

Geology 284 - Mineralogy, Fall 2008
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Microscopic Properties of Minerals and the Petrographic Microscope

Light

- **Visible Electromagnetic Radiation**
- Wavelength, λ (Greek letter "lambda")
- Frequency, ν (Greek letter "nu")
- Velocity, $v = \lambda\nu$
- Velocity of light in a vacuum $c = 2.998 \times 10^8$ meters per second

The Electromagnetic Spectrum - see handout

Colors and Wavelengths of Visible Light - see handout

Polarization of Light

- Electric vectors of unpolarized light vibrate in all directions
- Light can be constrained (forced, allowed) to vibrate in only a single plane by a polarizing filter
- Such light is said to be Plane Polarized Light (PPL)

The Petrographic (polarizing) Microscope - see handouts. We have two kinds:

- New Leica DM-EP Microscopes
- Older Olympus Microscopes
- Both work essentially the same way; get used to one or the other, or both.

Non-opaque Minerals are either

Isotropic

- having the same properties in all directions

Anisotropic

- having different properties in different directions

Why do Mineralogists use Polarized Light Microscopes?

Light interacts differently with anisotropic minerals depending on the light's vibration direction relative to planes of atoms in the mineral structure (see handout).

Petrographic microscopes have rotating stages, so you can rotate the sample (thin section) relative to the polarizer.

Properties observable in Plane Polarized Light (PPL):

Relief

- Relief is determined by the difference between the refractive index (n) of the mineral and the refractive index of its surroundings

- Refractive index, $n = \text{velocity}_{\text{vacuum}} / \text{velocity}_{\text{mineral}}$
- n_{minerals} mostly between 1.5 and 2.0

Refractive Index is directly related to Density

Relief - Examples of Low, Moderate and High Relief in Thin Sections

Shape in PPL

Euhedral, Subhedral, Anhedral

Prismatic, equant, acicular, etc.

Cleavage in PPL

Color and Pleochroism

Color in transmitted light results when some wavelengths (colors) of white light are absorbed more than others

Pleochroism is when anisotropic minerals absorb polarized light differently along different directions in the mineral and therefore have different colors in different directions.

Pleochroism: Color change depends on orientation of grain relative to polarizer-

Biotite (and most other pleochroic minerals) is darkest when long direction of grain and cleavage are parallel to the polarizer

Tourmaline is darkest when long direction is perpendicular to the polarizer

Minerals observed in Cross-polarized light (XPL)

- Viewed between two perpendicular polaroid filters
- the Polarizer below the sample
- the Analyzer above the sample (insert using rod)

When an isotropic substance is viewed in Cross-Polarized Light (XPL) it appears dark. **Why?**

Double Refraction (separation of light into two rays that travel at different speeds and along slightly different paths) happens in all Anisotropic Minerals

- but Calcite Displays Double Refraction Most Dramatically

Constructive and Destructive Interference

When polarized light enters an anisotropic mineral, it is split into two "rays" which vibrate perpendicular to each other (see handout)

- The "fast" ray travels faster

- The "slow" ray travels slower $v_{fast} > v_{slow}$
- Remember velocity $(v) = \lambda \nu$
- Wavelength (λ) changes, but frequency (ν) remains the same, therefore

$$\lambda_{fast} > \lambda_{slow}$$

When light passes thru an anisotropic mineral - see handout

Lagging of the "slow" ray behind the "fast" ray is called Retardation

- When the two rays recombine at the Analyzer, they recombine by vector addition and interfere (constructively or destructively) with each other. There is generally a component of light parallel to the Analyzer
- Different colors of light experience different amounts of Retardation

Retardation and Interference

Interference Colors - Plate 4.11 in text and color chart in lab

Appearance of Minerals between Crossed Polars (in XPL)

All anisotropic minerals go extinct (black) 4 times as you rotate the stage 360°

Why?

- Because at those positions, the two perpendicular "allowed" vibration directions are parallel to the polarizer and the analyzer.

Quartz has Low Birefringence (gray to white in XPL)

Plagioclase has Low Birefringence and polysynthetic Albite twinning

Microcline has Low Birefringence and plaid twinning

Pyroxene has Moderate Birefringence (in XPL)

Olivine has High Relief (in PPL) and Moderate Birefringence (in XPL)

Muscovite has Moderate Birefringence

Calcite and Sphene have Extremely High Birefringence

Interference Colors – see chart

Properties Best or Only observed in XPL

- Isotropic or anisotropic
- Birefringence or interference colors
 - Mineral color may obscure this
- Extinction
- Twinning
- Special properties like “bird’s-eye” extinction in micas
- Grain boundaries of similar relief minerals
- Others?