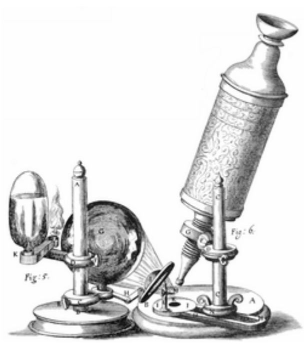
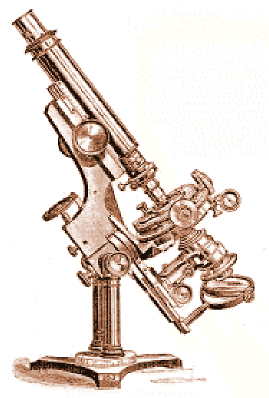
Optical Mineralogy

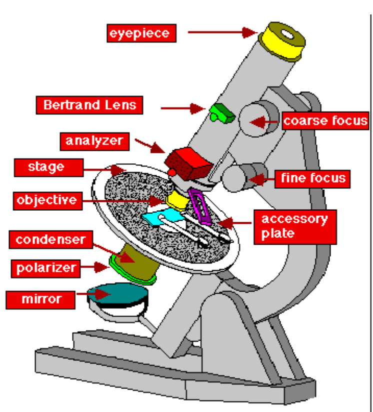
Lecture 1

What is optical mineralogy ?

- Identification of minerals by their optical properties using a petrographic microscope
- Interpretation of textures and intergrowths observed in a microscope







Transmitted Light Microscopy

- Light is sent through a sample and observed through several magnifying lenses
- The light is filtered before and after interacting with the sample

Illuminator

Light is emitted by halogen Bulb.

Filtered through a blue glass filter

Light intensity is adjusted by an electrical control or by inserting grey filters

Substage Assembly

- **Lower polar**: make light vibrate in one direction only
- **Iris diaphragm:** Narrows the cone of light, increasing the contrast.
- **Condensor lenses:** Gives you the ability to view the sample in orthoscopic or conoscopic illumination

Microscope Stage

- **Goniometer:** Is used to measure angles between different features in the sample, or between sample features and vibration directions of the light

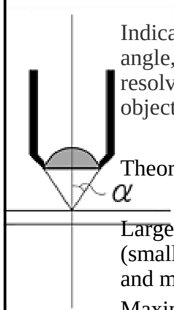
Objective Lenses

- Magnify x2.5 to x40 on normal petrographic microscope.
- These may need to be centered relative to the rotational movement of the stage.

Objective Lens

Magnification
Numerical Aperture
Tube length / thickness of coverglass

Numerical Aperture (NA)

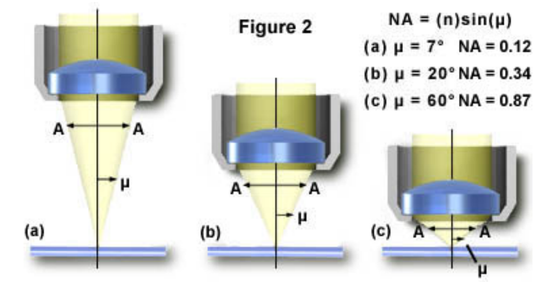


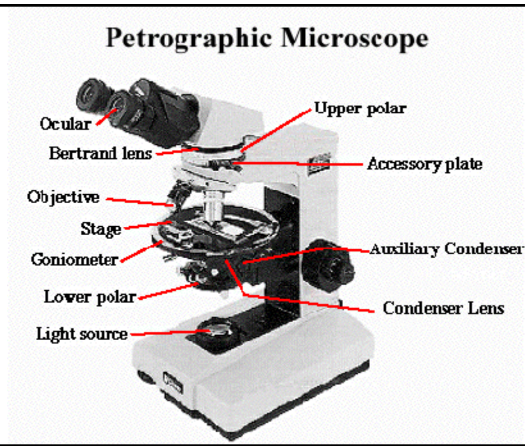
Indicates a critical value of the light acceptance angle, which determines the light gathering power, resolving power, and depth of field of the objective.

Theoretical Resolution limit = alpha/2NA

Larger numerical aperture gives higher resolution (smaller resolution limit), poorer depth of field and more light.

Maximum total magnification is 1000 x NA





Accessory Plate

- Gypsum Plate
- Mica Plate
- Quartz Wedge

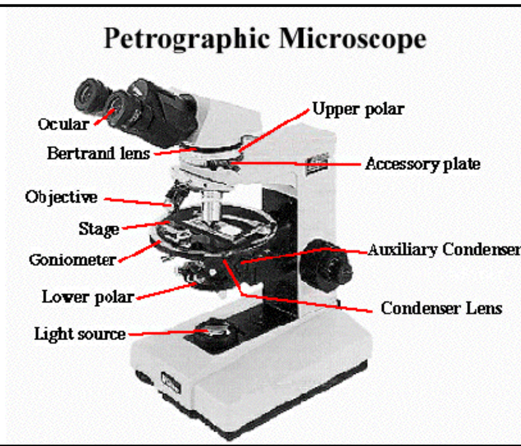
These slows the light vibrating in the indicated direction (usually SW-NE) a full wavelength or a quarter of a wavelength

Upper Polar

- The upper polar only allows light vibrating in one direction to pass through.
- When the upper polar is in and oriented perpendicular to the direction of the lower polars, the polars are said to be crossed.
- If the upper polar is out, the sample is viewed in plane polarized light
- If the upper polar is in but the the angle between the polars is different from 90 degrees, they are partially uncrossed
- Polars are sometimes referred to as Nicols

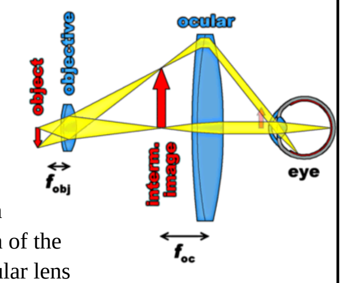
The Bertrand Lens

- This lens can be introduced or removed from the optical path. Usually it is out, unless conoscopic illumination is used to view interference figures.
- Can be equipped with a pinhole or iris diaphragm to limit the field of view



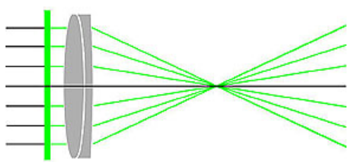
Ocular or Eyepiece

- Additional magnification
- Focus the image to fit the eye
- Total magnification is the magnification of the objective lens x ocular lens



Focusing Mechanism

- Coarse Focus
- Fine Focus



- Focusing is achieved by lowering and raising the stage so that the sample lies in the plane of focus.

Basic Rules

- Microscopes are expensive (15.000 $ for a student scope) so treat them with care
- Lift them in the base and arm with both hands
- Lenses should not polished or touched
- Change objective lens by turning the lens holder, not by pulling the objectives
- Take a break once and a while if your eyes get strained

Basic Operations

- Focusing
- Adjusting oculars
- Adjusting Illuminator
- Centering objectives
- Alignment of polars
- Adjusting the substage assembly

Focusing

- Make sure the thin section is correctly oriented with the rock slide / cover slip upwards. If you turn it upside down you might push the lens into the slide trying to focus
- Focus first with the lowest magnification using no force whatsoever
- The objectives should all be focused in roughly the same plane – some fine adjustment is needed

Adjusting Oculars

- Crosshairs should go N-S and E-W
- On a binocular microscope you can often adjust the ocular lenses independently to fit the users eyes – if you have significant astigmatism you will still need to wear your glasses though

Adjusting the illuminator

- Turn the light up reasonably slowly to a comfortable intensity. Usually this is between 50-75% of maximum power.
- Turn the light of reasonably slowly

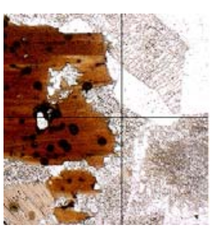
Centering of Objectives

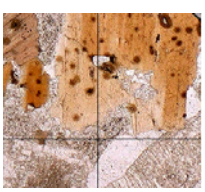
Some objectives may be off centered relative to the axis of rotation of the stage.

1 Focus on a thin section and rotate. Find the centre of rotation.
2 Adjust the centering screws so that the center of rotation coincide with the crosshairs

Alignment of Polars

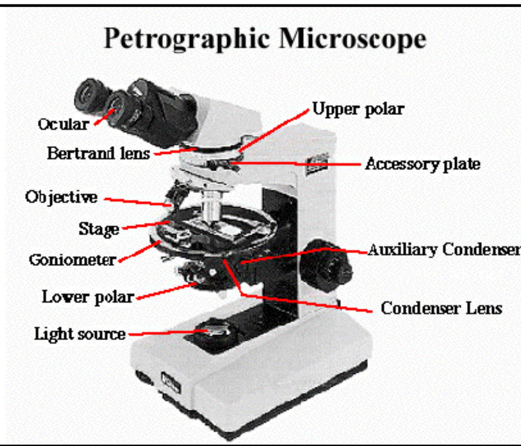
- The lower polar is aligned using a grain of biotite with visible cleavage
- The biotite grain should be darkest when the cleavage is parallel to the orientation of the lower polar.
- Upper polar should be perpendicular





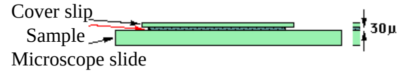
Adjusting the Substage Assembly

- The substage can be centered after the objectives have been centered.
- Insert the condensor lens and close the iris diaphragm. A single spot of light can then be seen with the lowest power objective.
- Move the substage using the centering screws until this spot of light is in the crosshairs
- The substage should be raised so that the condensor lens just clears a slide placed on the stage.



The Thin Section

- The thin section is a slice of rock, 30 microns thick, glued to a microscope slide with a cover slide glued on to it

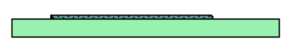


How is a thin section made

- Rock is cut
- A surface is polished and glued to a slide
- Cut again and polished on the other side, until it has the right thickness
- Then a coverslide is glued to it

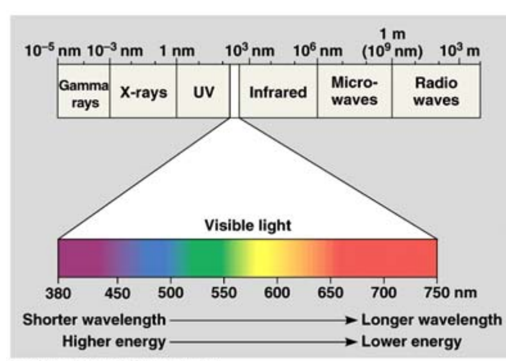
Polished thin section

- These are often somewhat thicker (50 microns) and do not have a coverslip.
- Can be used for transmitted and reflectedl ight microscopy, as well as SEM and Electron Microprobe analysis



What is light ?

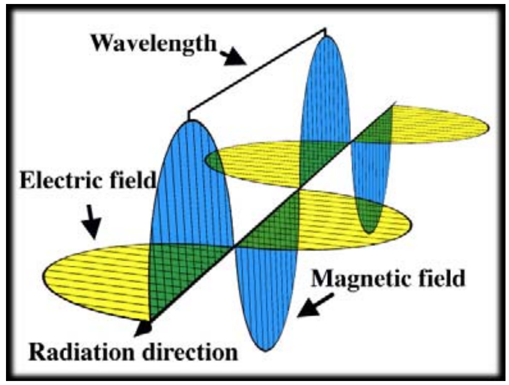
- Light is electromagnetic radiation in a certain wavelength range
- It can be viewed a single particles called photons but for explaining optical theory it is more convenient to use wave theory
- The waves have both magnetic and electrical properties, hence electromagnetic waves



Velocity, Wavelength and Frequency

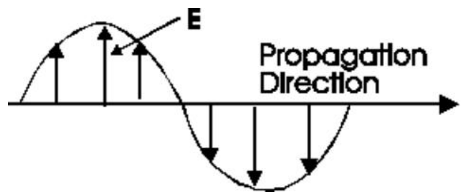
$$v = f\,\lambda$$

- The frequency of light remains constant, regardless of the material light travels ses though
- If the velocity changes the wavelength must also change, hence the color



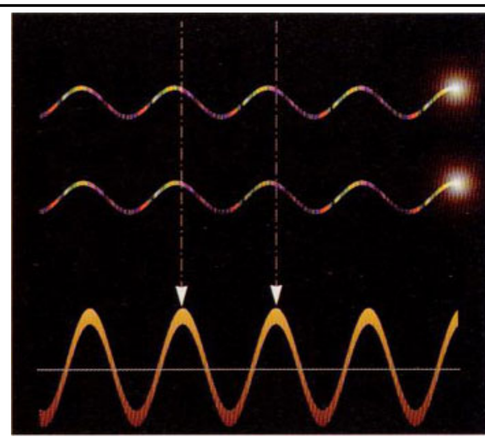
Vibrates in two directions, practically one

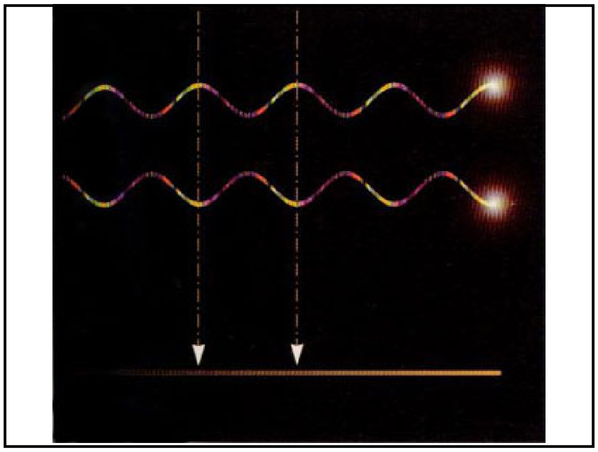
- When considering light – mineral interaction, we only consider the electrical component of the vibrations and not the magnetic as the forces arising from the magnetic vibrations have few direct consequences

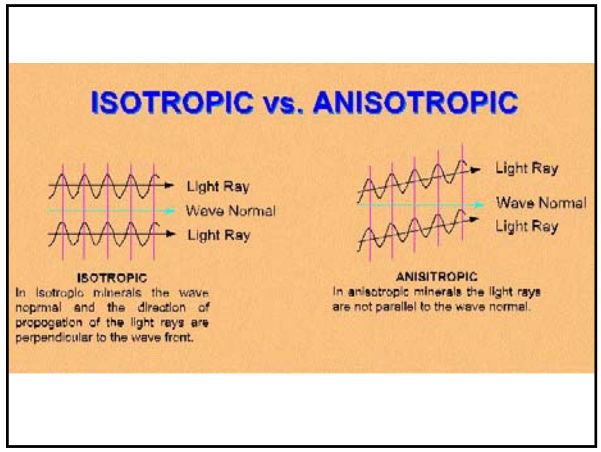


In phase / out of phase

- If two waves vibrate in the same plane they interfere
- If one wave lags behind, the difference is called retardation
- If the retardation is an integer number of wavelengths, the waves are in phase
- If the retardation is ½ a wavelength displaced from the in phase position, the waves are out of phase






ISOTROPIC vs. ANISOTROPIC
Light Ray
Wave Normal
Light Ray
ISOTROPIC
In isotropic minerals the wave noprmal and the direction of propogation of the light rays are perpendicular to the wave front.
Light Ray
Wave Normal
Light Ray
ANISITROPIC
In anisotropic minerals the light rays are not parallel to the wave normal.