Geology 221a - Mineralogy
Problem Set

Optics II

1. Identify the refractive index (if any) of a hexagonal mineral that can be measured for a grain with its **c**-axis in the following orientations:

   (a) vertical
   (b) horizontal and E-W
   (c) horizontal and N-S
   (d) horizontal and NE-SW
   (e) inclined in an E-W vertical plane
   (f) inclined in a N-S vertical plane
   (g) inclined in a NE-SW vertical plane

   Assume that the grain is mounted in an appropriate oil on a petrographic microscope that has an E-W polarizer.

2. A tetragonal mineral is optically positive with principal indices 1.632 and 1.644.

   (a) What is the maximum birefringence of this mineral?
   (b) What is the value of $\mathbf{n}_{\omega}$?
   (c) If the mineral has a perfect (110) cleavage, what refractive indices will be easy to measure for grains of this mineral dispersed on a glass slide in oils?
   (d) If the mineral occurs as crystals that are tabular parallel to (001), what refractive indices will be easy to measure for grains of this mineral dispersed on a glass slide in oils?

3. A tetragonal mineral with $\mathbf{n}_{\varepsilon} = 1.65$ and $\mathbf{n}_{\omega} = 1.48$ is cut parallel to (001) and mounted as a thin section (30 μm thick).

   (a) Draw the interference figure for this mineral. Show the vibration directions for light rays emerging in the centers of each of the four quadrants and on the boundaries between the quadrants. Label these vibration directions ω, ε', or ε as appropriate.
   (b) Make a second drawing of the interference figure with the quartz plate (550 nm) added. Use colored pencils. Label the quadrants of addition and subtraction. Let the slow ray of the quartz plate be oriented NE-SW.
   (c) Is the mineral positive or negative?
   (d) Remove the quartz plate and Bertrand lens. What retardation (interference color) is displayed by this mineral?

4. An optically positive orthorhombic mineral has good cleavages parallel to (100), (010), and (001). For this mineral the three principal refractive indices $\mathbf{n}_\alpha$, $\mathbf{n}_\beta$, and $\mathbf{n}_\gamma$ are for light vibrating in the **a**, **b**, and **c** directions, respectively. In other words, X=**a**, Y=**b**, Z=**c**. This mineral has a **2V**=30°.

   (a) What refractive indices are measurable in a dispersed grain mount on grains that rest on (100)? on (010)? on (001)?
   (b) What type of interference figure is observed for grains that rest on (100)? on (010)? on (001)? The choices are BxA, BxO, and flash figure (O.N.).
   (c) Make a drawing of the interference figure of this mineral for grains resting on (001) with the mineral at 45° from extinction. Label the following features on your drawing: isogyre(s), melatope(s), trace of the optic axial plane, traces of principal planes.
   (d) Show and label the vibration directions on the interference figure of (c) for light rays emerging at the melatope(s), isogyre(s), and in the center of the field of view.

5. (a) What are the angles between the $\mathbf{n}_\beta$ vibration direction and the optic axes of a biaxial mineral?
   (b) Which refractive indices can be measured on a biaxial grain that is oriented to give a centered optic axis figure?
   (c) When the slow ray of the quartz plate is parallel to the $\mathbf{n}_\gamma$ vibration direction of a biaxial mineral grain, will the retardation of the grain increase (addition) or decrease (subtraction) when the plate is inserted?
   (d) How are the appropriate grains for measurement of $\mathbf{n}_\alpha$, $\mathbf{n}_\beta$, and $\mathbf{n}_\gamma$ identified in a dispersed mount ?

6. True or false.

   (a) The **2V** of a mineral is dependent on the principal refractive indices of the mineral.
   (b) "Double Refraction" occurs only in uniaxial minerals.
   (c) For biaxial negative minerals, $\mathbf{n}_\alpha$ is the index of refraction for the **slow ray**.
   (d) A biaxial mineral grain showing the maximum retardation in a dispersed grain mount will yield a flash figure (an optic normal figure), if all thicknesses are about the same.
   (e) For biaxial positive minerals $\mathbf{2V}_\alpha$ is an acute angle.
   (f) In a monoclinic mineral the three principal vibration directions X($\mathbf{n}_\alpha$), Y($\mathbf{n}_\beta$), and Z($\mathbf{n}_\gamma$) are parallel to the three crystallographic axes.