Cross-Polarized Light and Interference

Lecture 2

Birefringence

- Birefringence, or double refraction, is the decomposition of a ray of light into two rays when it passes through anisotropic materials.

Birefringence

- The two rays travel at different speeds, and vibrate in perpendicular directions.
- One ray travels straight through the crystal and is called the ordinary ray.
- The other ray is refracted through the crystal and is called the extraordinary ray.
- The extraordinary ray vibrates in a direction that would connect it with the ordinary ray.

Sign of Birefringence

- If the ordinary ray is faster than the extraordinary ray, then the mineral is positive.
- If the ordinary ray is slower than the extraordinary ray, then the mineral is negative.
Birefringence and the PLM

Retardation = Birefringence × Thickness

Consider a plane polarized light wave (one that has already passed through the polarizer) as it approaches a mineral sample on the microscope stage.

In this case the light is vibrating in a diagonal plane.

CASE 2:
1 Wavelength Retardation

Imagine that the mineral splits the incoming beam into two beams that vibrate perpendicular to each other, and both travel at different velocities such that the slower wave lags behind by one wavelength by the time it emerges from the mineral.
CASE 2: 1 Wavelength Retardation

When the light emerges from the mineral and resolves itself into one beam again (vectors add) then the beam that emerges will vibrate in the same plane as the one that entered the mineral.

CASE 3: ½ Wavelength Retardation

Imagine that the mineral splits the incoming beam into two beams that vibrate perpendicular to each other and both travel at different velocities such that the slower wave lags behind by one half wavelength by the time it emerges from the mineral.

CASE 3: ½ Wavelength Retardation

When the light emerges from the mineral and resolves itself into one beam again (vectors add) then the beam that emerges will vibrate perpendicular to the one that entered the mineral.

Retardation In Whole Number Multiples of Wavelength

If light either experiences no retardation, or retardation of the slow wave by whole wavelengths (1, 2, 3, etc), then the light will emerge vibrating perpendicular to the analyzer. In these cases, these waves will be entirely blocked by the analyzer and will not reach your eye.
Interference and Color

- Each color has a different wavelength
- If all light is retarded by the same distance, then each color of light will be affected differently
- Some colors may increase in intensity and some may decrease
- The result is that the light that results when the rays recombine will have a distinct color due to the interference from a given retardation

The Optic Axes

- An optic axis is a straight line through a mineral along which light does not diverge into two separate rays
- Corresponds to an axis of symmetry such that the speed light would be the same no matter what direction the ray vibrates
- Along the optic axis the mineral behaves as if it were isotropic (no retardation)
Uniaxial Minerals

- Some anisotropic minerals (such as calcite and quartz) have only one optic axis, and so are called **uniaxial**.

Biaxial Minerals

- Most anisotropic minerals (such as muscovite) have only two optic axes, and so are called **biaxial**.

Orthoscopic vs Conoscopic Light

- **Orthoscopic Light**
  - Ray 1 travels along the optic axis.
  - Ray 2 travels at a low angle to the optic axis.
  - Ray 3 travels at a moderate angle to the optic axis.

- **Conoscopic Light**
  - Length of path of each ray within the mineral grain.
Uniaxial Interference Figure

Key Terms

- Birefringence
- Ordinary ray
- Extraordinary ray
- Retardation
- Interference
- Optic axis
- Uniaxial
- Biaxial
- Orthoscopic
- Conoscopic
- Interference Figure
- Isochrome
- Isogyre
- Melatope