PART 5
FRAMEWORK SILICATES


Quartz

FRAMEWORK SILICATES = TECTOSILICATES

- "tecto" = framework
- 2/3 of the Earth's crust
- Important tectosilicates:
  - Quartz
  - Plagioclase
  - Sodalite
  - Leucite
  - Scapolite
  - Alkali feldspar
  - Nepheline
  - Alkali feldspar
  - Leucite
  - Scapolite

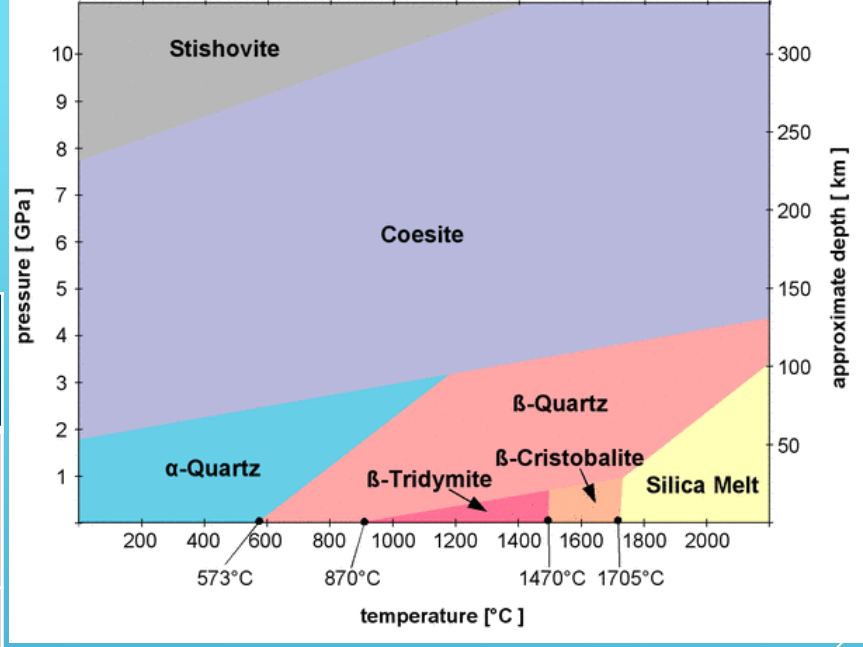
FRAMEWORK SILICATES = TECTOSILICATES

- **All the O in the TO_4 tetrahedra is shared with other tetrahedra: ratio Si:O = 1:2**
- Si - O bonds: strong covalent bonds + interlocked structure ⇒ **high hardness.**
- **BUT, repulsion of cations in TO_4 ⇒ open structures:**
  - **Can accommodate large cations (Ca^{2+}, K^{+}, Na^{+}) ⇐ substitution of Si for Al in the TO_4**
  - **Density significantly lower than minerals with anions arrangement in close-packing**
    Ex: Quartz (2,65) vs Forsterite (3.27) while Z(Si) = 28.09 and Z(Mg)=24.31

SiO_2 MINERALS

- **9 polymoprhs**

Name	Crystal System	Density (g/cm^3)	Comment
Stishovite	Tetragonal	4.35	High pressure
Coesite	Monoclinic	3.01	
Low (α) quartz	Hexagonal	2.65	Low pressure from low to high temperature * high to low transformations: displacive ⇒ do not exist on Earth'surface
High (β) quartz	Hexagonal	2.53	
Kaetite (synthetic)	Tetragonal	2.50	
Low (α) Tridymite	Mon. or orth	2.26	
High (β) tridymite	Hexagonal	2.22	
Low (α) cristobalite	Tetragonal	2.32	
High (β) cristobalite	Isometric	2.20	



SIO_2 MINERALS

- **Quartz**
  - Crystals from microscopic to several tons
  - Euhedral (in cavities), anhedral (ex.: in granite), microcrystalline masses (chert) or as fibrous masses (chalcedony)
  - **Where?** - One of the most common minerals
    - siliceous igneous rocks (rhyolite, granite)
    - metamorphic rocks – all grades – main constituent of sand
    - varieties of sedimentary rock because highly resistant to weathering
  - **Varieties:** - rock crystal (clear, in open cavities)
    - Amethyst (violet – due to trace of iron)
    - Rose quartz (due to traces of Ti)
    - Smokey quartz (dark – traces of Al)
    - Citrine (yellow)
    - Milky quartz (white – due to fluid inclusions – in pegmatite and hydrothermal veins)
    - Chalcedony (fibrous)

SIO_2 MINERALS

- **Quartz**

SiO_2 MINERALS

- **Trydinite**
  - High temperature polymorph
  - **Where?** - Igneous rocks that cooled rapidly: rhyolite, associated with cristobalite and sanidine

- **Cristobalite**
  - High temperature polymorph
  - **Where?** - Igneous rocks that cooled rapidly: rhyolite, associated with trydinite and sanidine
    - Thermally metamorphosed sandstones

- **Opal**
  - amorphous: $SiO_2 \cdot nH_2O$
  - Crystallize at low temperature – in fracture or faults of many different rocks

FELDSPARS

- **Most common mineral in Earth's crust**
- **3 end-members:**

Orthoclase (or)	Albite (ab)	Anorthite (an)
$KAlSi_3O_8$	$NaAlSi_3O_8$	$CaAl_2Si_2O_8$

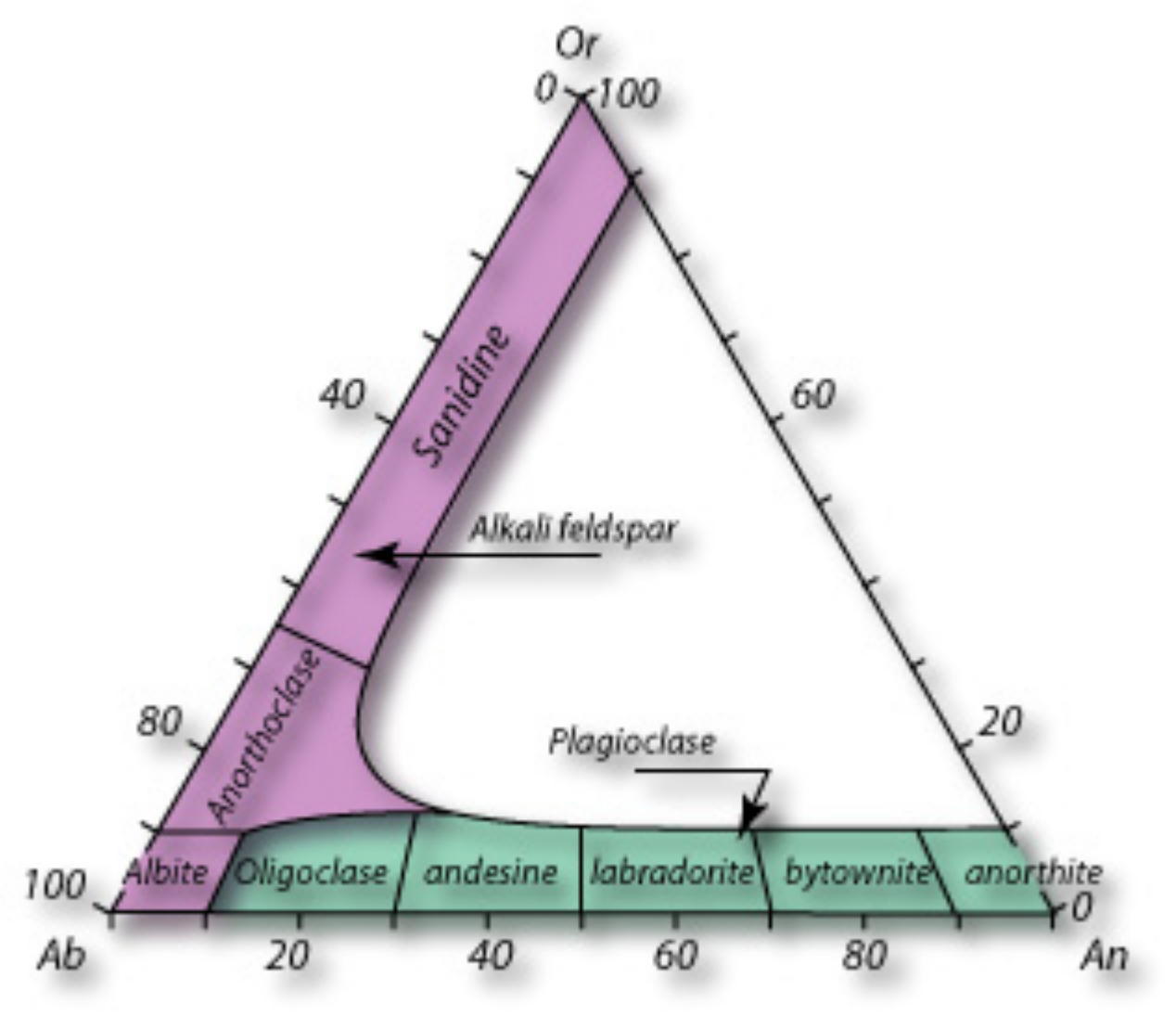
Alkali Feldspars solid solution

- ¼ of Si^{4+} replaced by Al^{3+}
- Accommodation of K^+ or Na^+

Plagioclase Feldspars solid solution

- ¼ to ½ of Si^{4+} replaced by Al^{3+}
- Accommodation of Na^+ or Ca^{2+}

FELDSPARS

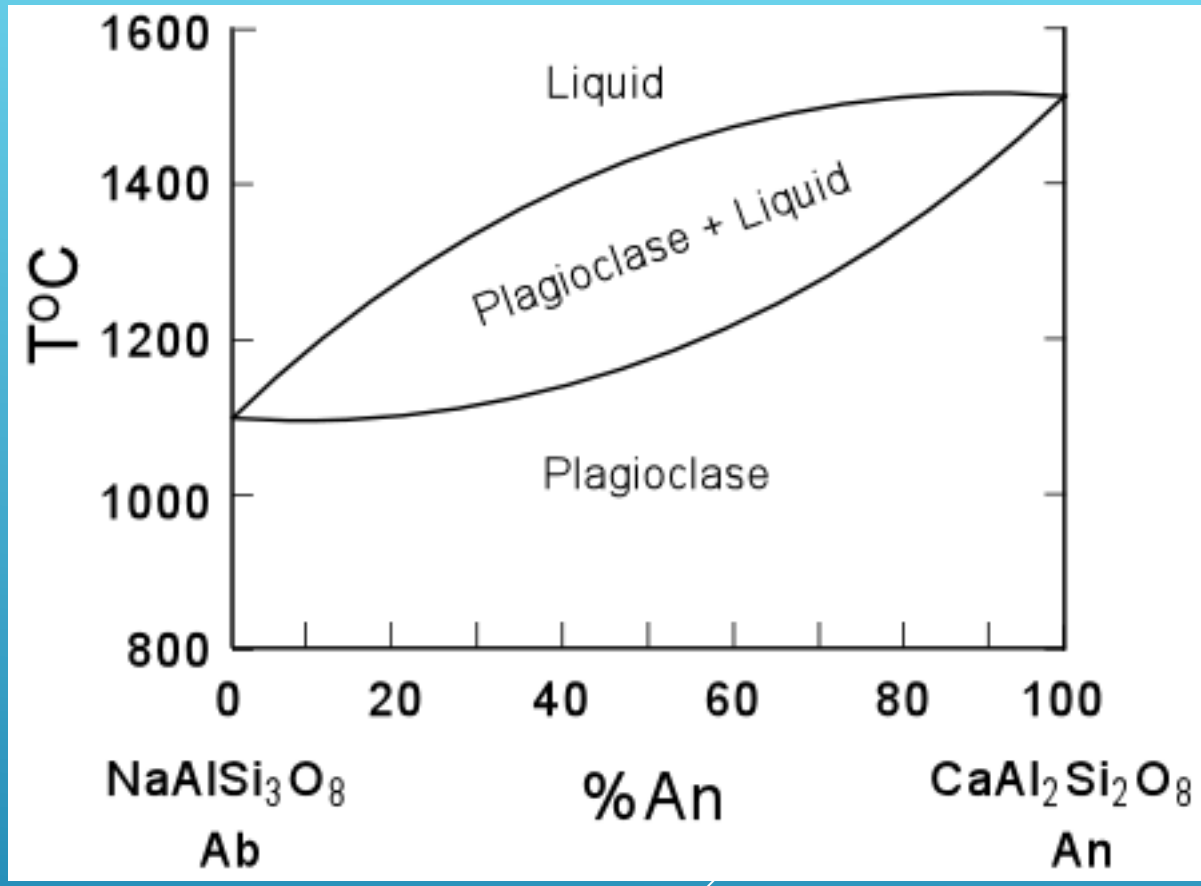


- **Alkali feldspar solid-solution: < 5% an component**
- **Plagioclase solid-solution: < 5% or component**

FELDSPARS

- **Plagioclase $(Ca, Na)(Al,Si)_4O_8$**
  - **Most common feldspar**
  - **Forms by the crystallisation of a magma**
  - **Solid-solution with coupled substitution $Na^{+}+Si^{4+} \leftrightarrow Ca^{2+}+Al^{3+}$**
  - **Where?**
    - in basalts, andesites, dacites, rhyolites, gabbros, diorites, granodiorites, and granites: with albite twinning.
    - in metamorphic rock: no twin
    - not common in clastic sedimentary rock (less stable than alkali feldspar)

Identification with hand specimen: white colored and shows perfect {100} and good {010} cleavage. Can show zoning and twins



- **Zoning =** incomplete reaction of crystals with liquid during cooling of a solid solution

FELDSPARS

- **Alkali feldspar $(K, Na)AlSi_3O_8$**
  - **Sanidine (HT) vs. orthoclase (MD), microcline (LT): order-disorder transformations**

Volcanic rock Plutonic & metam. rocks (+ exsolution lamellae if cooling very slow)

- **Sanidine**
  - **Habit: Equant**
  - **Perfect (001) and (010) cleavages**
- **Orthoclase**
  - in granitic rocks and K - Al rich metamorphic rocks.
  - **Perfect (001) and (010) cleavages**

FELDSPARS

- **Microcline**
  - combination of albite twinning and pericline twinning ⇒ cross-hatched pattern (thin section)

- **Anorthoclase**
  - **Na-rich feldspar with equivalent amounts of an and or.**
  - **In Na-rich volcanic rock**
  - **Perfect (001) and (010) cleavages**
  - **Habit: tabular, elongated**

FELDSPATOIDS

- Similar structure and physical properties than feldspars
- Common feldspatoids: nepheline, leucite, sodalite group
- Smaller Si/(Na+K) ratio ⇒ never found with quartz
- In alkali-rich and silica-poor igneous rocks (not common)

FELDSPATOIDS

- **Nepheline $(Na,K)AlSiO_4$**
- **Where?** In both volcanic and plutonic alkali-rich igneous rocks
  Ex: nepheline syenite, foidite, phonolite
- **Associated minerals:** K-feldspar, Na-rich feldspar, biotite, sodic and sodic calcic amphibole and/or pyroxene
- **Identification: -** hard to distinguish from feldspars in hand specimen – yellowish color alteration
  - much easier in this section because hexagonal ⇔ uniaxial (while feldspar are biaxial)

FELDSPATOIDS

- **Sodalite $3NaAlSiO_4.NaCl$**
- **Where? -** Mostly in plutonic alkali-rich igneous rocks - Ex: syenite
  - in contact metamorphosed carbonate rocks – Ex: lapis lazuli
- **Associated minerals:** K-feldspar, Na-rich feldspar, biotite, sodic and sodic calcic amphibole and/or pyroxene
- **Identification: -** vitreous, often light to dark blue

- **Leucite $KAlSi_2O_6$**
- **Where? -** Mostly in potassium-rich volcanic rocks
- **Associated minerals:** plagioclase, nepheline, sanidine, cpx, sodic or sodic-calcic amphiboles
- **Identification: -** inclusion of other minerals are common
  - multiple twins