

12.108 Lab#15: Optics III - Uniaxial Minerals

Nov. 16, 2004

1. Refraction in calcite: Mount calcite grains in an immersion oil with $n=1.54$, and observe a few grains under plane polarized light.

a) Describe what you see as the stage is rotated.

b) Sketch a series of diagrams which explain the optical phenomenon you observe, designating the preferred vibration directions of the ordinary ray (ω) and the extraordinary ray (ϵ) with respect to calcite cleavage planes and the polarization direction of incident light.

2. Optic axis interference figures for calcite Calcite (0001): Obtain an interference figure for the oriented thin section.

a) Sketch the interference figure (using color), both with the accessory plate in and with it out.

b) What is the optic sign for Calcite?

Off axis figures for calcite Calcite (1010): Obtain an interference figure for the oriented thin section.

c) Describe the interference figure for the oriented thin section. Explain what you see, using a sequence of diagrams to illustrate what happens to an off-axis interference figure when the stage is rotated

d) Draw a diagram for calcite, showing the relationship of the optical indicatrix to the crystallographic axes and crystal faces.

3. Optic axis interference figure for quartz: Obtain an interference figure for the Quartz (0001) oriented thin section

a) Sketch the interference figure (using color), both with the accessory plate in and with it out.

b) What is the optic sign for Quartz?

c) Draw a diagram for quartz, showing the relationship of the optical indicatrix to the crystallographic axes and crystal faces.

4) Recognition of minerals in hand-sample and thin section- Hand sample M-1 and associated thin section

a) describe quartz in the hand sample

b) using all the skills you've learned (color, crystal symmetry, cleavage, optical properties, etc.) distinguish quartz in the thin section. Draw a view of the thin section, noting quartz (and any other minerals you may recognize).

Describe the quartz (color, morphology, cleavage, optical properties, etc.) in the thin section.

c) what percentage of the thin section is quartz?

Methods for obtaining optic axis interference figures and the determination of optic sign for uniaxial minerals:

Set the microscope at low or medium magnification and focus on a good clear spot within the grain of interest. Change to the highest magnification objective, rotate the converging lens into place and refocus the image, under crossed nichols. At this point you will still see an image of the grain. Now move the Bertrand lens into place and focus it if necessary, to view the upper surface of the objective lens, upon which an interference figure will be projected. (see Zoltai and Stout, p 284-6 for an explanation of the physics of this procedure, but note that figure 11.27 is incorrectly labeled; a corrected version is provided below).

1. *Optic axis interference figure (oriented thin section)*: A uniaxial interference figure will consist of areas of blackness (extinction) called isogyres and of interference colors distributed along circular curves (isochromes). The isogyres form black bars, curved at their edges, which run N-S and/or E-W in the field of view. Whenever these two black bars intersect to form a cross, this intersection marks the point where light which traveled along the crystal's optic axis emerges in the field of view. If the crystal's optic axis is exactly perpendicular to the stage, the intersection will be centered in the field and remain so during complete rotation of the stage. Such a figure is called a centered optic axis figure.

Fig. 8-1

Image removed due to copyright considerations.

2. *Optic sign of mineral (positive or negative)*: Once a good interference figure has been obtained, the optic sign of the mineral can be determined. Insert the quartz accessory plate into the microscope and observe the changes in colors of interference rings in the figure.

Accessory plates: Crystal plates for which the retardation and the fast and slow vibration directions are known. These are commonly used to distinguish the slow from the fast direction for unknown minerals. The quartz wedge contains a wedge of quartz usually with the slow vibration direction (denoted by an etched arrow labeled Z or γ) perpendicular to the length of the wedge. Because its thickness varies, retardation will vary from about 0 at its thin end to about 2200 nm (or less) at its thick end.

Viewing a grain as a quartz wedge is slowly inserted: if the slow directions of the wedge and grain are parallel, the higher order isochromes will move toward the positions formerly occupied by the lower ones. If the slow directions are perpendicular, lower order isochromes will move toward the higher order isochromes.

a) *Optically positive minerals*: If the ordinary ray (ω) is smaller than the extraordinary ray (ϵ) the effect of this quartz plate will be additive with respect to interference colors in the northwest and southeast quadrants, and subtractive in the other quadrants.

Fig. 8.6 a,c

Image removed due to copyright considerations.

b) *Optically negative minerals*: If the ordinary ray is larger than the extraordinary ray, the effect of the quartz plate will be *subtractive* with respect to interference colors in the northwest and southeast quadrants, and additive in the other quadrants.

Fig 8-6 b,d

Image removed due to copyright considerations.

3. *Optic sign determination using interference figures (non-oriented thin section or unmounted grains)*: The optic sign is most easily determined from a centered or nearly centered optic axis figure, but with practice nearly any uniaxial interference figure can be used.

In general, a centered optic axis figure is obtained from a grain which remains dark on rotation of the stage (under crossed nicols). Such grains will likely be oriented so that the single circular section of their indicatrix is parallel, or nearly so, to the microscope stage. Consequently, the two indices they exhibit, ω and ϵ' (with a value very close to ω) differ little. Hence, interference colors are low, and permits their identification.

Smaller grains with highest order of interference colors display the principal ellipse with the semi-axes equal to ω and ϵ , and give flash figures under conoscopic observation. Flash figures consist of a diffuse isogyre which almost fills the entire field of view when the crystal is at extinction position. With a very slight rotation of the stage, this cross breaks up into hyperbola which rapidly leave the field of view. *Determination of optic sign from flash figures is difficult at best*

Fig. 8-5

Image removed due to copyright considerations.

Off-centered optic axis figures are obtained from grains with intermediate interference colors. The optic axis may or may not appear in the field of view, depending on the angle of inclination. If it does not appear in the field of view, only a single bar of the isogyre may usually be observed and rotation of the stage will successively bring different parts of the figure into view. With care, optic sign can be determined from off-centered optic axis figures. If you can identify the quadrant being observed, the rules cited above apply with respect to addition and subtraction.

Fig. 8-7a,b

Image removed due to copyright considerations.