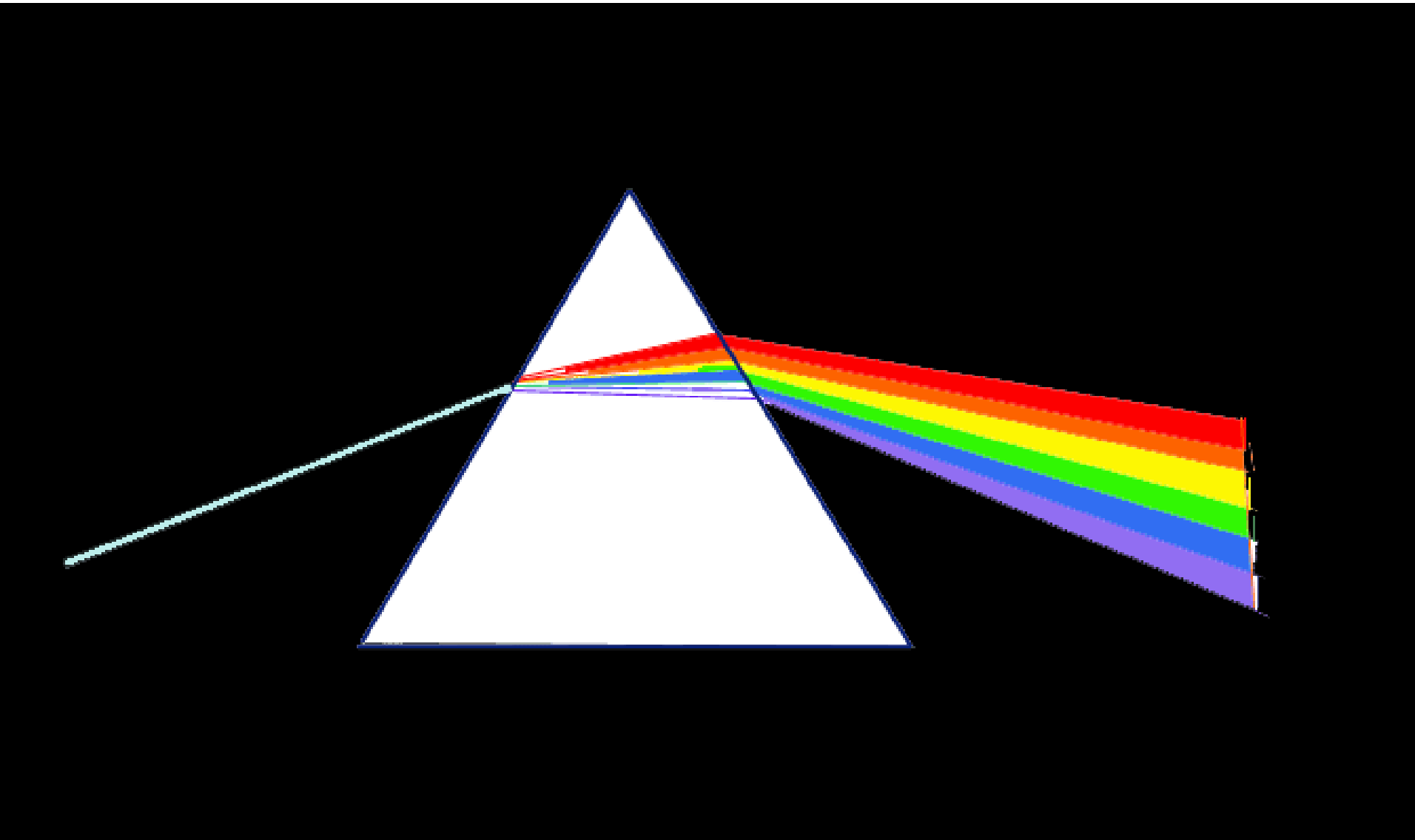
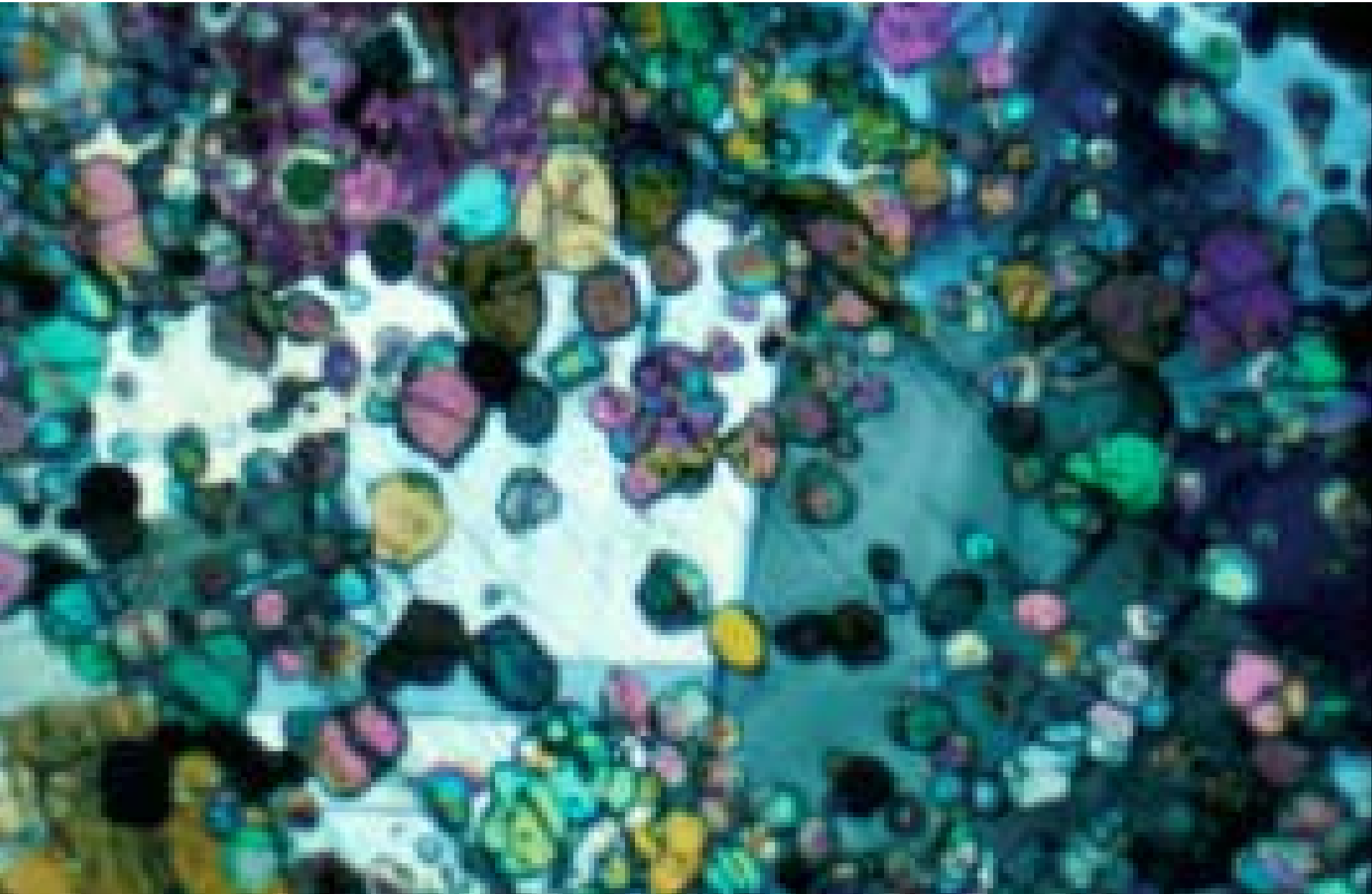
Light in Minerals



Light in Minerals

- Looking at Geologic Materials
- Light can be focussed and we can use the images to understand minerals and rocks

Thin Section of Gabbro



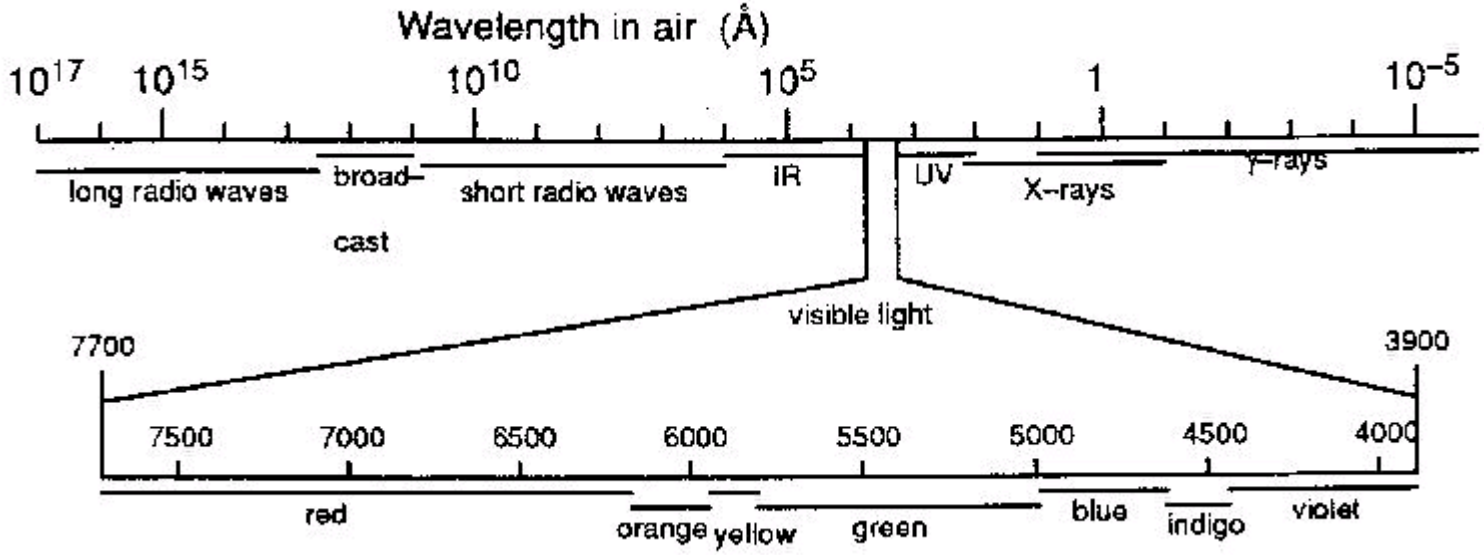
Properties of light

- Wavelength λ 4000 - 8000Å
- Frequency hertz $\nu = c/\lambda$
- Velocity $c = 3.0*10^8$ m/s in a vacuum
- Light behaves as a corpuscle and as a wave.
- Light has a vibration direction (polarization vector)

Properties of Light

- Light is conducted through materials on the valence electrons.
- Light travels more slowly in materials.
- 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)

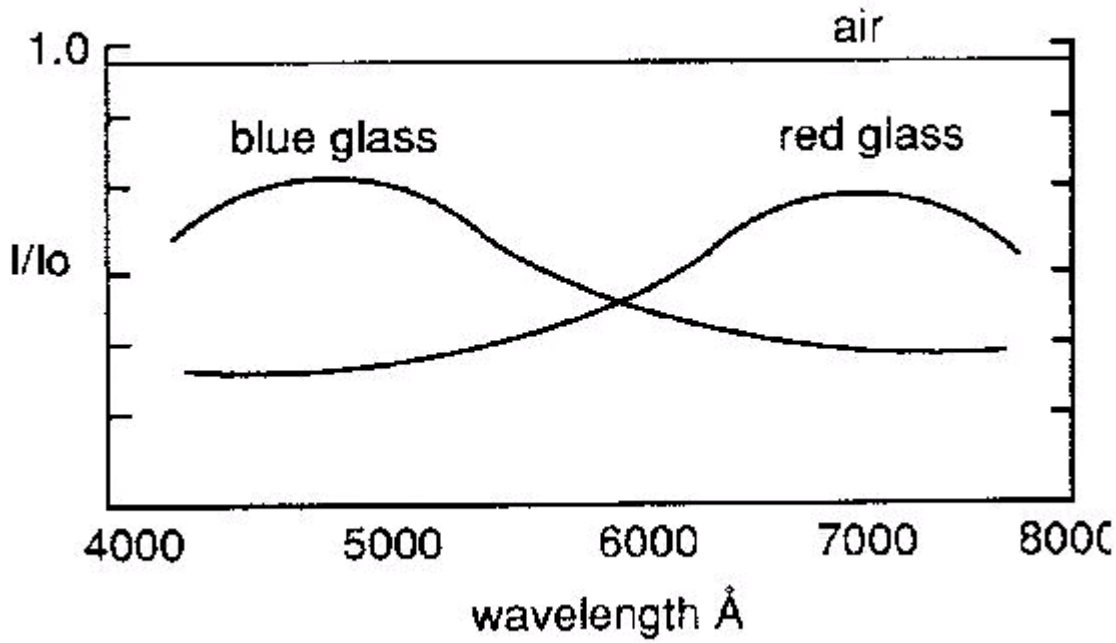
Absorption

- 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:

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

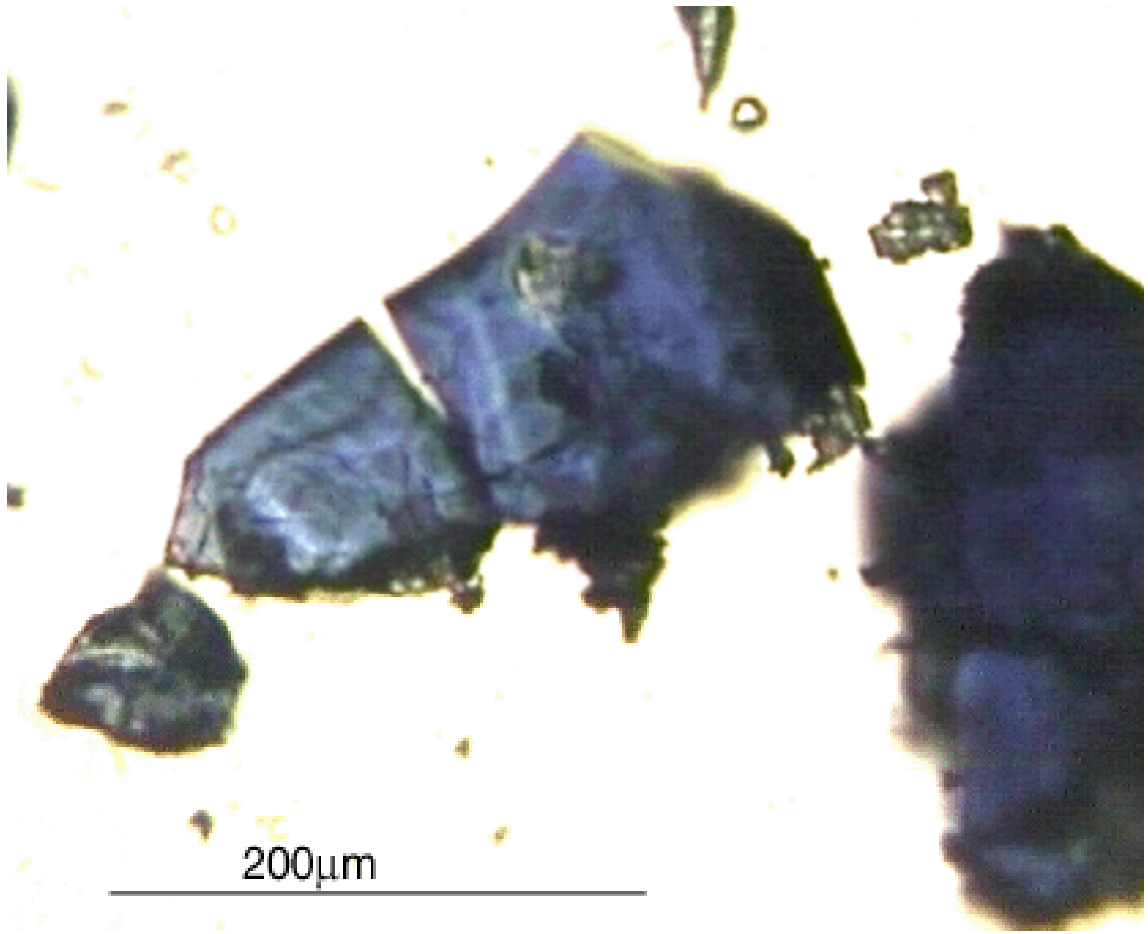
Color

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



Ringwoodite is Blue

- (γ-$Mg_{1.63}Fe_{0.22}H_{0.4}Si_{0.95}O_4$)
- ~10 % of Fe present as ferric (Mössbauer)

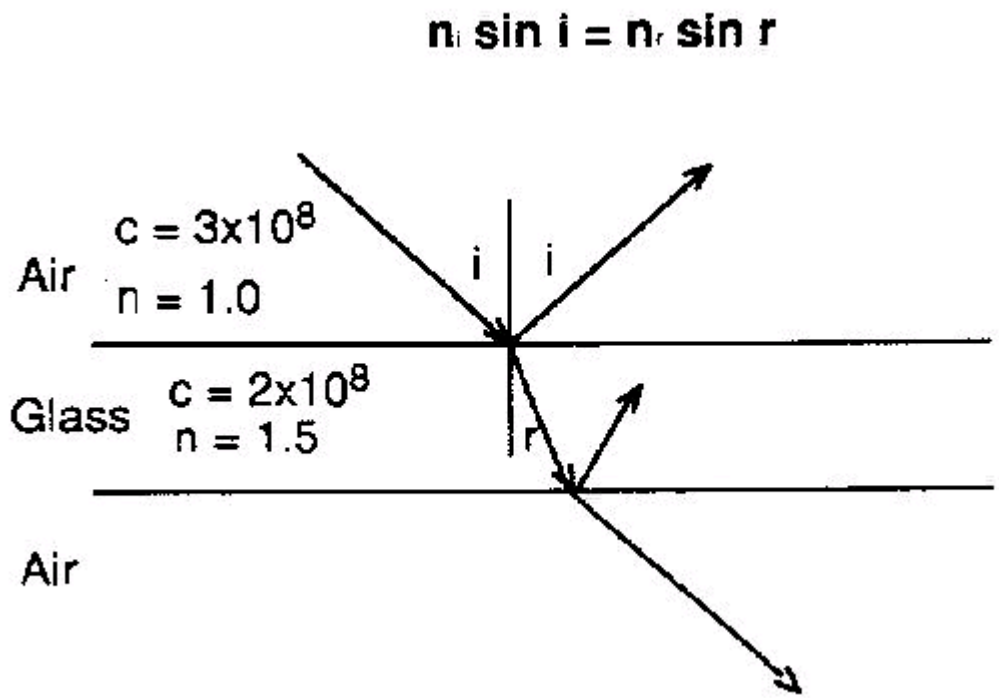


Pleochroism

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

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

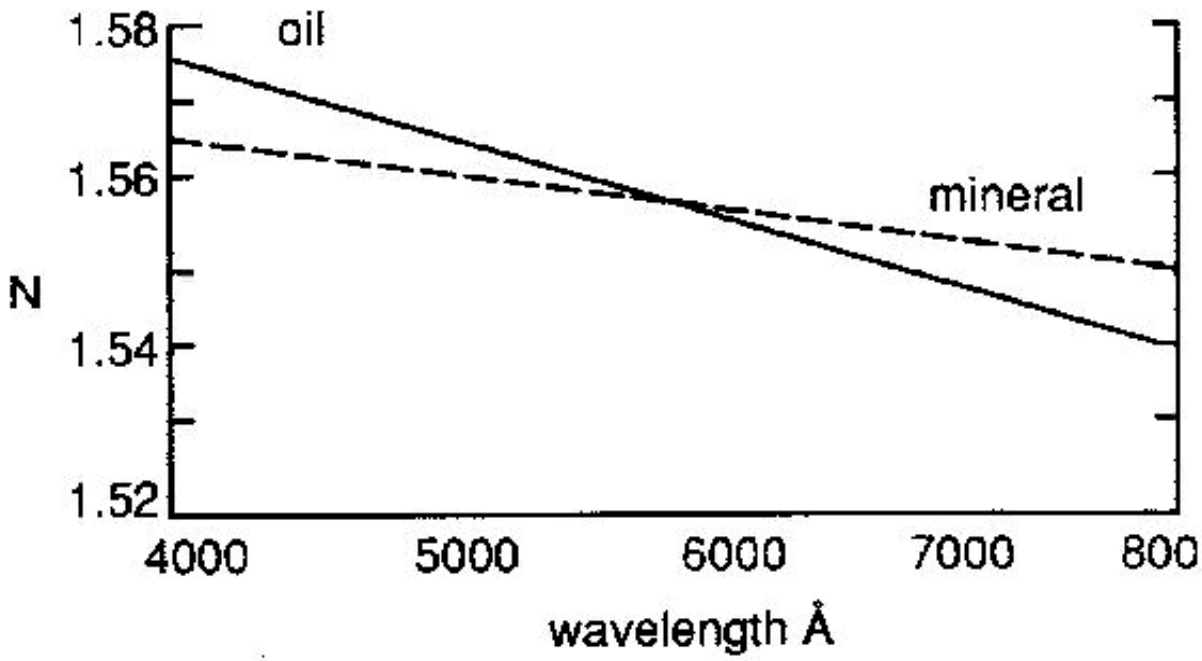
- Water has an index of refraction of 1.33. Light enters water at an angle of 40º from vertical What is the angle it makes in the water?
- $n_i \sin \omega_i = n_r \sin \omega_r$
- $1.0 \sin 40^\circ = 1.33 \sin \omega_r =$
- $\omega_r = \sin\text{-}1\ (.6428/1.33)$
- $\omega_r = 28.9^\circ$

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
- $1.33 \sin \omega_c = 1^* \sin 90^o$
- $\omega_c = \sin^{-1}(1/1.33)$
- $\omega_c = 48.8^o$

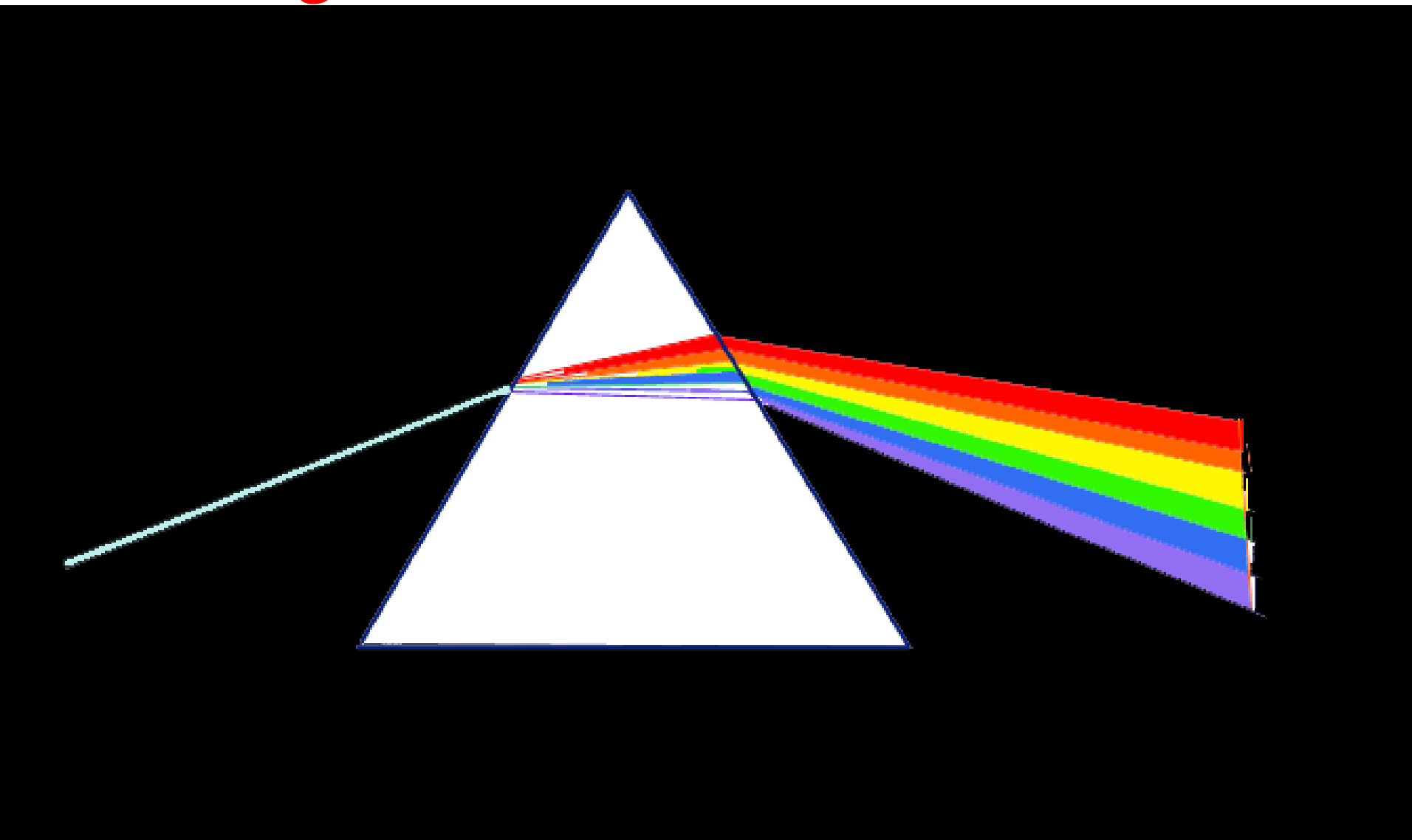
Dispersion

- 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.