LAB 2: OPTICAL PROPERTIES AND THE PLM #2

Optical Properties in Conoscopic Light

Learning Objectives:

- Students will be able to describe optical properties of minerals in conoscopic light
- Students will be able to use the Nikon E200 POL microscope to determine optical properties of minerals in conoscopic light

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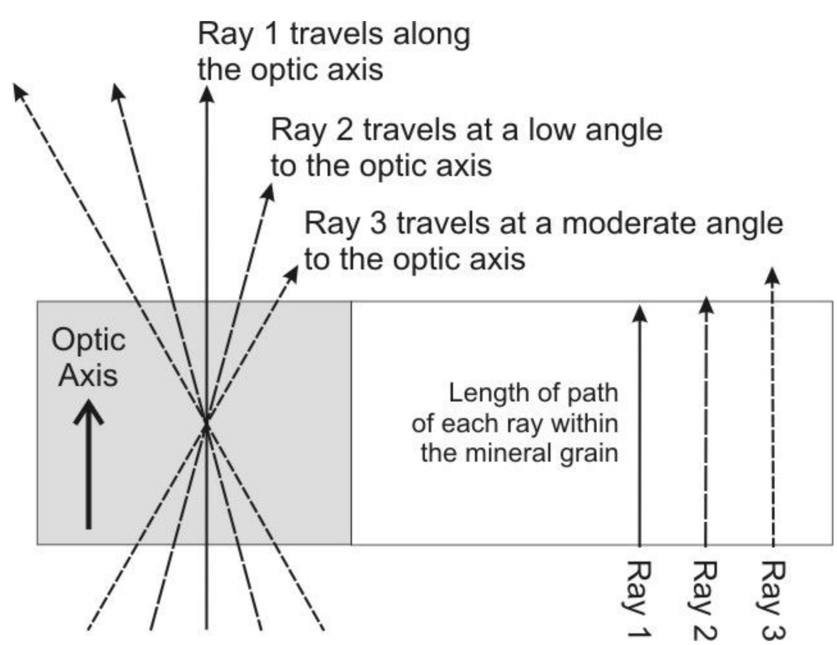
CONOSCOPIC LIGHT

In Lab 1 you examined minerals under orthoscopic light, that is the light rays that travel from the light source to your eye such that the light rays remain parallel to each other. The addition of the conoscopic lens to the light path causes the light to bend such that the light rays converge on the sample in a cone shape, and of diverge in an inverted cone above the sample. Thus light rays travel through the sample in different directions and over different distances (i.e., the more oblique the angle, the longer the path of the light ray through the sample).

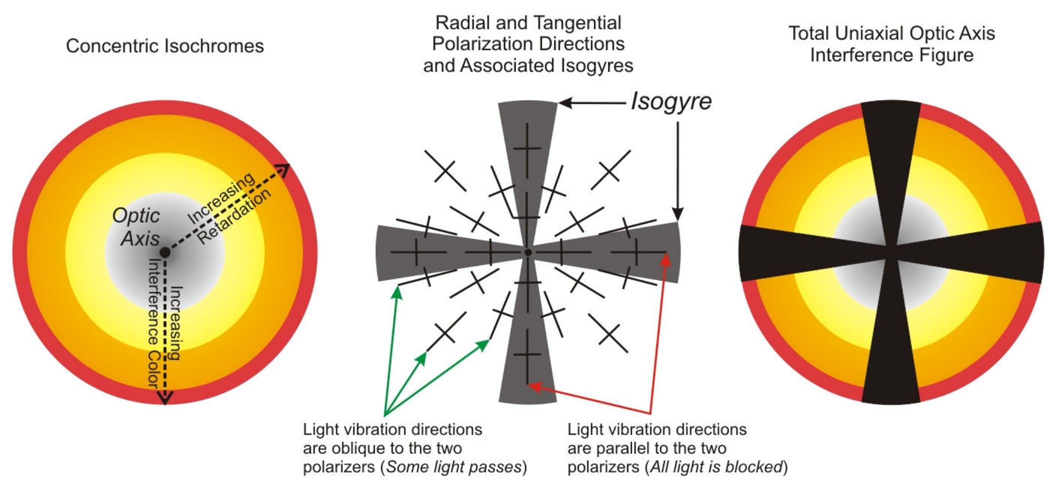


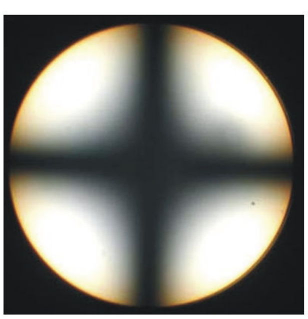
UNIAXIAL NTERFERENCE FIGURES

Hexagonal, trigonal and tetragonal minerals have a high degree of symmetry such that the atomic configuration and electron density is the same in any direction perpendicular to the c-axis. The c-axis corresponds to the optic axis. Minerals with one optic axis are termed **UNIAXIAL**.

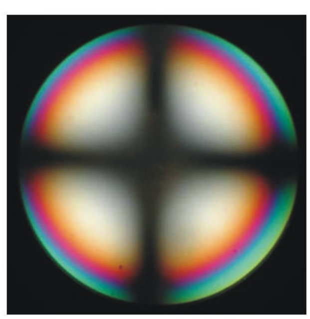
Uniaxial minerals under conoscopic light exhibit interference colors that increase concentrically away from the optic axis because retardation (path length x δ) increases away from the optic axis. These bands of color in the interference figure are called **isochromes**. The isochromes closest to the center are first order colors, and the sequence of colors outward from the center follow the interference color spectrum.

The vibration directions of the two split rays are always radial from, and tangential to, the optic axis. The analyzer extinguishes all rays that vibrate in the direction of either polarizing filter, resulting in a black cross that is centered on the optic axis. These black bands are called **isogyres**. If the optic axis is not exactly perpendicular to the stage, then the cross will be off-center and will orbit around the field of view, but the isogyres will remain in N-S and E-W orientations. The center of the cross corresponds to the position of the optic axis, and is referred to as the **melatope**.

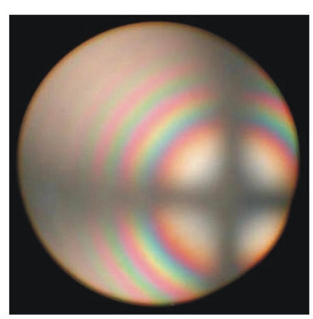




Centered Uniaxial Optic Axis Interference Figure (Low Birefringence Mineral)

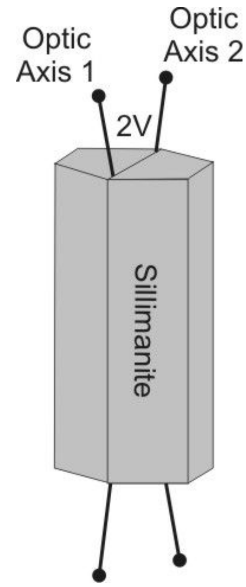


Centered Uniaxial Optic Axis Interference Figure (High Birefringence Mineral)

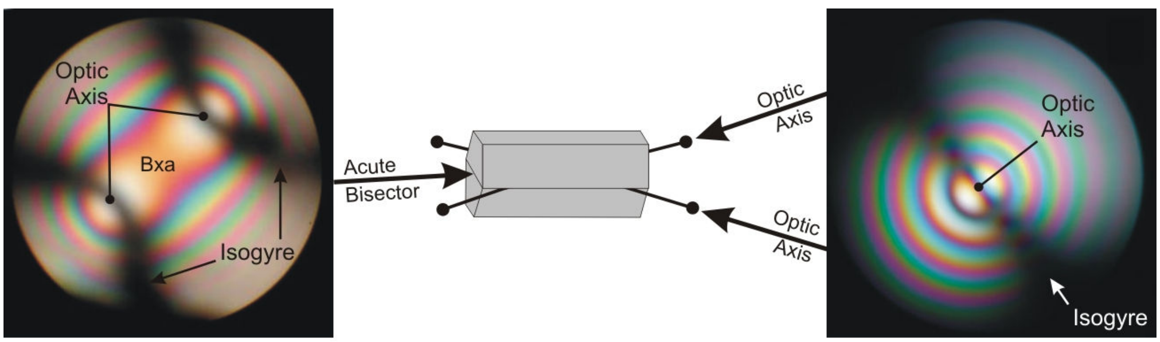


Off-Center Uniaxial Optic Axis Interference Figure (High Birefringence Mineral)

BIAXIAL NTERFERENCE FIGURES



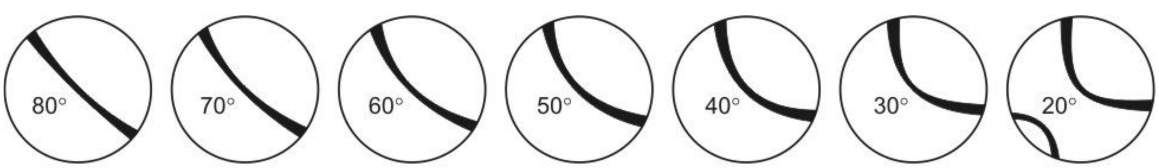
Orthorhombic, monoclinic and triclinic minerals have a lower degree of symmetry, and have two optic axes, and so these minerals are called **BIAXIAL**. The optic axes rarely correspond to the axes of the mineral grains themselves (i.e., they are not usually parallel or perpendicular to the length of the crystal). As with uniaxial minerals, biaxial minerals will exhibit low interference colors if they are oriented such that an optic axis is perpendicular to the stage. Such a crystal yields a **biaxial optic axis figure**, which consists of a single curved isogyre and a set of isochromes that are centered on the center of curvature of the isogyre (the melatope which corresponds to the optic axis). If instead, the mineral is oriented such that the bisector of the acute angle between the optic axes is perpendicular to the stage, then both isogyres corresponding to both optic axes may be seen.



Centered Biaxial Acute Bisectrix (Bxa) Interference Figure

Centered Biaxial Optic Axis Interference Figure

The angle between the two optic axes is one of the diagnostic properties of biaxial minerals, and is referred to as the **2V angle**. This angle can be estimated from the curvature of the isogyre, which is best documented in an optic axis figure.

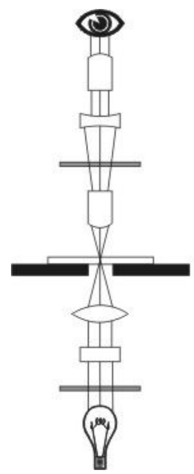


2V Angles for Centered Optic Axis Figures

Obtaining an Interference Figure

Interference patterns are related to optic axes. Therefore, the interference pattern that you obtain will depend both upon the mineral, and the orientation of the mineral. To simplify the situation we will focus on obtaining interference figures from minerals that oriented with an optic axis perpendicular to the stage (optic axis figures). Such grains will exhibit the *lowest interference colors*. When such a mineral grain is found, you can obtain an optic axis figure by doing the following:

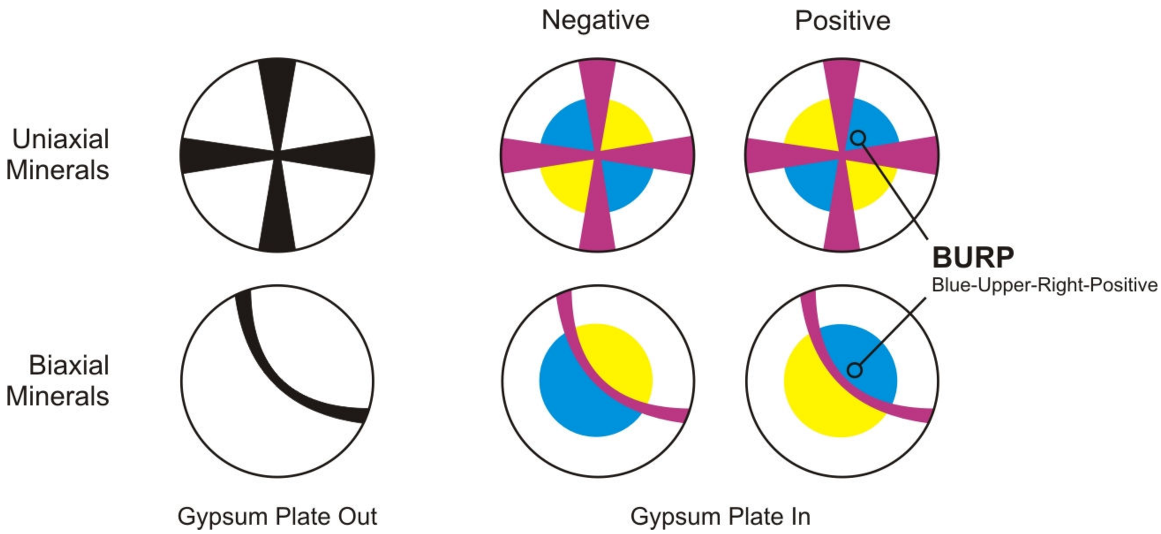
- Position your view inside the grain away from irregularities such as grain boundaries, fractures or inclusions
- Insert highest power objective lens
- Refocus
- Insert polarizer
- Insert the conoscopic lens
- Insert the Bertrand lens
- Focus the Bertand lens



Optic Sign

In some minerals the refractive index is lowest along the optic axis (**positive** optic sign), whereas in others refractive index is highest along the optic axis (**negative** optic sign). Determining the optic sign is similar to determining the sign of elongation (Lab 2) because both properties are based on the directions in which light travels fastest and slowest through the mineral; optic sign is based on the refractive index directions relative to the optic axis, whereas sign of elongation is based on refractive index directions relative to crystallographic axes. Accordingly, both methods involve the insertion of the gypsum plate and the documentation of the resulting change in interference colors. For optic sign, the gypsum plate is inserted to note color changes in the isochromes.

Obtain an optic axis figure. If the mineral is biaxial, rotate the stage until the isogyre is concave toward the northeast, as is illustrated below. Insert the gypsum plate and note the color in the northeast quadrant immediately adjacent to the isogyre. If the first color band in that position is blue, then the mineral has a positive optic sign, whereas if it is yellow, then the mineral is optically negative. A mnemonic to recall this definition is **BURP**—**B**lue **U**pper **R**ight **P**ositive.



ASSIGNMENT

Examine the INT FIG thin-section and practice the procedure for obtaining interference figures.

- Confirm that quartz in uniaxial positive
- Confirm that topaz is biaxial positive
- Confirm that muscovite is biaxial negative

For the minerals samples listed in the following table, determine if they are uniaxial or biaxial, the 2V angle if appropriate, and the optic sign. Identify mineral grains that will most likely yield optic axis figures (i.e., grains with the lowest interference colors).

Mineral	Uniaxial or Biaxial?	2V	Optic Sign
Calcite			
Diopside			
Enstatite			
Epidote (INT FIG)			