Due Date: Thurs, November 21.

Exercise 1: Working with polarized light
Total Points: 5

Objective: To become familiar with the properties of polarized light and how light becomes polarized in anisotropic minerals.

Procedure:
1) Determine the polarizing direction for one of the polarizing films by seeing which orientation blocks out the glare on the windowsills in the classroom. This glare is horizontally oriented polarized light created by sunlight reflection off the tile.
   Polarizing direction for the angle-graduated polarizing film - _________________
   Polarizing direction for the rectangular polarizing film (parallel to short or long edge?) _________________

2) Place a clear rhombheedral crystal of calcite on a sheet of newspaper. You will notice that two images of the text appear. This represents a property common to anisotropic minerals of light rays splitting into two polarized rays which typically* have different indices of refraction (this difference is particularly strong in calcite). Rotate the crystal and notice that one image circles around the other. The stationary image is created by what is called ordinary rays and the circling image is created by extraordinary rays. Place the polarizer on the top of the crystal and address the questions below:
   Both the ordinary and extraordinary rays are polarized. How can you tell? ___________________________
   ________________________________________________________________________________________
   ________________________________________________________________________________________
   What is the relative orientation angle of polarization in the two rays? __________________________
   Is the orientation of polarization in either ray parallel to the cleavage directions in the calcite?
   ________________________________________________________________________________________

3) Place a clear rhombheedral crystal of halite on a sheet of newspaper and, using the polarizer film again, answer the following questions:
   How many images are visible? __________________________
   Are the light rays for the image(s) polarized? __________________________
   Are the optics of halite isotropic or anisotropic? (circle one)
   What does this tell you about the crystal system of halite? __________________________
Exercise 2: Determining indices of refraction by oil immersion
Total Points: 10

Objective: To become familiar with how indices of refraction can be determined by oil immersion techniques

Procedure:
Part 1: Dispersion, Relief, and Birefringence (5 pts)
1) Prepare a grain mount with either the quartz or the albite granulated samples. To do this, drip about 3 drops of refraction oil* on to a glass slide; with tweezers sprinkle a small amount of sample into the oil; set a thin glass cover slip on top of the oil drop.

* use 1.55 oil for quartz (n_ω = 1.544; n_ε = 1.553); use 1.53 oil for albite (n_α ~ 1.530, n_β ~ 1.533, n_γ ~ 1.539)

2) View your section in plane polarized light using medium power and medium illumination. When the grains are in sharp focus you should notice a halo of bluish and yellowish light on the perimeter of the grains. This is color dispersion of the Becke line as illustrated in the figure below and it is visible when the n of the immersion oil is close to that of the mineral. When you move the stage down (rotate focus knob clockwise), which way do the color bands move?

Bluish band _________________________________________
Yellowish band ______________________________________

From Bloss (1961)

3) When you rotate the stage, what do you notice about the relief of the mineral (i.e. the degree that is stands out in the oil?) ____________________________________________

4) Switch on the upper polarizer (the analyzer). Choose a mineral with very high interference colors. Rotate the stage until the mineral is at extinction. Switch off the analyzer and note the degree of relief. Is it high, medium, low, or barely visible?

Rotate the stage 90º (the mineral should be at extinction again when viewed with crossed polars). How would you describe the relief now?

__________________________________________________________________________

5) Switch the analyzer on again and find a mineral with low interference colors (gray to dark gray). Perform the same operation of noting the relief at two positions of extinction.

Position 1 ________________________, Position 2 (Pos. 1 + 90º) ____________________________
6) You should notice that there is a difference in the change in relief at the two extinction positions between the high interference colored mineral and the low interference colored mineral. As we will learn in coming lectures and labs, this is because the orientation of mineral controls the amount of refraction of the two polarized light rays. When you rotate the stage to an extinction position, you are viewing just the light rays that are vibrating parallel to the lower polarizer (which is why it gets blocked out when you put in the analyzer). The difference in the amount of refraction between the two light rays is called the **birefringence** and is manifest in the order of the interference colors (see color chart). The highest colors displayed indicate that the mineral is oriented such that two light rays have the highest and the lowest \( n \)'s for that mineral. Minerals that display very low colors indicate that the \( n \)'s of the two rays are almost the same and the birefringence is low. We will discuss why this is so in subsequent labs and lectures. Based on this information, what are the \( n \)'s of the two light rays viewed in step C above and the maximum birefringence:

\[ n_{\text{high}} = \quad ; \quad n_{\text{low}} = \quad ; \quad \text{Birefringence} = \quad \]

**Part 2: Determination of Index of Refraction by Oil Immersion and the Becke Line Test (5 pts)**

As a group at your table, work on determining the An content (Ca/Ca+Na %) of a plagioclase mineral (#12) by trying to match the \( n \) of the plagioclase with different refraction oils. Share your observations with your “optical detective” teammates. The figure below shows the range of refractive indices for different plagioclase compositions (use the \( \beta \) curve as the average \( n \)). Use relief and the Becke line test to determine if the \( n \) of the oil is higher or lower than the mineral and to zero in to a best fit oil.

![Optical Detective Team Name] ________________

\( n \) of best fit oil ____________

Estimated An content of sample __________