**Extinction**
Extinction results when the vibration directions of a mineral are parallel/perpendicular to the vibration directions of the polarizers.

The fast and slow rays are perpendicular to each other, and when either of the two are parallel/perpendicular to the polarizer directions, no light will come through - extinction results.

![Diagram showing extinction](image1)

**Inclined or parallel extinction**
Extinction of a mineral compared to its crystallographic features.

*Parallel extinction* is when extinction occurs parallel to the cleavage or crystallographic direction.
*Inclined extinction* is when extinction occurs at an angle to the cleavage or crystallographic direction.
*Symmetrical extinction* occurs when extinction angle is 45.

![Diagram showing inclined and parallel extinction](image2)

**Anomalous Extinction**
When the mineral won’t go into good extinction with crisp black edges.

Some light still comes through as dark muddy colors. This is due to dispersion – extinction positions are different for different colors (wavelengths) of light. Some minerals are more sensitive to this than others.

Some highly colored minerals will affect the resulting color of birefringence.
1 – light comes out of lower polarizer vibrating N-S
2 – is refracted upon entering mineral into a fast and a slow ray and emerges from mineral
3 – analyzer (upper polarizer) resolves the fast and slow rays into E-W components (lets pass the E-W components)
4 – where they interfere with each other causing the phenomena of birefringence and retardation

**Abbreviations & Definitions:**

- **Bf** = Birefringence (unitless)
- **Δ** = Retardation (units = $m\mu = 10^{-7}$ cm)
- **n** = index of refraction (unitless – it’s a ratio)
- **n_{slow}** = index of refraction of slow ray
- **n_{fast}** = index of refraction of fast ray
- **thickness** of sample (units = $\mu \times 1000$)
  (standard thin section = 30 $\mu$)

**Index of Refraction**

The ratio of velocity of light in a vacuum (set = 1.0 as reference) to the velocity of light in a mineral

*or*

the ratio of the distance that light travels in a vacuum to the distance that light travels in the mineral *during the same time interval.*

**Birefringence** - Difference between maximum & minimum index of refraction

$$Bf = n_{slow} - n_{fast}$$

**Retardation** - Phase difference between the fast and slow rays after they travel through the sample

$$\Delta = (n_{slow} - n_{fast}) \times \text{thickness}$$

**Example**: Quartz

- $Bf_{\text{max}} = 0.009$ (parallel to C-axis)
- $\Delta = 270 m\mu = \text{very light grey}$
- thickness = 30,000 $m\mu = 30 \mu = 0.03\text{mm}$

but at $Bf_{\text{min}} = 0$ (perpendicular to C-axis)

- $\Delta = 0 m\mu = \text{black}$

**Pleochroism** - Differential absorption of light by different crystallographic directions of the mineral. This causes the mineral to change color (or depth of color) as the mineral is rotated under plane light