Biaxial Minerals Descriptions

- Olivine
- Pyroxenes
  - Orthopyroxene
  - Clinopyroxene
- Amphibole
  - Hornblende
  - Actinolite
- Micas
  - Biotite, muscovite, chlorite
- **Feldspars**
  - **Plagioclase**
  - **Microcline, orthoclase, sanidine**

Feldspars

Tectosilicates - Si:O = 1:2

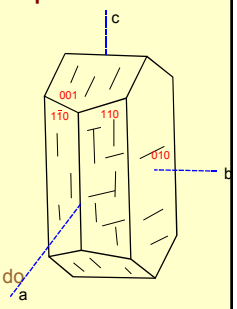
- Most abundant group of minerals. Found in igneous, metamorphic and sedimentary rocks
- Two groups of feldspar:

1. Alkali Feldspars
   - orthoclase]
   - microcline] $KAlSi_3O_8$
   - sanidine]
   - Each of these polymorphs are stable at different temperatures.
2. Plagioclase Feldspar - variable compositions
   - $NaAlSi_3O_8$ - $CaAl_2Si_2O_8$ - NiSi = CaAl
   - Albite Anorthite
   - General Formula $(Na,Ca)Al(Al,Si)Si_2O_8$

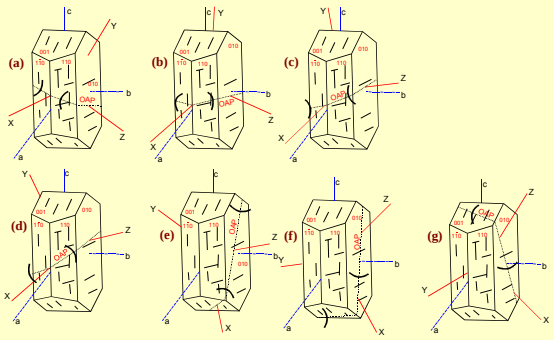
Plagioclase Feldspars

- Mixture of Albite (Na-rich) and Anorthite (Ca-rich).

	% Ab	% An
Albite	100 - 90	0 - 10
Oligoclase	90 - 70	10 - 30
Andesine	50 - 70	30 - 50
Labradorite	30 - 50	50 - 70
Bytownite	10 - 30	70 - 90
Anorthite	0 - 10	90 -100



- All are triclinic, with low symmetry, indicatrix and crystallographic axes do not coincide



Variations in the optic orientation of the plagioclase feldspars with composition: (a) high-albite, (b) low-albite, (c) oligoclase, (d) andesine, (e) labradortie, (f) bytownite, (g) anorthite. Note how the position of the optic axial plane moves with increasing An content.

Plagioclase

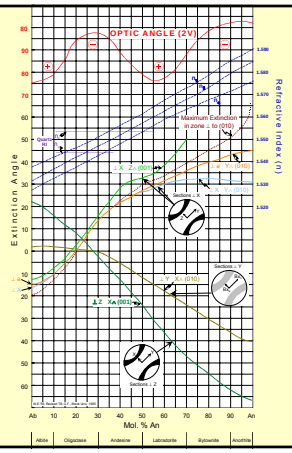
R.I.

	Ab	An
n_α	1.527	1.577
n_β	1.531	1.585
n_γ	1.534	1.590

- variation with composition (figure 15.6, p. 262)

- Low relief
- Low birefringence - maximum 1st order grey or white
- $2V_X$ angle varies from 45 to 102°, +ve or -ve with varying composition

- Colourless in thin section; non pleochroic may be cloudy in plane light due to alteration to sericite.



Plagioclase

- Physical and optical properties vary with composition

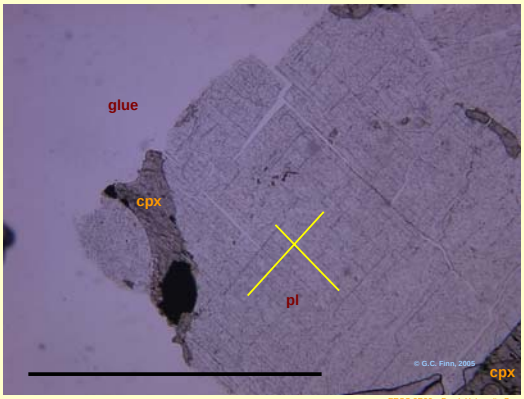
- Composition of Plagioclase can be determined to within < 5% An by measuring extinction angles which reflect variations in the optical properties due to variations in composition.

Plagioclase

Cleavage

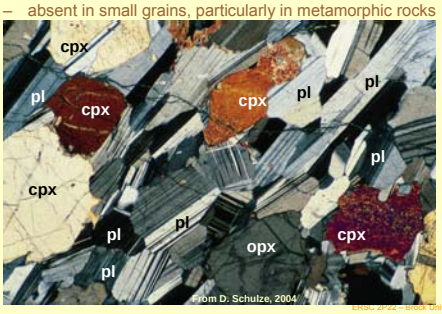
- 1 perfect cleavage ‖ to 001
- 1 good cleavage ‖ to 010
- intersect at 93 - 94°

- cleavages control fragment shape and orientation
- Plagioclase cleavage is best visible with the aperture diaphragm stopped down to emphasize the little relief present.



Plagioclase

- **Twinning is characteristic of plagioclase**.
  - absent in small grains, particularly in metamorphic rocks

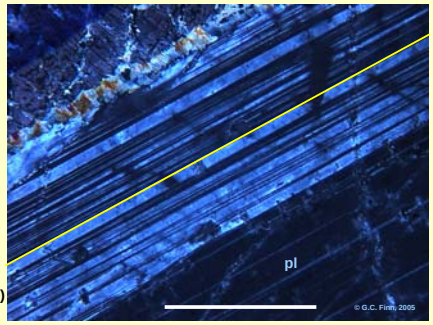


Plagioclase

- Twins are based on various twin laws
- Common twin laws are:
  1. **Albite**
     - 010 composition plane, polysynthetic or repeated twinning (these are the twins visible as striations in a hand sample of plagioclase)
  2. **Pericline**
     - h01 composition plane, polysynthetic, twofold rotation about b axis,
  3. **Carlsbad**
     - 010 composition plane, penetration twin, twofold rotation about c axis
- Albite twinning observed in all compositions, pericline and Carlsbad in intermediate and calcic plagioclase (An-rich).

Polysynthetic Twin

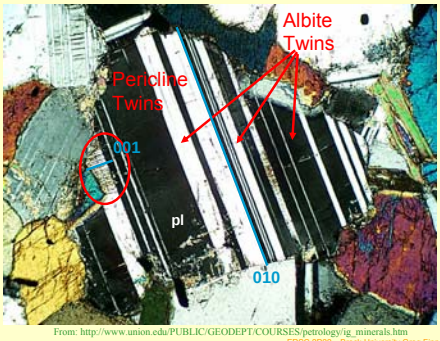
Consists of numerous twin segments joined on parallel twin planes



Albite Twin Plane (010 plane)

Polysynthetic Twin

Consists of numerous twin segments joined on parallel twin planes

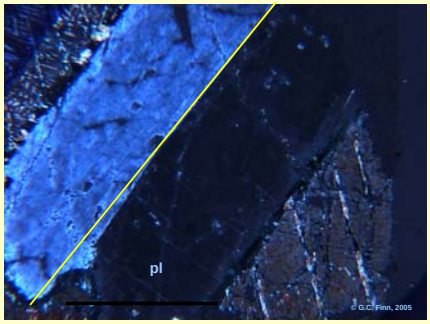


From: http://www.union.edu/PUBLIC/GEODEPT/COURSES/petrology/ig_minerals.htm

Contact Twins

Joined by a smooth twin plane separating the segments

Carlsbad-albite Twin Plane

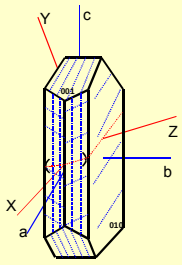


Plagioclase

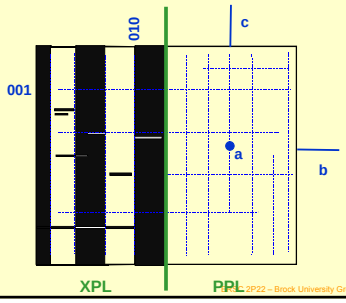
100 section, ⊥ to a axis

In PPL - 2 cleavages not at 90°

In XPL - albite and pericline twins



Crystallographic Orientation

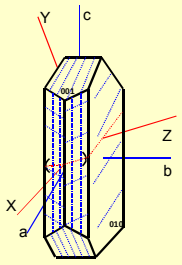


Plagioclase

100 section, ⊥ to a axis

Albite twins are length fast

Pericilne twins are length slow

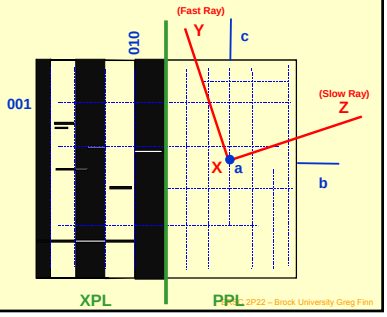


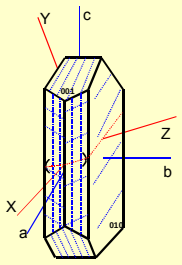
Optic Orientation

Can measure two extinction angles:

Y ^ 010

Z ^ 001





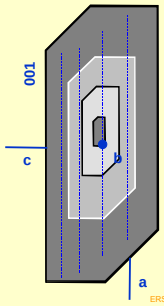
Crystallographic Orientation

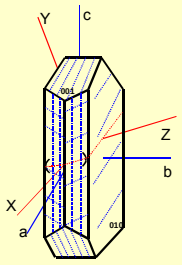
Plagioclase

010 section, ⊥ to b axis

In PPL - 1 cleavage ‖ to 001

In XPL - pericline twins/zoning





Optic Orientation

Can measure extinction angle: **X ^ 001**

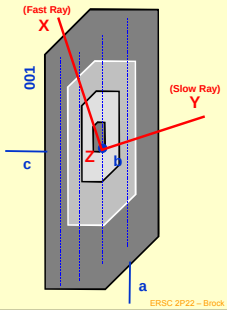
Each zone will have a separate extinction angle

Plagioclase

010 section, ⊥ to b axis

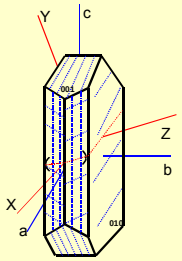
Pericline twins, ‖to 001, are length fast

Albite twins not visible



‘Anomalous’ Extinction

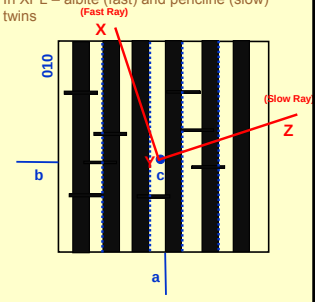
- Chemical Zonation
  - Optical properties vary with chemical composition, resulting in varying extinction directions for a mineral
    - eg. zoned minerals like plagioclase and olivine



Plagioclase

010 section, ⊥ to c axis

In PPL - 1 cleavage ‖ to 010
In XPL – albite (fast) and pericline (slow) twins



Crystallographic Orientation/Optic Orientation

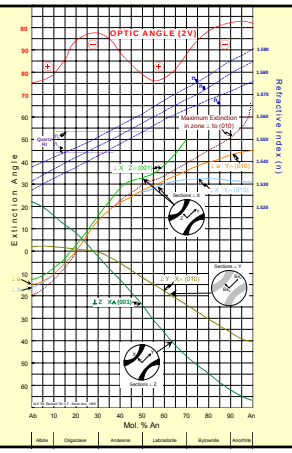
Can measure extinction angle: **X ^ 010**

Plagioclase

- Optical orientation varies on a regular basis with composition and provides a means of determining compositions (Do in Petrology)

Distinguishing Features

- low relief
- colourless
- biaxial
- twinning



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