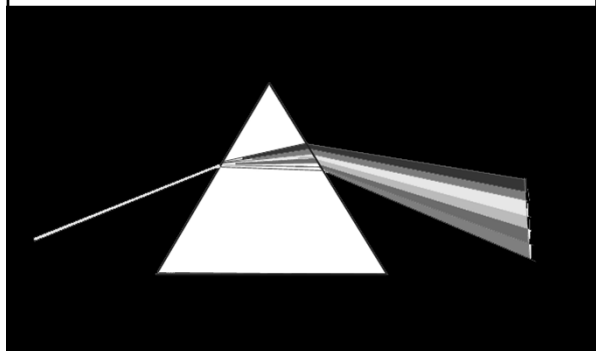


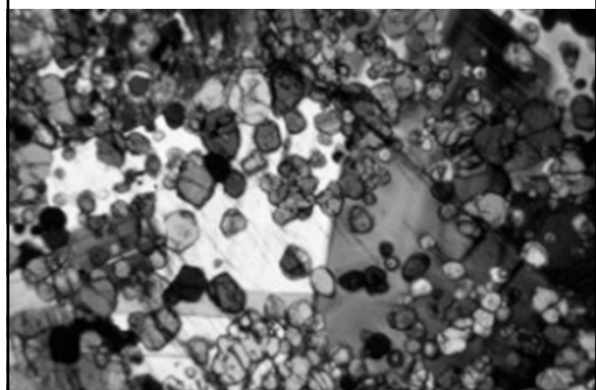
Light in Minerals I



Light in Minerals

- *Looking at Geologic Materials*
- *Light can be focused, and we can use the images to understand minerals and rocks.*
- *Thin sections are thin slices of a rock prepared to 30 μm thickness.*

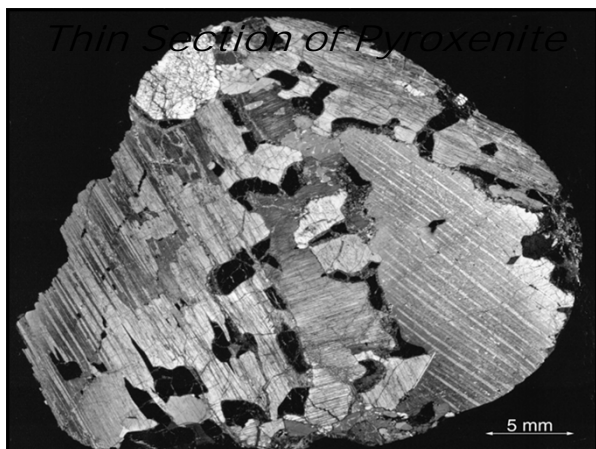
Thin Section of Gabbro



Thin Section of Gabbro



Thin Section of Pyroxenite



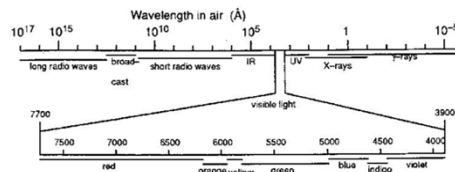
Properties of light

- *Wavelength λ 4000 - 8000 \AA*
- *Wave numbers 25,000 - 12,000 cm^{-1}*
- *Frequency hertz $\nu = c/\lambda$*
- *Velocity $c = 3.0 \cdot 10^8$ m/s in a vacuum*
- *Light behaves as a particle and as a wave.*
- *Light has a vibration direction (polarization vector) as well as propagation direction.*

Properties of Light

- Light is conducted through materials on the valence electrons.
- Light travels more slowly in materials than in vacuum or air.
- Electrically conducting materials are opaque.

Electromagnetic Spectrum



Visible Light: 7700 - 3900Å

Behavior of Light in Materials

- Absorption (light is absorbed by materials)
 - Color (absorption is a function of wavelength)
 - Pleochroism (absorption is a function of direction)
- Refraction (light travels slowly in some materials)
 - Dispersion (velocity is a function of wavelength)
 - Birefringence (velocity is a function of direction)

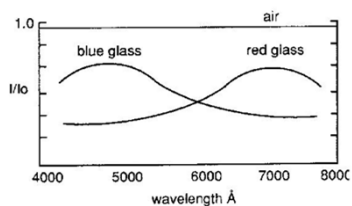
Absorption

- Light is attenuated on entering any material.
- The attenuation is a function of distance.
- I is intensity at some point t
- I_0 is initial intensity.
- k is absorption coefficient in cm^{-1} .
- Lambert's Law:

$$I / I_0 = e^{-kt}$$

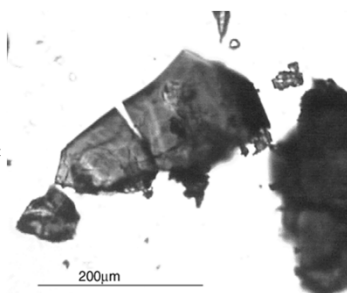
Color

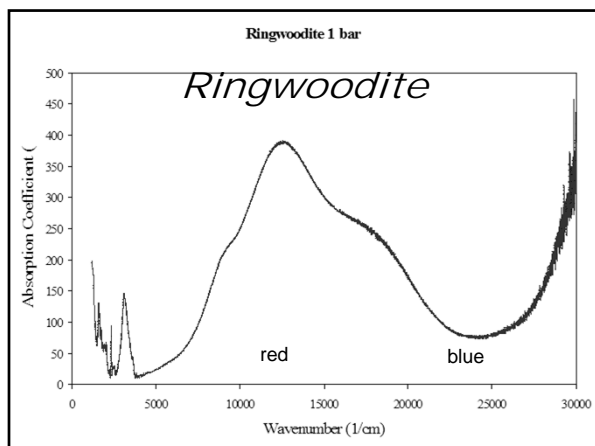
- Absorption may be a function of wavelength.
- Materials may appear colored in transmitted light



Ringwoodite is Blue

- $(\gamma\text{-Mg}_{1.63}\text{Fe}_{0.22}\text{H}_{0.4}\text{Si}_{0.95}\text{O}_4)$
- ~10 % of Fe present as ferric (Mössbauer)





Pleochroism

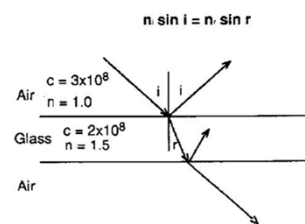
- Pleochroism is the variation of absorption with direction in a crystal.
- Pleochroism is observed as a color change on rotation in plane-polarized light (not crossed polars).
- Pleochroism only occurs in non-cubic crystals.
- Pleochroism indicates the presence of transition metals (esp Fe, also Mn, Cr, V, etc).
- Biotite, tourmaline, amphibole.

Behavior of Light in Materials

- Absorption (light is absorbed by materials)
 - Color (absorption is a function of wavelength)
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 - Birefringence (velocity is a function of direction)

Refraction and Reflection

- When light strikes a polished surface of a material it is split into two rays.
- One is reflected and the other refracted.



Refraction (Snell's Law)

- The angle ω that the refracted ray makes with the vertical depends on the velocity contrast.
- The index of refraction (r) is the ratio of the velocity of light in a vacuum to the velocity of light in the material.
- Snell's Law
- $n_i \sin \omega_i = n_r \sin \omega_r$

Refraction Calculation

- Water has an index of refraction of 1.33. Light enters water at an angle of 40° from vertical. What is the angle it makes in the water?
- $n_i \sin \omega_i = n_r \sin \omega_r$ (Snell's Law)
- $1.0 \sin 40^\circ = 1.33 \sin \omega_r =$
- $\omega_r = \sin^{-1} (.6428/1.33)$
- $\omega_r = 28.9^\circ$

Critical Angle

- Going from a high-index (slow) to a low-index (fast) medium, there is a critical angle above which the light cannot escape.
- For water $n = 1.33$.
- $1.33 \sin \omega_c = 1 * \sin 90^\circ$.
- $\omega_c = \sin^{-1}(1/1.33)$.
- $\omega_c = 48.8^\circ$.

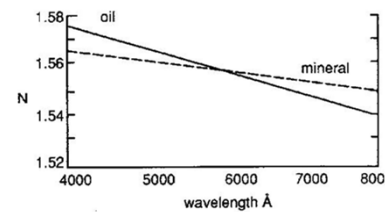
- *Why is the sky blue?*

- *Why is the sky blue?*

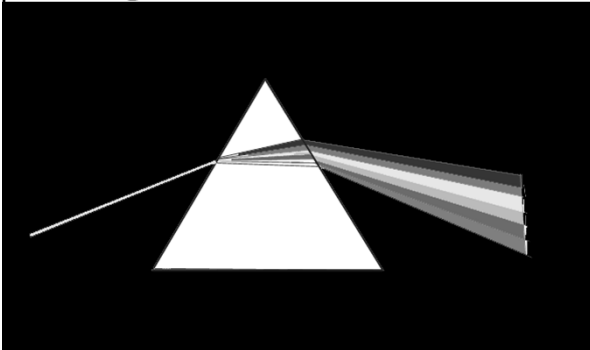
Dispersion

Dispersion

- The index of refraction (velocity) varies with wavelength.



Dispersion Long bent less than Short



Birefringence

- Birefringence is the phenomenon of light vibrating in different directions traveling at different speeds in a solid.
- It is a property of non-cubic crystals.