Introduction to Light

Lecture 1

Definition of Light

- Light is electromagnetic radiation.
- Light exhibits properties of both a particle (e.g., ability to travel through a vacuum) and a wave (e.g., interference and polarization).
- For understanding behavior of light in minerals we can focus on the wave properties of light.

Aspects of Light

- Amplitude (height of wave) corresponds to the intensity (brightness) of light.
- Wavelength corresponds to the energy of light.
  - In the visible spectrum wavelength corresponds to color.

Wavelength of Light

- Visible light is only a tiny, moderate energy fraction of the electromagnetic spectrum.
- Longer wavelengths (e.g., radio waves) have less energy.
- Shorter wavelengths have more energy.

Visible light is within a range of 400 to 700 nanometers (nm).
Why is the Visible Spectrum Visible?

Absorption and Emission of Light

Absorption Results in Color
(A Familiar Example from Biology)

Speed of Light

- The speed of light varies with the media through which it passes

- Light moves fastest in a vacuum (3 x 10^8 m/s)

- Light moves slower in other media (e.g., 1.2 x 10^8 m/s in diamond)

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Refraction

- Refraction is the change in direction of a wave due to a change in its velocity when a wave passes from one medium to another.

- When light passes from a less dense medium to a more dense medium, the wave will bend toward the normal (perpendicular to the interface).

Refractive Index (RI)

- Refractive Index is the ratio of the speed of light in a vacuum to the speed of light in another medium.

- The speed of light in a vacuum is always faster than in any other medium so all RI values are >1.

- RI of minerals range from 1.32 to 2.40, with most between 1.50 and 1.80.

RELIEF: A Visual Estimate of Relative Refractive Indices

- Low Relief: $\Delta RI < 0.04$
- Moderate Relief: $0.04 < \Delta RI < 0.12$
- High Relief: $\Delta RI > 0.12$

BECKE LINE: An Indicator of Positive or Negative Relief

- Becke line moves into higher RI when stage is lowered.
- Positive relief: Greater than epoxy (1.54)
- Negative relief: Less than epoxy (1.54)
Vibration and Polarization of Light

- Most light waves vibrate in all planes that are perpendicular with respect to the direction of propagation.
- If the electric field vectors are restricted to a single plane by filtration of the beam with specialized materials, then the light is referred to as plane polarized with respect to the direction of propagation.

Polarizing Filters

- Polarizing filters are materials in which electrons can move freely in one direction but not another.
- Intuitively, you might think light polarized parallel to the direction of freedom might be able to “slip through”. In fact, the opposite is the case.
- Light polarized parallel to the easy direction moves the electrons back and forth. In the process it does work and is absorbed.
- Light oriented perpendicular to that direction cannot move the electrons very much, does no work, and passes through.

Polarizing Filters on a PLM

- The lower polarizing filter (polarizer) allows “N-S” vibrating light to pass
- The upper polarizer (analyzer) allows “E-W” vibrating light to pass

Isotropic vs Anisotropic Minerals

- **Isotropic minerals** have the same structure, composition and properties in all directions
- **Anisotropic minerals** (vast majority of minerals) have structures, and/or compositions, and properties that vary with direction
Anisotropic Minerals

- Anisotropic minerals may exhibit variations in their optical properties under a PLM as a sample is rotated as a result of the variation in chemical properties with direction.

Key Terms

- Refractive index
- Relief
- Becke line
- Polarization
- Plane-polarized
- Isotropic
- Anisotropic
- Pleochroism

PLEOCHROISM: Change in Color with Orientation of Mineral

VARIABLE RELIEF: Change in Relief with Orientation of Mineral

Calcite: Lower Relief
Calcite: Higher Relief