WARD'S
REFRACTIVE INDEX IMMERSION SLIDE STUDY SET
44-0250

NAME: _____ **DATE:** _____

Background

The refractive index is a fundamental property of minerals and other crystalline matter that relates the speed of light in the substance to the speed of light in air. The index of refraction, *n*, is a measure of the degree of slowing in the velocity of light passing through a mineral. The constant *n* is computed by measuring the ratio of the sine of the angle of incidence and the sine of the angle of refraction. Rather than measuring the degree of bending (refraction) as light enters a mineral, it is easier to compare the *n* of a mineral to the *n* of an oil of known refractive index. The comparison of indices is done with a microscope using the **Becke line.** The Becke line is a bright band of light that moves from the grain-oil interface into the medium of higher *n* when the focal length of the microscope is increased. The immersion slides in the set you will be using for this exercise are prepared with a permanent mounting medium possessing a refractive index of 1.53. All minerals with a refractive index, or *n,* larger than 1.53 will become brighter as the Becke line moves into them (when the focal distance of the microscope is raised). Those minerals with *n* less than the immersion medium will show the Becke line moving into the mounting medium. An immersion medium with a refractive index of 1.53 permits the separation of K-feldspars (they have an $n < 1.53$) and quartz and plagioclase ($n > 1.53$).

The following chart shows the range of refractive indices for key minerals in this investigation:

Chart I

Mineral	Refractive Index Range
Fluorite	1.43
Microcline	1.52 - 1.53
Immersion Medium	1.53
Albite, plagioclase	1.53 - 1.54
Quartz	1.54 - 1.55
Labradorite, plagioclase	1.56 - 1.58
Biotite	1.57 - 1.69
Calcite	1.49 - 1.66
Hornblende	1.61 - 1.70
Almandine	1.82

MATERIALS (Part I)

1 Set of prepared immersion slides, #1 - #9
1 Polarizing microscope
1 Set of copymaster worksheets

PROCEDURE (Part I)

In this investigation, you will learn how to evaluate the refractive index of minerals using the Becke line test.

A. Examine your microscope and determine which way the focus knobs must be rotated to increase the focal distance between the stage and objective. It is important to remember in which direction the knob must be turned to increase the focal distance.

B. Place slide #5 on the stage, and focus on the grains mounted on the slide using 50X to 100X magnification (the product of the eyepiece magnification factor times the objective magnification). Close the iris diaphragm on the microscope about 2/3 to 3/4 of the way for better relief.

Now, repeatedly increase and decrease the focal distance by rotating the focusing knob, bringing a grain boundary just in and out of focus. As the focal distance is increased, note which way the bright band of light moves---either into the grain or into the immersion medium. In this case, the bright Becke line of light moves toward the grain; this is the mineral labradorite, and its refractive index is greater than the surrounding immersion medium. Have each person in your team practice this simple test to become familiar with the Becke line and its motions. **Remember, as the focal distance between the slide and the objective is increased, the Becke line always moves toward the medium of higher refractive index.**

C. Next, examine slide #1. Note how the Becke line moves from the grain into the immersion medium; This mineral is fluorite and has an *n* lower than 1.53. Also note how high the grains seem to stand out from the mounting medium in relief. Relief increases as the difference in *n* between the grain and immersion medium increases. Now view slide #3. This mineral, albite, has a refractive index nearly the same as the mounting medium. Note how low the relief is. In general, mineral grains are nearly invisible when their *n* matches the *n* of the mounting medium; minerals have greater relief with increased *n*.

D. Examine slide #9. Note the high relief of almandine (garnet). Its ***n*** is 1.83, much higher than the 1.53 of the immersion medium. Cross the polarizers on your microscope by inserting the analyzer and note the extinction ("blacking out") of the grains. Garnet is isotropic, and all isotropic mineral colors are extinguished under crossed polars. Notice that garnet has no distinct cleavage in plane light.

E. Now, examine slide #7 and note which way the Becke line moves. You will find some grain orientations that are greater than *n* of the mounting medium and some that are less. This mineral, calcite, has a strong ability to split light into two rays, one faster (low *n*) and one slower (high *n*). This is the phenomenon known as **birefringence** and accounts for the strong colors seen under crossed polars. Also note the good rhombic cleavage of calcite when you compare slide #7 to the garnet in slide #9.

F. Examine each slide #1 through #9 in turn, comparing your observations and filling in the chart below as completely as possible. Be sure to note which is of greater *n*, the mineral or the mounting medium. State relief as low, medium or high, mark birefringence as the general color seen under crossed polars. Those minerals that are dark when the polars are crossed should be marked "isometric." Make note of the cleavage as good, poor, or none. Your knowledge will be tested in Part II where you will identify an unknown rock.

Slide #	Sample	Mineral n >,<,= media	Relief	Birefringence	Cleavage
1					
2					
3					
4					
5					
6					
7					
8					
9					

QUESTIONS (Part I)

1. Compare the mineral grains in slides #1 and #9. How are they similar or different? Why?

2. How can you distinguish the minerals in slides #6 and #8, biotite and hornblende? What characteristics about the cleavage and birefringence are different?

3. Does the Becke line in slide #3 give consistent results? Why does albite have low relief and show colored fringes of dispersion?

4. How can you distinguish the minerals in slides #4 and #5?

Table of Immersion Slide Properties

Slide #	Sample	*n*	Key Optical Properties
1	Fluorite	1.43	high relief, isometric, good octahedral cleavage, $n < 1.53$
2	Microcline	1.52 - 1.53	very low relief, $n < 1.53$, low birefringence colors (gray to yellow), perthitic texture some alteration, some cleavages
3	Albite	1.53 - 1.54	very low relief $n >\= 1.53$, low birefringence colors, some dispersion colors in Becke line
4	Quartz	1.54 - 1.55	low relief, $n > 1.53$, low birefringence (mostly gray to yellow), no cleavage
5	Labradorite	1.56 - 1.58	medium to high relief, $n > 1.53$, some prismatic cleavages, some twinning, gray to yellow birefringence colors
6	Biotite	1.57- 1.69	medium relief, brown cleavage plates, very dark under crossed polars
7	Calcite	1.49 - 1.66	high relief, rhombic cleavages, twinning common, very high birefringence
8	Hornblende	1.61 - 1.70	high relief, brown to green-brown, some prismatic cleavages, $n > 1.53$, deep color under crossed polars
9	Almandine	1.82	very high relief, isometric, lacks cleavage, $n > 1.53$
10	Granite		mixture of microcline, quartz, albite and biotite