LECTURE FOUR: Birefringence and Retardation

IN THIS LECTURE
- Isotropic versus Anisotropic Minerals
- Interference Phenomena
- Retardation
- Birefringence
- Interference at the Upper Polar

Isotropic vs Anisotropic
Anisotropic minerals differ from isotropic minerals because the velocity of light varies depending on the direction through the mineral and they show double refraction. When light enters an anisotropic mineral it is split into two rays of different velocity which vibrate at right angles to each other. In anisotropic minerals there are one or two directions, through the mineral, along which light behaves as though the mineral were isotropic, ie the light is not split into two rays. This direction or these directions are referred to as the optic axis.

Hexagonal and tetragonal minerals have one optic axis and are optically UNIAXIAL. Orthorhombic, monoclinic and triclinic minerals have two optic axes and are optically BIAXIAL.

Fast and Slow Rays
It is possible to measure the index of refraction for the two rays using the immersion oils, and one index will be higher than the other.

The ray with the lower index is called the fast ray. Recall that $n = V_{vac}/V_{medium}$. If $n_{Fast\ Ray} = 1.486$, then $v_{Fast\ Ray} = 2.02 \times 10^{10}$ m/sec

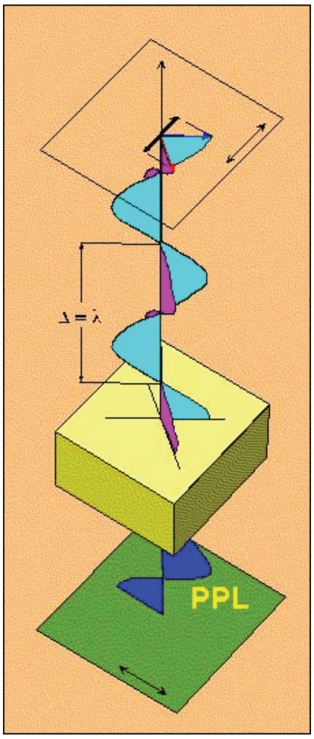
The ray with the higher index is the slow ray. For example if $n_{Slow\ Ray} = 1.658$, then $v_{Slow\ Ray} = 1.8\ 1 \times 10^{10}$ m/sec

Birefringence and Retardation
We have already seen that retardation is defined by the relationship $\Delta = d(n_s - n_f)$. The relationship $(n_s - n_f)$ is called birefringence and is given the Greek lower case symbol δ (delta). δ represents the difference in the indices of refraction for the slow and the fast rays.

In anisotropic minerals the path along the optic axis, exhibits zero birefringence, others show maximum birefringence, but most show an intermediate value. The maximum birefringence is characteristic for each mineral. Birefringence may also vary depending on the wavelength of the incident light.

Interference at the upper polariser
The colours for an anisotropic mineral observed in thin section under crossed polars are called interference colours and are produced as a consequence of splitting the light into two rays on passing through the mineral.

Now look at the interference of the fast and slow rays after they have exited the anisotropic mineral with the fast ray is ahead of the slow ray by some amount = d. Interference phenomena are produced when the two rays are resolved into the vibration direction of the upper polar.

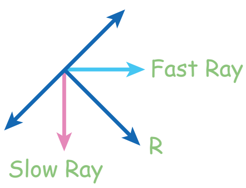


Upper Polar

Mineral

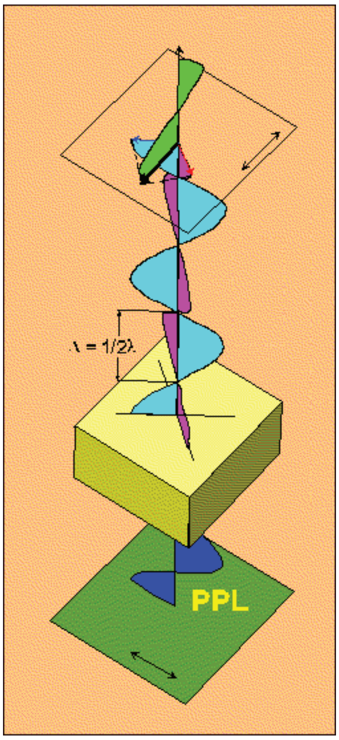
Lower Polar

The two rays exiting the mineral are in phase with the slow ray lagging behind the fast ray by one whole wavelength



The vector R, the sum of the two rays, is at right angles to the vibration direction of the upper polariser

=> no light passes the upper polar

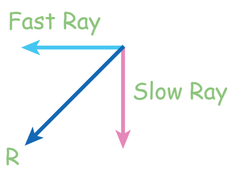


Upper Polar

Mineral

Lower Polar

The two rays exiting the mineral are out of phase with the slow ray lagging behind the fast ray by half a wavelength



TThe vector R, the sum of the two rays, is parallel to the vibration direction of the upper polariser

=> light passes the upper polar