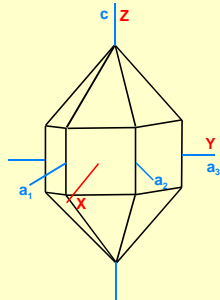


Uniaxial Minerals Descriptions

- Look at 6 uniaxial minerals
 - Quartz
 - Nepheline
 - Calcite
 - Apatite
 - Tourmaline
 - Zircon
- Examine composition, relief, colour, form, cleavage, twinning, birefringence, occurrence

Quartz

- Hexagonal
- Uniaxial + ve
- pure SiO_2 ,
 - minor Ti, Fe, Mn + Al
- Low relief
 - $n_o = 1.544$
 - $n_e = 1.553$
- Colourless in thin section, non pleochroic
- May have numerous solid and fluid inclusions within it



Quartz

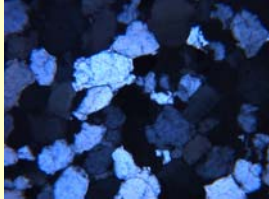
Form

- In igneous and metamorphic rocks irregular (anhedral granular) shapes - amoeboid
 - Phenocrysts of quartz may be present in some felsic volcanic rocks, will generally have hexagonal cross sections
- In sedimentary rocks grains are equant, rounded
- Generally no cleavage or twin planes are visible in thin section.



Quartz

- Birefringence of quartz is low, $\delta=0.009$,
- Interference colours range up to first order white to yellow
 - quartz interference colours can be used to judge how thick thin section is.



Quartz

- Normally uniaxial +ve interference figure quartz may often show **undulatory extinction**, if it has been deformed, in which case the interference figure may appear biaxial

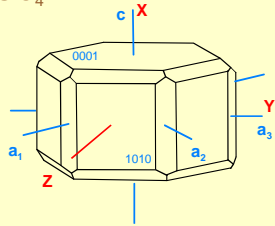


Quartz

- Widely abundant mineral present in a variety of igneous, metamorphic and sedimentary rocks
- Distinguishing Features
 - Low relief
 - Low interference colours
 - Uniaxial +ve
- The only mineral which may truly be mistaken for quartz is nepheline

Nepheline

- Hexagonal
- Uniaxial -ve
- Pure nepheline - $\text{NaAlSi}_3\text{O}_8$
 - in nature comp is $\text{Na}_3\text{K}(\text{Al}_4\text{Si}_4\text{O}_{16})$
 - K substituting for Na
- Low negative relief
 - $n_o = 1.529 - 1.546$
 - $n_z = 1.526 - 1.544$
 - Variable RI due to the substitution K for Na (increases RI)

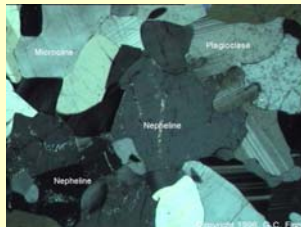


Nepheline

- Colourless in thin section, non pleochroic
- May contain very small inclusions and/or be altered, giving nepheline a cloudy appearance
- Anhedral to subhedral (amoeboid grains) in intrusive rocks, subhedral to euhedral in extrusive rocks
- Cleavage and twinning rarely observed in thin section

Nepheline

- Birefringence $\delta = 0.003$ to 0.005
- Interference colours - low to middle first order grey and white.



Nepheline

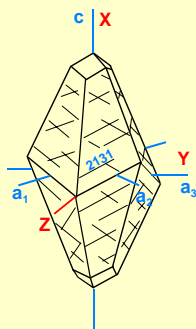
- Interference Figure - uniaxial negative. Optic axis figure no isochromes
- Common in syenite, nepheline syenite and related alkalic rocks
 - **Nepheline and quartz will not occur together in igneous rocks**, have one or the other
- In metamorphic rocks the two minerals may co-exist

Nepheline

- Distinguishing Features
 - Low negative relief
 - Resembles quartz
 - May be altered
 - Uniaxial negative

Calcite

- Hexagonal (trigonal)
- CaCO_3 - pure
 - substitution of Fe, Mg, Mn, Zn, for Ca
- Relief variable, due to wide difference between n_c and n_o
 - $n_o = 1.658$
 - $n_c = 1.486$
- Colourless in thin section

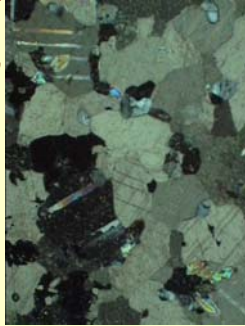


Calcite

- Forms a variety of shapes - scalenohedrons and rhombohedrons to anhedral (irregular) granular shapes.
- Exhibits good rhombohedral cleavage
 - angle between cleavages = 75°
- Twins are common, usually parallel to one edge of the calcite rhomb or parallel to long diagonal of rhomb.
- Inclined or symmetrical extinction to rhombohedral cleavage
 - fast ray parallel to the short diagonal of the rhomb

Calcite

- Extreme birefringence, giving high order (8th or 9th), creamy, interference colours, even when optic axis is vertical
- Twin lamellae will show as bands of pink or green on a creamy background.
- Uniaxial negative interference figure with numerous isochromes.

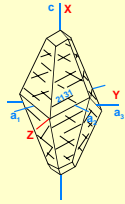


Calcite

- Calcite will occur in most igneous, metamorphic and sedimentary rocks as a major or minor constituent
 - The presence in a rock is dependent on the original chemical composition and/or any later alteration affects.
- Calcite can be distinguished from dolomite ($(\text{Mg,Ca})\text{CO}_3$), magnesite (MgCO_3) and siderite (FeCO_3) by staining of thin sections or hand samples

Calcite

- Distinguishing Features
 - Rhombohedral cleavage
 - Variable relief
 - Extreme interference colours
 - Uniaxial –ve figure with numerous isochromes

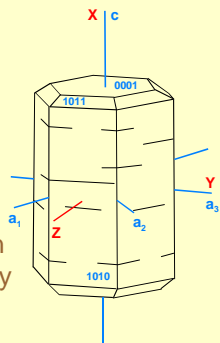


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Apatite

- Hexagonal
- $\text{Ca}_5(\text{PO}_4)_3(\text{Cl}, \text{F}, \text{OH})$
- Moderate relief
 - $n_w = 1.633-1.667$
 - $n_e = 1.629-1.665$
- Colourless in thin section
some samples may rarely be weakly pleochroic



Apatite

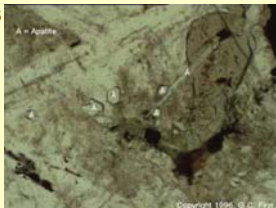
- Form - small euhedral to subhedral elongate prismatic crystals with hexagonal cross sections, exhibits a poorly developed cleavage, not always observed.
- Elongate sections are length fast and show parallel extinction.
- Birefringence $\delta = 0.001 - 0.007$

Apatite

- In thin section apatite exhibits low, first order grey interference colours, some grains may appear isotropic, but give a uniaxial negative interference figure
- Interference figures may be difficult to get on small grains
- Occurs as an accessory mineral, <10% of rock, in igneous, metamorphic and sedimentary rocks

Apatite

- Distinguishing Features
 - Moderate to high relief
 - Low birefringence
 - Low interference colours
 - Small prismatic grains



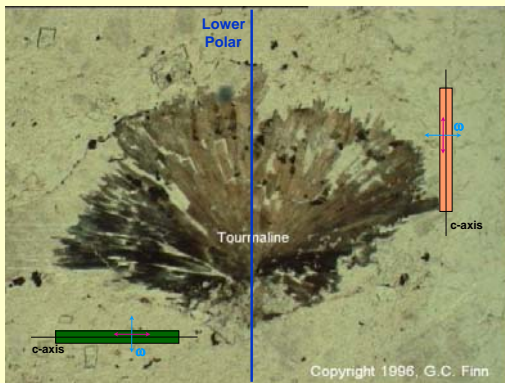
Tourmaline

- Hexagonal (trigonal)
- Borosilicate
 - $\text{Na}(\text{Mg,Fe,Li,Al})_3\text{Al}_6(\text{Si}_6\text{O}_{18})(\text{BO}_3)_3(\text{OH,F})_4$.
- Moderate to high positive relief
 - $n_\omega = 1.631 - 1.698$
 - $n_\epsilon = 1.610 - 1.675$
- Birefringence $\delta = 0.015 - 0.035$

Tourmaline

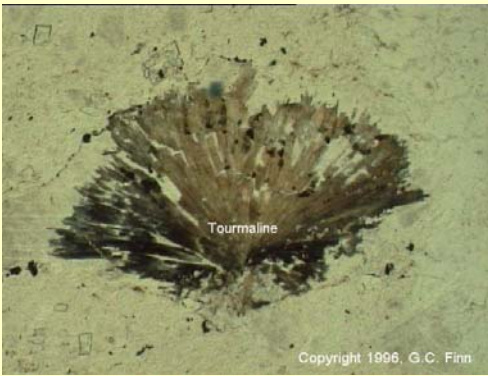
Colour and pleochroism

- Highly variable, but coloured varieties are strongly pleochroic
- $\omega > \epsilon$, when long axis of grain perpendicular to lower polar the grain shows the darkest pleochroic colour
- Basal sections are black, strongly absorb light



Tourmaline

- Elongate sections show parallel extinction and are length fast
- Interference colours up to second order green, but mineral colour may mask interference colour.
- Basal sections - give centred uniaxial figure
- Longitudinal sections >>flash figure



Tourmaline

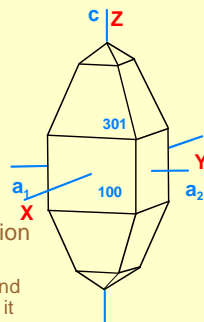
- Occurs in granitic lithologies, as an accessory mineral
- Metamorphic rocks
- Detrital grains in sedimentary rocks

Tourmaline

- Distinguishing Features
 - Crystal habit
 - Distinct pleochroism
 - **Tourmaline exhibits its darkest pleochroic colour when the long axis of the grain is aligned perpendicular to the lower polar**
 - All other common pleochroic minerals, (eg. biotite, hornblende, pyroxene, etc.) display their darkest pleochroic colour when the long axis is parallel to the lower polar

Zircon

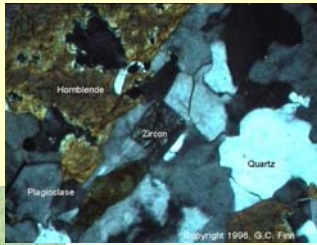
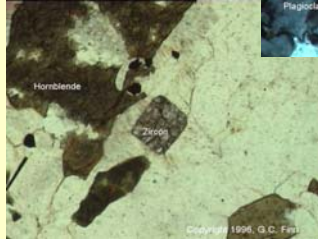
- Tetragonal
- $ZrSiO_4$
- Uniaxial +ve
- Very strong positive relief
 - $n_o = 1.920 - 1.960$
 - $n_e = 1.927 - 2.015$
- Usually colourless in thin section
 - may be pale brown in colour
 - The combination of high relief and generally small grain size make it appear darker in thin section



Zircon

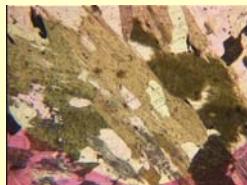
- Euhedral to subhedral grains
- Elongate sections have parallel extinction and are length slow
- Birefringence $\delta = 0.036 - 0.065$
- Interference occurs range up to 4th order
- Grains are often very small and do not allow for interference figures to be obtained

Zircon



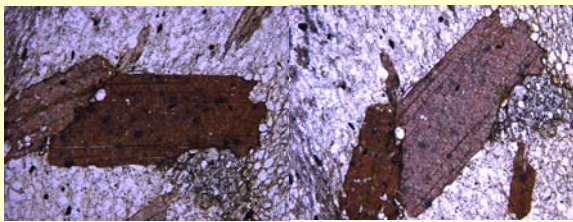
Zircon

- Occurs as a common accessory mineral in granitic compositions, is rarer in mafic igneous rocks. It is found in sedimentary rocks as a common accessory and in metamorphic rocks
- Its presence in a rock can be inferred from the observation of pleochroic halos around grains of zircon in biotite. These result from the radioactive decay of U and Th, which substitute for Zr, in the zircon structure



Zircon

Pleochroic haloes



Zircon

- Distinguishing Features
 - Small high relief grains as inclusions in a variety of minerals
 - High interference colours
