Anisitropic Minerals

Other Optical Properties

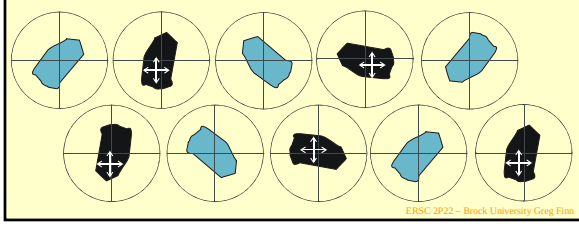
Anisotropic Minerals

Previously looked at Interference Colour (retardation) and Birefringence. Now will examine other optical properties of Anisotropic minerals useful in their identification:

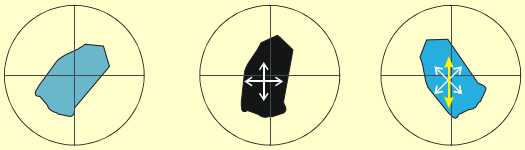
- Extinction
- Sign of Elongation
  - Accessory Plates
- Relief
- Pleochroism

Extinction

- Anisotropic minerals go _____ under crossed polars every _____ of rotation
- Extinction occurs when one vibration direction of light in the mineral is _____ to the polarization directions



Extinction – What Happens?

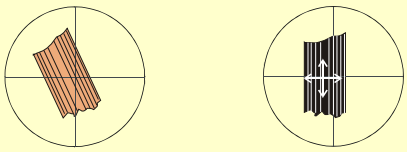


- At extinction no _____ of light can be resolved into the _____ direction of the upper polar, all light exiting the mineral is _____, and the mineral appears _____.
- 45° from extinction the _____ component of the slow and fast rays is available to be resolved into the vibration direction of the upper polar, allowing a _____ amount of light to pass, and the mineral appears _____.
- **On rotating the stage, the interference colour gets brighter or dimmer, with no actual change in colour**

Types of Extinction

Four types are recognized

- Parallel

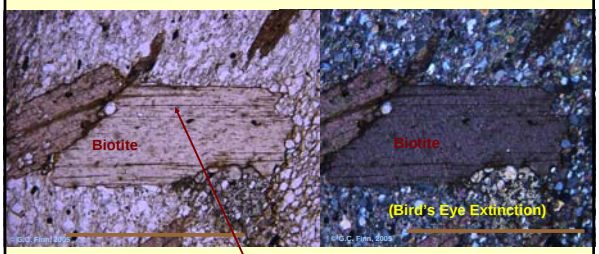


EA = 0°

Vibration direction of light in mineral is parallel to the polar (i.e. the crosshair)

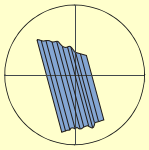
Parallel Extinction

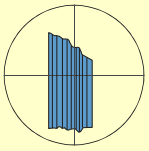
eg. Biotite

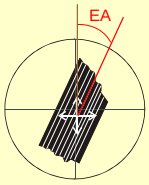


Types of Extinction

- Inclined







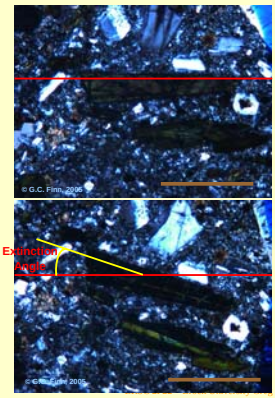
EA = XX°

When mineral is aligned with cleavage parallel to the crosshair, the grain is not at extinction.

The grain must be rotated to get to extinction. Vibration direction of light in mineral is now parallel to the polar (i.e. the crosshair).

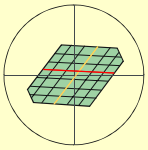
Inclined Extinction

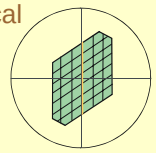
eg. Hornblende

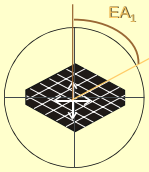


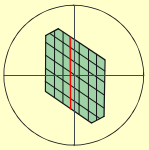
Types of Extinction

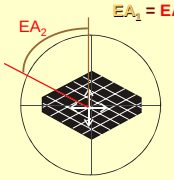
- Symmetrical





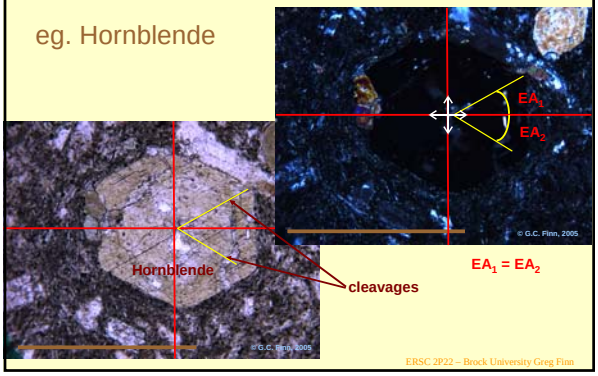






Symmetrical Extinction

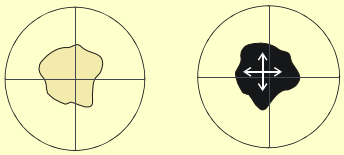
eg. Hornblende



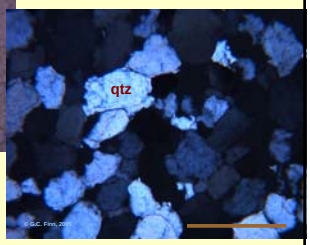
$EA_1 = EA_2$

Types of Extinction

'No Cleavage'



'No Cleavage'



eg. Quartz

‘Anomalous’ Extinction

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

‘Anomalous’ Extinction

_____

- During deformation some grains become bent, resulting in different portions of the grain having different orientations which go to extinction at different times.

Accessory Plates

- Accessory plates allow for the _____ of the **fast** (low n) and **slow** (high n) rays which exit the mineral
- The plates consist of pieces of gypsum, mica or quartz, mounted in a holder such that the vibration direction of the mineral are parallel to the long and short axis of the holder

Accessory Plates

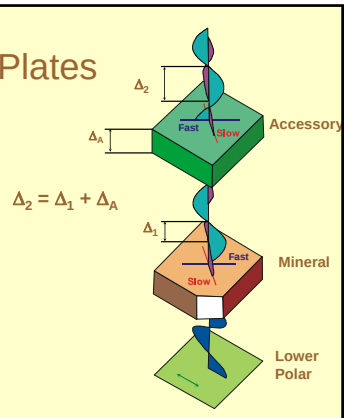
The sample is oriented 45° to extinction and has retardation = Δ_1.

The slow ray of the mineral and the slow ray of the accessory coincide

Resulting in a total retardation of Δ_2, where:

$$\Delta_2 = \Delta_1 + \Delta_A.$$

Which is greater than Δ_1, yielding higher order interference colours.



Accessory Plates

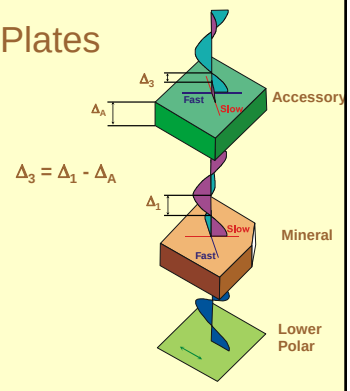
The sample is rotated an additional 90°, and still has retardation = Δ_1

Now the **slow** ray of the mineral is parallel with the **fast** ray in the accessory

Resulting in a total retardation Δ_3, where:

$$\Delta_3 = \Delta_1 - \Delta_A.$$

Which is lower than Δ_1, yielding lower order interference colours.



Types of Accessory Plates

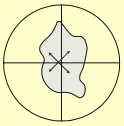
- _____ _____ (First Order Red Plate)
  - Produces ~550 nm of retardation, corresponding to a distinct magenta colour

- _____ _____ (1/4λ Plate)
  - Retardation of ~147 nm of retardation, corresponding to a 1st order white interference colour

- _____ _____
  - Wedge shaped and produces a range of retardations and corresponding range of interference colours

Determining the Vibration Directions (Fast and Slow) of a Mineral

1) Rotate the grain to extinction



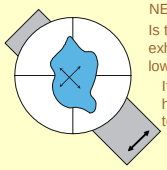
2) Rotate the grain 45° from extinction and record the interference colour

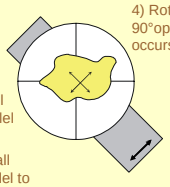
3) Insert the Gypsum Plate. The slow ray in the plate is aligned NE-SW.

Is the interference colour exhibited by the grain higher or lower than in Step 2?

If the colour **increased** (overall higher Δ) then the S_{min} is parallel to S_{acc}.

If the colour decreased (overall lower Δ) then the F_{min} is parallel to S_{acc}.

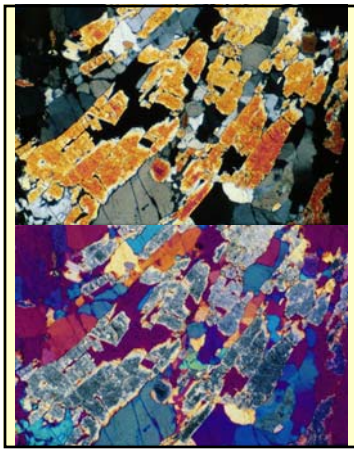




4) Rotate 90°opposite occurs.

Sign of Elongation

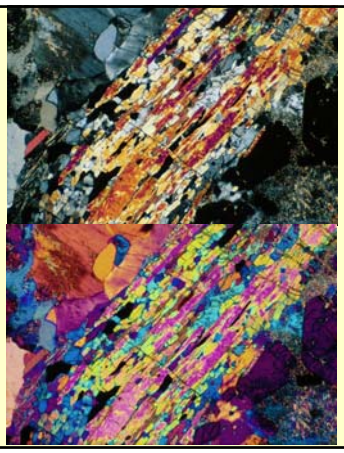
- Applicable only to minerals which are obviously elongated or exhibit a single cleavage
- _____ (Negative Elongation)
  - The _____ray in the mineral vibrates parallel with the length or single cleavage of the elongate mineral
- _____ (Positive Elongation)
  - The _____ ray in the mineral vibrates parallel with the length or single cleavage of the elongate mineral



Tourmaline

Length Fast

Images from D. Schulze, 2004



Sillimanite

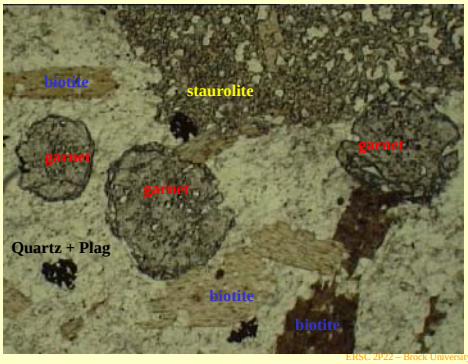
Length Slow

Images from D. Schulze, 2004

Relief

- Minerals in thin section will exhibit relief, but it will be _____ to their neighbours or the epoxy
- Minerals with a moderate to strong birefringence may display a _____ in relief as the stage is rotated in plane light
- This change in relief results from the the fast and slow rays having _____ _____ refractive indices

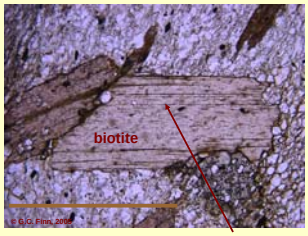
Relief



Pleochroism

- Change in _____ of a mineral as the stage is _____, when viewed in plane light
- Results because the two rays of light are _____ differently as they pass through the coloured mineral
- **NOT RELATED TO INTERFERENCE COLOURS**

Biotite Pleochroism



cleavage