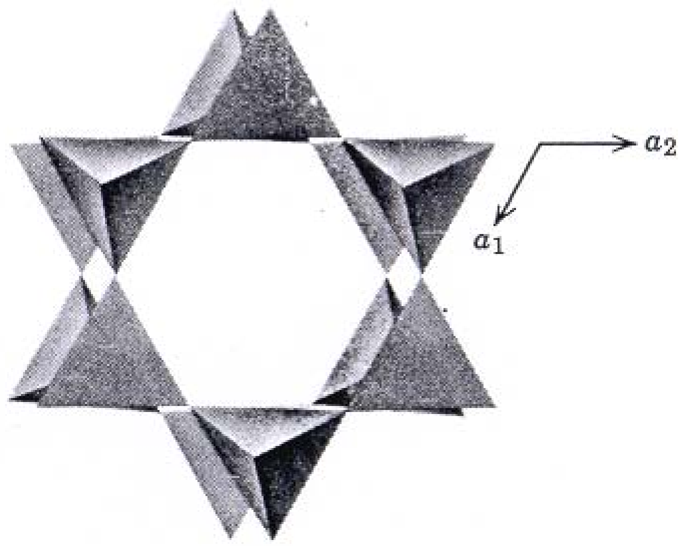
- At high T, infinitive network of SiO_2 tetrahedra ➔ relatively high symmetry, fairly open atmomic arrangement
- At low T, SiO_2 tetrahedra ➔ kinked arrangement, less symmetry, transform twin



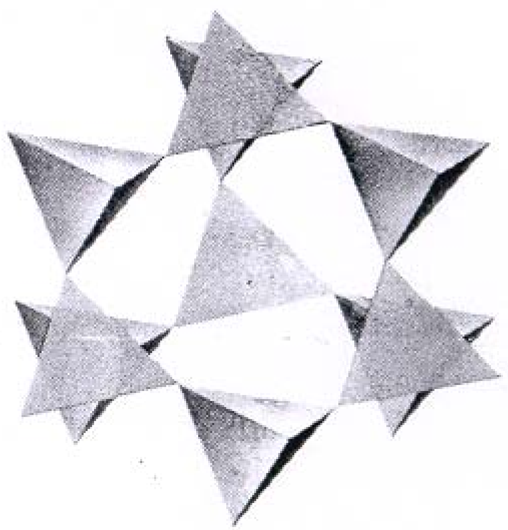




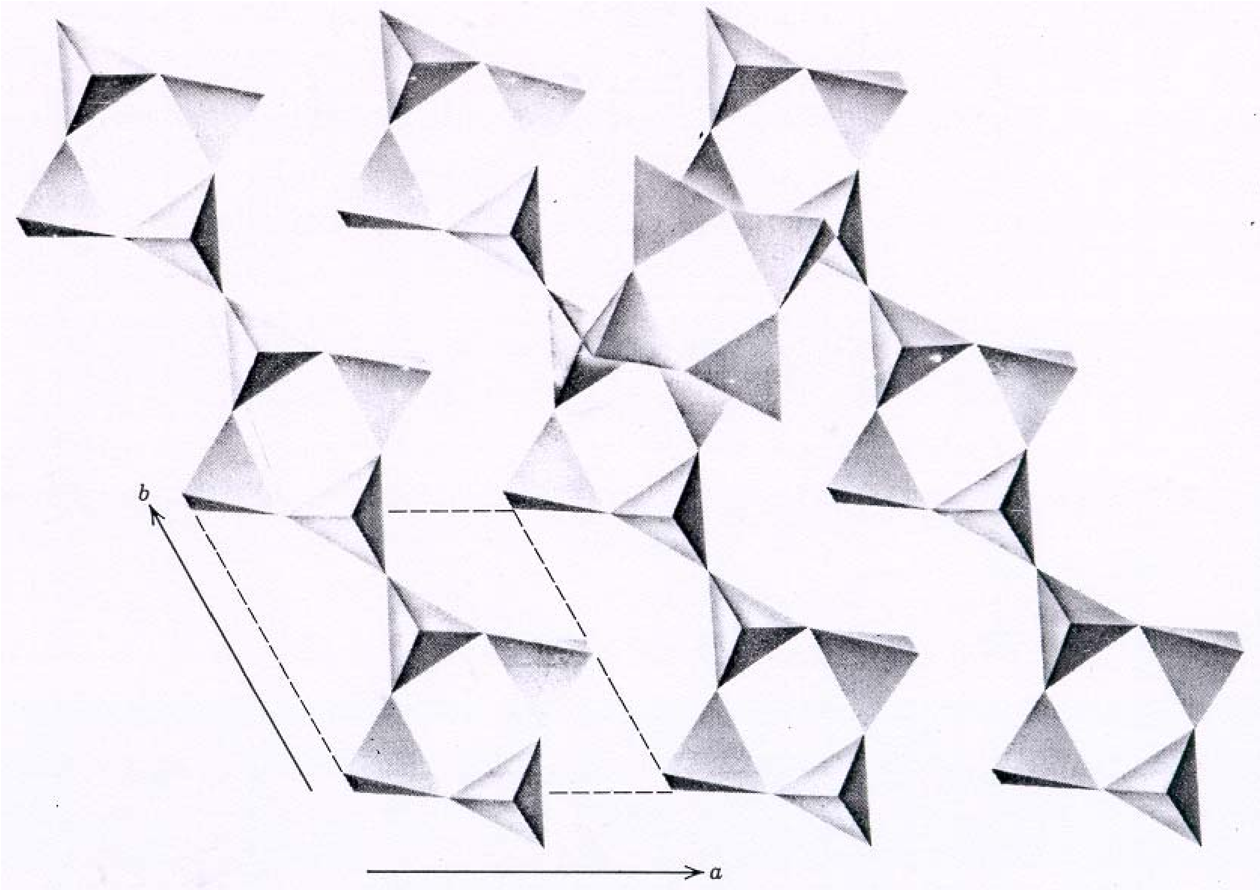
High quartz P6₂22
Low quartz P3₂21
Twin axis
180° rotation about
[0001]
A
B
● = 0, 1
⦶ = 1/3
○ = 2/3
Heights
above
page



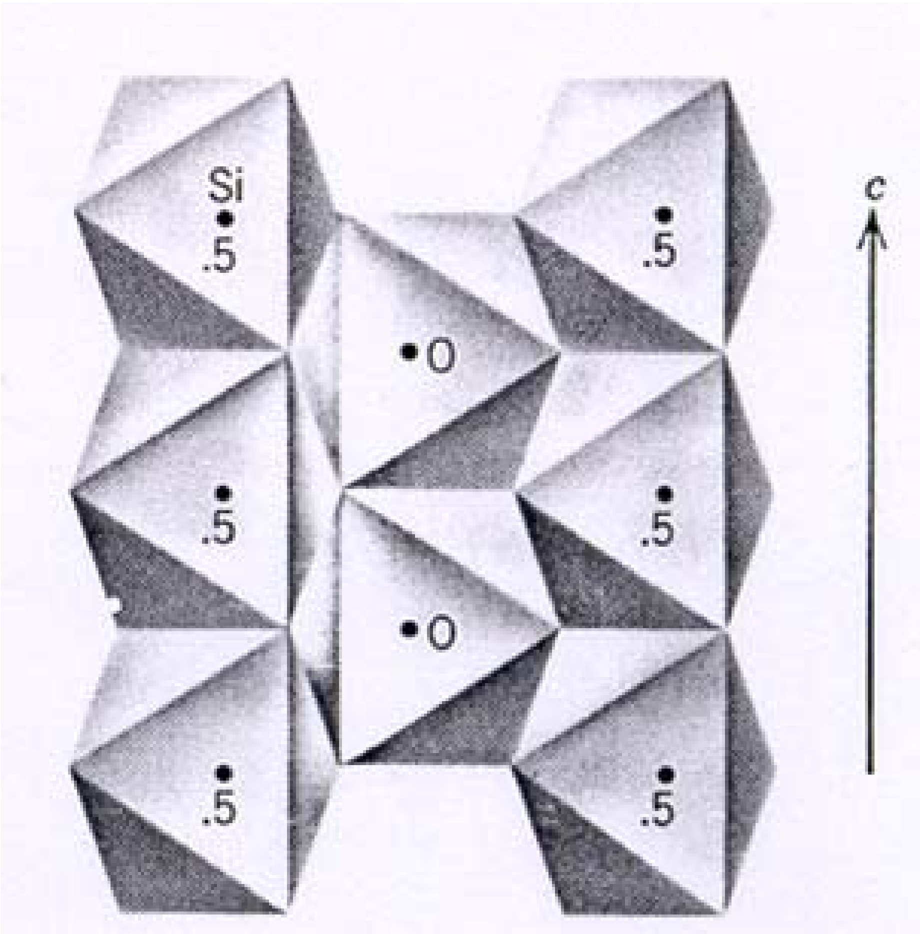
- Tetrahedral layers of high tridymite (look along c-axis)



- Portion of high cristobalite structure project on (111)



- Coesite structure showing 4-tetrahedral rings parallel to (001)



- Structure of stishovite with Si in octahedral coordination, project on (100)

Quartz

- Hexagonal, xtals commonly prismatic with prism faces and horizontal striated. Twins are common; Japan twin, Brazil twin, Dauphine twin.
- Conchoidal fracture, vitreous lustre with some specimens greasy or splendant. Usually, colourless or white but frequently coloured by impurities ➔ can be any colour
- Recognised by glassy lustre, conchoidal fracture & xtal form.
- Two main varieties
  - Coarsely crystalline varieties
  - Microcrystalline varieties

- Coarsely xtalline varieties
  - Rock crystal ➔ col.less, distinct xtal
  - Amethyst ➔ shades of violet, colour from iron as $[FeO_4]^{4-}$
  - Rose quartz ➔ rose-red to pink, small amount of Ti^{4+}give colour
  - Smoky quartz ➔ smoky yellow to brown or almost black, colour from Al^{3+} in $[AlO_4]^{4-}$
  - Citrine ➔ light yellow, small amount of Fe^{2+}-Fe^{3+}
  - Milky quartz ➔ milky white due to minute fluid inclusion
  - Rutilated quartz ➔ fine needles of rutile inclusion, can also be tourmaline,
  - Aventurine quartz ➔ brilliant scales of col-minerals like hematite, Cr-mica (fuchsite)

- Microcrystalline varieties; Fibrous vs Granular
  - Fibrous varieties
    - Chalcedony ➔ brouwn to grey, translucent, waxy, deposited from aqueous solution and found lining or filling cavities in rocks
      - Carnelian ➔ red that grades into brown sard
      - Chrysoprase ➔ apple green due to Ni-oxide
      - Agate ➔ alternating layers of chalcedony with different colour and porosity. Moss agate is mosslike pattern of Mn-oxide inclusion
      - Onyx ➔black & white agate
      - Sardonyx ➔ onyx with sard alternating
      - Bloodstone ➔ green chalcedony with red spots of jasper
      - Petrified wood, silicified wood ➔ SiO_2 replacement

- Granular varieties
  - Flint and chert ➔ dark, siliceous nodules
    - Flints are usually found in chalk
    - Cherts are lighter-coloured bedded deposits
  - Jasper ➔ red due to hematite, dull lustre
  - Prase (plasma) ➔ dull green similar to jasper and occur with it

- Qtz is common and abundant minerals occuring in diversity of environment. Present in Igneous & metamorphic rocks, major constituent of granite pegmatites. It is the most common gangue mineral in HD and metal-bearing veins.
- Flint & chert➔ qtz deposits on sea floor with enclosing rock or SiO_2 solution replaced limestone to form chert horizon
- Use widely as gemstones. Qtz sands is used in mortar, concrete, as a flux, abrasive and manufacture of glass and silica brick. In powdered form, it is used in porcelain, paints, sandpaper, scouring soaps and as a wood filler. In quartzite form, it is used as a building stone and paving purposes
- Qtz is also used in scientific instruments➔ qtz lenses & qtz prism, qtz wedge in polarizing microscope
- Qtz has piezoelectricity property thus using as oscillators in radios, watches and pressure gague

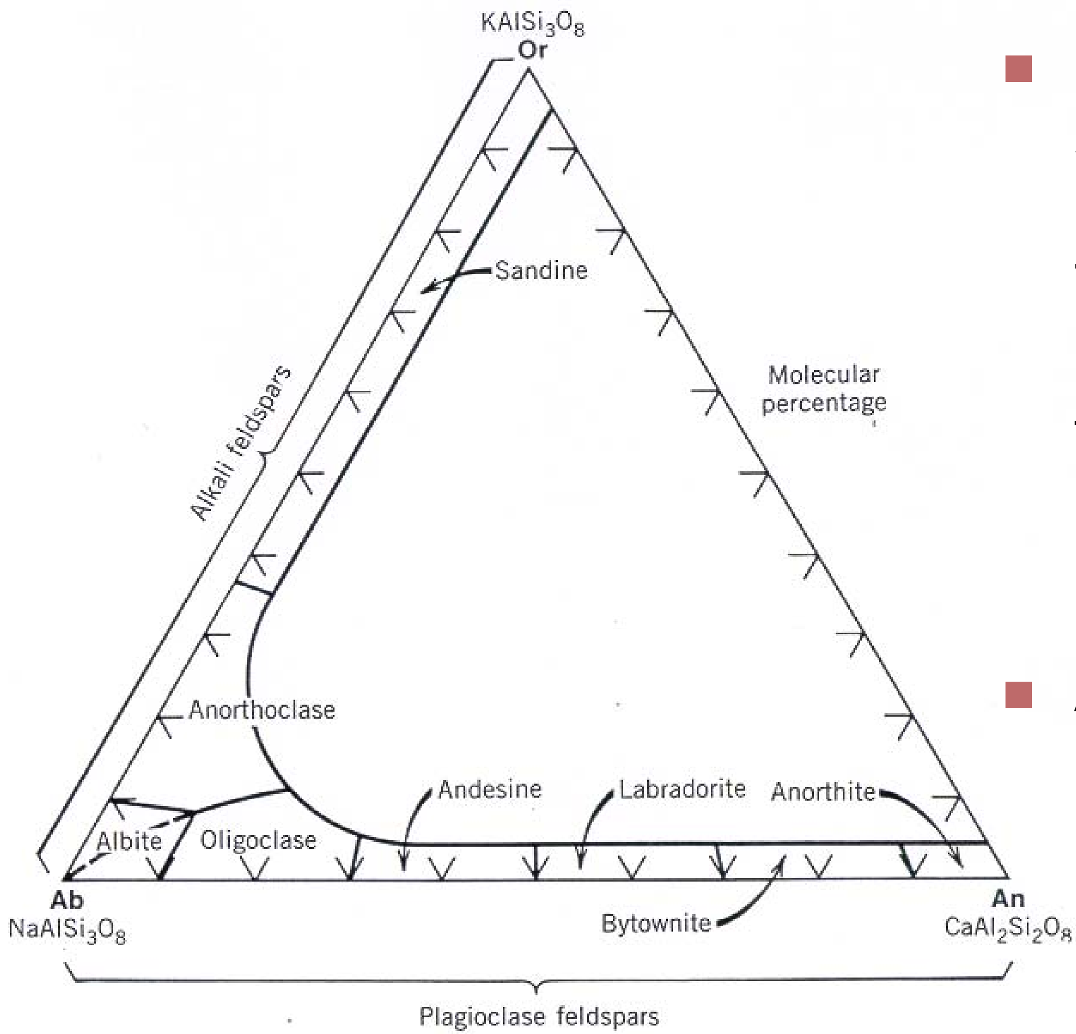
Tridymite: SiO_2

- Low tridymite is monoclinic/orthorhombic and high tridymite is hexagonal. Xtals are small, commonly twinned.
- Hardness 7, SG 2.26, Col.less to white, vitreous lustre, transparent – transluent
- Identified under microscope with xtal outlines and RI to distinguish it from other SiO_2 minerals
- Occurs commonly in siliceous volcanic rocks like rhyolite, obsidian and andesite. Commonly associated with sanidine and cristobalite and also found in stony meteorites and lunar basalts

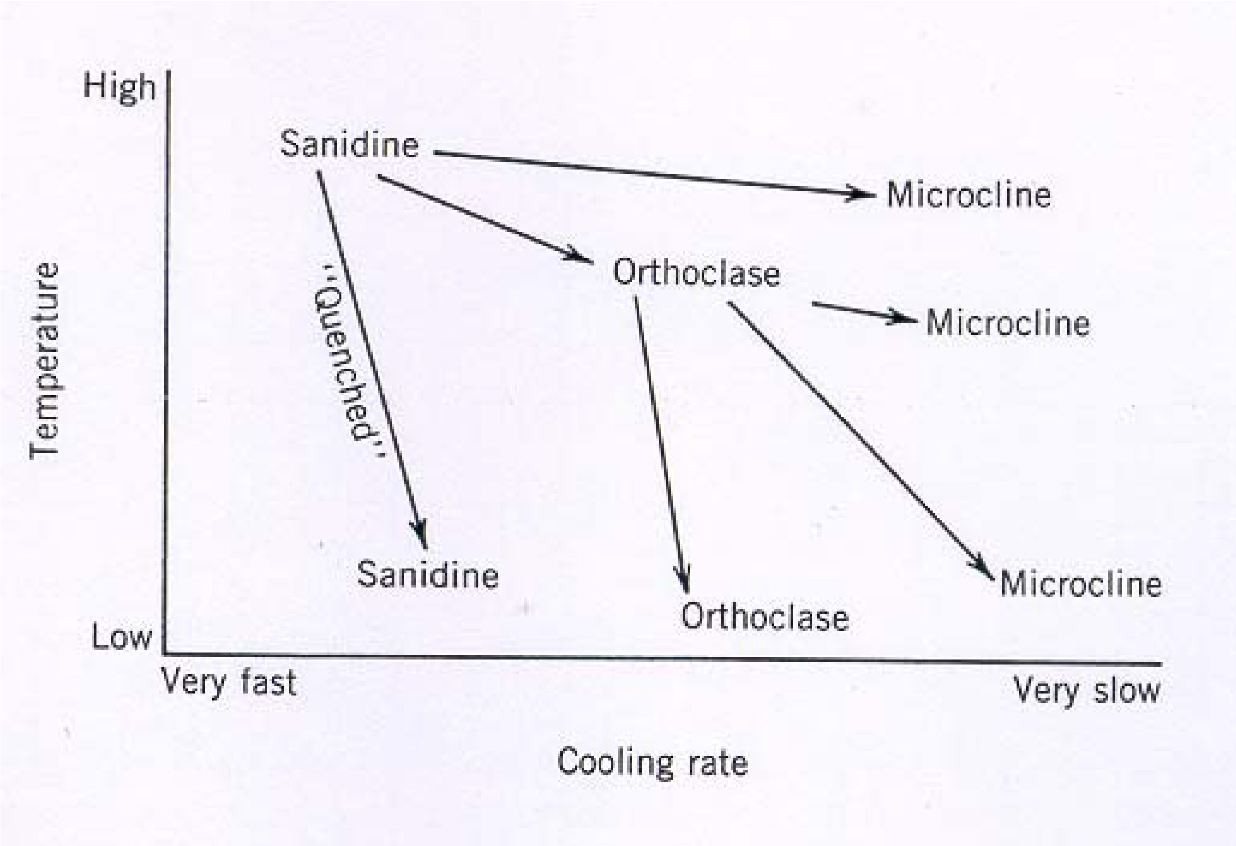
Cristobalite

- Low cristobalite is tetragonal and high cristobalite is isometric. Small octahedron xtals (retained on inversion from high to low cristobalite) and spherical aggregate.
- Hardness 6.5, SG 2.32, vitreous lustre, Col.less & transparent
- Recognised by spherical aggregate in lava cavities, but positive identified must be done under microscope.
- Occurs in many siliceous volcanic rock, both as lining cavities and fine-grained groundmass.

Feldspar group



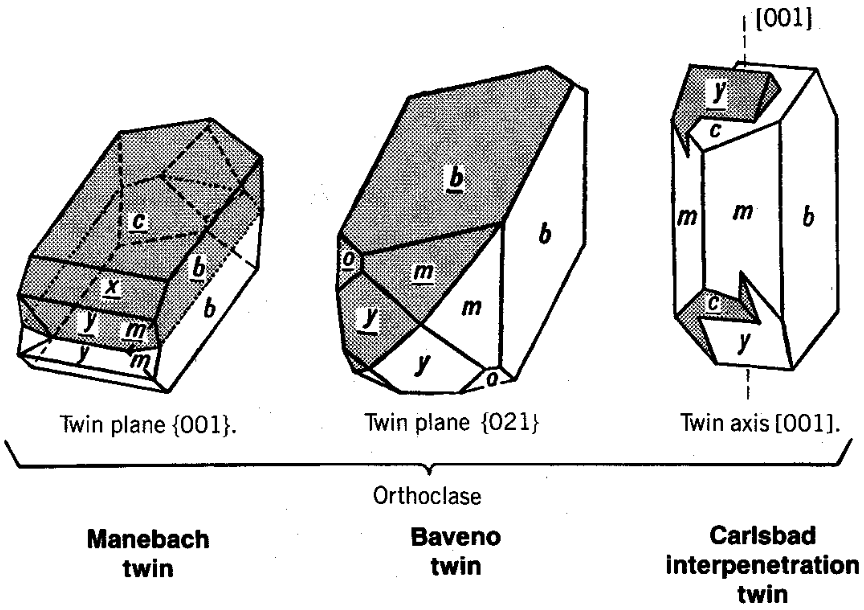
- Major compositions are in system $KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$. The series $KAlSi_3O_8$ – $NaAlSi_3O_8$ ➔ alkali feldspars and the series $NaAlSi_3O_8$ –$CaAl_2Si_2O_8$ ➔ plagioclase feldspars.
- All feldspars show good cleavages in 2-direction of nearly 90° to each other. Hardness 6, SG 2.55-2.76.



- Various cooling paths for potassium feldspar as a function of temperature and cooling rate

Microcline: $KAlSi_3O_8$

- Triclinic, habits & xtal forms similar to those of orthoclase. Microcline may be twinned as the twin laws in orthoclase (Carlsbad twins are common but Baveno & Manebach twins are rare). Combining albite & pericline twin gives a "tartan structure"



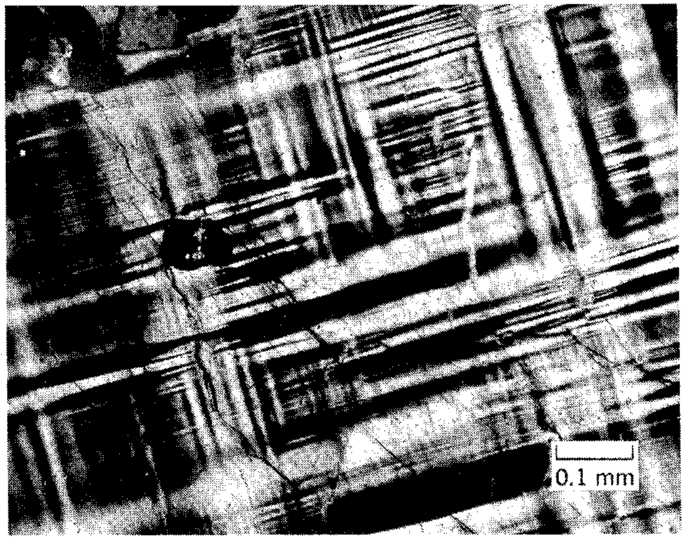
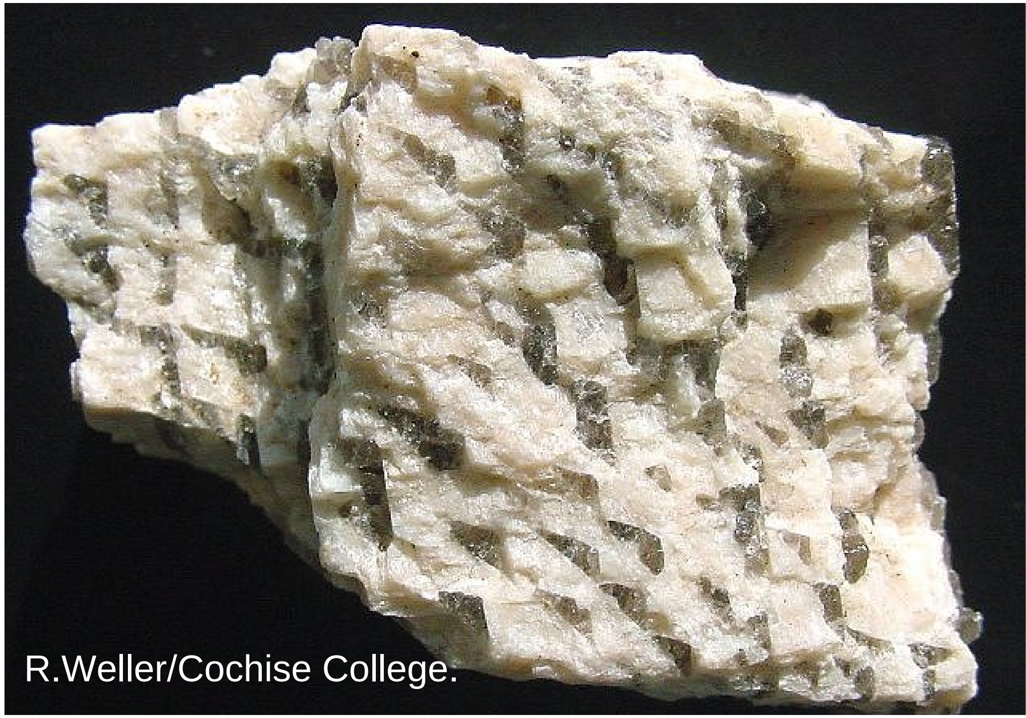


FIG. 2.114. Photomicrograph of transformation twinning (see p. 156) in microcline. The specimen is viewed under a microscope with crossed polarizers. The section of the photograph is approximately parallel to (001). The twin laws represented are albite with twin and composition plane (010), and pericline with twin axis direction [010].

- Microcline is found in cleavable masses, xtas and a rock constituent in irregular grains. Microcline in pegmatite may be intergrown with qtz forming graphic granite
- Microcline frequently has irregular and discontinuous bands crossing {001} and {010} result from albite exsolution ➔ Perthite or Microperthite (if fine)
- Hardness 6, SG 2.54-2.57, vitreous lustre, white to pale yellow and rarely red or green. Green microcline➔ Amazonite due to Pb substitution for K
- Occur as a prominent constituent of granites and syenites that cooled slowly and at considerable depth. In sedimentary rocks, microcline occurs in arkose and conglomerate. Metamorphic rocks, it occurs in gneisses.
- Use in porcelain and glass manufracture and as a gemstone

Graphic intergrowth (graphic granite)



Perthitic texture

Orthoclase : $KAlSi_3O_8$

- Monoclinic, short prismatic elongated // to *a* or *c* and flattened on {010}. Frequently twinned following laws; Carlsbad, Baveno and Manebach. Commonly xtals or coarsely cleavable to granular masses; rarely fine-grained, massive and cryptocrystalline.
- Hardness 6, SG 2.57, cleavage {001} perfect, {100} good, {110} imperfect, vitreous lustre, col.less or white, grey, flesh-red, rarely yellow to green.
- Orthoclase is a major constituent of granite, granodiorite and syenites, which cooled at moderate depth and quite fast rates.

Sanidine: $(K,Na)AlSi_3O_8$

- Monoclinic, xtals are tabular // to {010}; also elongated on *a* with square cross section, Carlsbad twins common
- Cleavage {001} perfect and {010} good, hardness 5, SG 2.56-2.62, vitreous lustre, col.less and commonly transparent
- Occur as phenocrysts in extrusive igneous rocks like rhyolites and trachytes. Sanidine is characteristic of rocks that cooled quickly from initial high T of eruption. Most sanidines are cryptoperthitic.

Albite: $NaAlSi_3O_8$ – Anorthite: $CaAl_2Si_2O_8$

- Triclinic, xtals are tabular // to {010}; occasionally elongated on *b.* In anorthite, xtals may be prismatic elongated to *c*. Frequently twinned on Carlsbad, Baveno and Manebach twin laws and nearly always twinned on pericline law.
- Albite twinning ({010} twin plane) is commonly polysynthetic thus angle between (010) & (001) ~86°, {001} either xtal face or cleavage is crossed by parallel grooving or striations ➔ best proof that a feldspar is of plagioclase series.
- Cleavage {001} perfect and {010} good, hardness 6, SG 2.62-2.76, vitreous-pearly lustre, col.less-white-grey less frequent greenish or yellowish or flesh-red, transparent – translucent, frequently seen play of col. in labradorite – andesine.

- Recognised by albite twin striation {001}
- Plagioclase feldspars are widely distributed and more abundant than potash feldspars, found in igneous and metamorphic rocks but rarely in sed.rocks.
  - Albite: included with orthoclase-microcline ➔ alkali feldspar. Commonly found in granites, syenites, rhyolites and trachytes. Albite is common in pegmatites by replacing earlier microcline. Some albite-oligoclase shows opalescent play of colour ➔ moonstone.
  - Oligoclase: characteristic of granodiorite and monzonite. Oligoclase may contain hematite giving a golden shimmer & sparkle appearance➔ Aventurine feldspar or sunstone
  - Andesine: rarely found except in andesites and diorites
  - Labradorite: common feldspar in gabbros – basalts and it is only important constituent in anorthosites. Labradorescence!
  - Bytownite: rarely found except as grains in gabbrous
  - Anorthite: rarer than more sodic plagioclase. Found in mafic rocks and in druses of ejected volcanic blocks and in contact metamorphic of granular limestones