

ESS 439 Igneous Petrology

Laboratory 1: Introduction to Optical Mineralogy

Prepare an inventory of the equipment. This should include:

1. Microscope Number
2. Number, type, and condition of objective lenses
3. Number, type, and condition of oculars
4. Number, type, and condition of accessory plates
5. Number of centering wrenches (if any)
6. Number of stage clips (if any).

Check the condition of the lenses using a hand lens. Look for nicks, scratches, and any other damage. Make two copies of your inventory and turn one in to the instructor.

Care and security

1. Never leave the microscopes unattended.
2. Lock the scopes in the cabinet when you are through.
3. Cover the scope with a dust cover when not in use.
4. Use only lens tissue to clean lenses. Do not use alcohol or acetone. If there is any oil on the lenses, use KODAK lens cleaning fluid to remove it.
5. Do not unscrew or disassemble lenses. Clean only the accessible parts.
6. Be careful with the accessory plates.
7. Be very careful when focusing the microscope particularly when using the high power objective. It is easy to rack the lens on to the thin section and smash both. Determine the free working distance (FWD).
8. When changing objectives, use the knurled ring, i.e., do **NOT** use the lenses.

Light Source

In this class, we will use polychromatic light exclusively (Tungsten lamp with a blue filter). Visible light has a wave length ranging from 380 nm (violet) to 780 nm (red). For some precise measurements of optical properties, it is essential to use monochromatic light usually provided with a Na vapor lamp. Na light has a wave length of 589 nm.

In optical microscopy we always use polarized light. Polarized light vibrates in a single plane and is obtained by passing the light through a polarizer. The polarizer is often called a Nicol after the inventor and early microscopes used the system devised by Nicol which consists of two carefully cut and glued parts of a calcite rhombohedron. Modern scopes use a polarizing plate inserted below the microscope stage. The direction of vibration is called the *privileged direction*. In the Nikon scopes, the privileged direction of the lower polarizer is **East-West** (assume you are facing North).

The following topics will be discussed:

1. Intensity (I), wavelength (λ), frequency (f), velocity (c) of light.
2. Refractive Index (n)
3. Isotropic and Anisotropic media
4. Reflection and Refraction of light rays: Snell's Law
5. Critical Angle and Total Reflection
6. Refraction of light across planar surfaces
7. Dispersion of polychromatic light
8. Absorption, Transmission of light: Color
9. Lenses and Magnification

THE POLARIZING MICROSCOPE

The following topics will be discussed/demonstrated:

1. Images and magnifications in compound microscope
2. Light Source and mirror (\pm field diaphragm)
3. Substage assembly
 - a. Lower polarizer (nicol)
 - (i) determination of privileged direction using biotite crystals.
 - (ii) observations in plane polarized light.
 - (iii) orientation
 - b. Lower condensing lens.
 - c. Iris diaphragm with adjustable aperture.
 - d. Upper condensing lens: a powerful converging lens that can be swung in or out of the light path. This lens is used only in conjunction with high power objectives and when obtaining an interference figure.
4. Microscope stage: goniometer with scale and vernier. A stage clamp, stage clips can be attached if required. The stage contains threaded holes for the attachment of a mechanical stage, a point counter, a Universal Stage, or a heating-freezing stage.
5. Objectives: Usually 3 (low, medium and high power)
 - a. Angular aperture (AA) = $2u$
 - b. Numerical Aperture (NA) = $\sin u$
 - c. Free working distance (FWD)
 - d. Depth of focus
 - e. Magnification
 - f. Oil immersion lenses (not used in our work)

6. Accessory slot (usually oriented NW-SE)

- a. Gypsum plate (550 nm plate)
- b. Quarter wave plate
- c. Quartz wedge

7. Analyser

The analyser is a second nicol prism or polarizing plate located above the stage that may be inserted or withdrawn. The analyser is oriented such that its privileged direction is at 90° to that of the polarizer, i.e., north-south. When both polarizer and analyser are in position (CROSSED NICOLS or CROSSED POLARS) the privileged directions are at 90° to each other and no light is transmitted to the eyepiece (field of view is black).

8. Bertrand Lens

This lens is used to focus on interference figures and not on the section. Some Bertrand lenses come with an iris diaphragm.

9. Ocular (Eyepiece)

- a. Magnifications (4X or 5X and 10X or 12X).
- b. Monocular/binocular scopes
- c. Cross hairs and/or reticule--calibration
- d. Focussing of cross hairs
- e. Eye guards (used to screen out stray light)

NEVER DISASSEMBLE THE LENSES.

Adjustments of microscope

1. Fine/course focusing
2. Centering the objectives. The lens axis, scope axis, stage axis and cross hair intersection must coincide.
3. Centering the substage assembly
4. Light source intensity
5. Orientation of polarizer and analyser (use biotite to check)
6. Cleaning lenses and slides

ROCK and MINERAL SECTIONS

1. *Thin sections*: 30 μm thick rock slice mounted on 2" x 1" glass plate with cover slip (160-180 μm). The rock slice is mounted in epoxy resin ($n = 1.54 - 1.57$) and the coverslip is glued with Lakeside Cement ($n = 1.54$). The coverslip can be easily removed by heating and the section cleaned with alcohol if necessary (e.g., to polish the rock slice).

2. *Polished thin section*: 30 micron thick rock slice mounted on 2" x 1" glass plate. Instead of a cover slip, the upper surface is polished. This type of section takes longer to prepare but is essential for reflected light microscopy and for electron probe analysis and ion probe analysis.

3. *Doubly polished "thick" sections*: Rock slice up to 100 microns thick, polished on both sides. This type of sample is required for fluid inclusion microscopy using the heating/freezing stage.

4. *Oil immersion mounts*: Sieved fractions of rocks or minerals mounted on 2x1 slide (+ cover slip) in an oil with roughly the same refractive index as the mineral.

5. Modern research scopes come equipped with a dedicated computer that can display images on a monitor. Image analysis software can be applied to these images to determine modal abundances, grain size distributions, grain shapes, etc. Professor Debbie Kelley in Oceanography has such a scope and is willing to give us a demonstration of its capabilities if anyone is interested.

LAB EXERCISES

1. Prepare inventory and record condition of microscope.
2. Center lenses
3. Determine and record free working distance (FWD) for each objective.
4. Determine magnification of all objective/eyepiece combinations.
5. Determine privileged direction (PD) of polarizer using a thin section containing biotite.
6. Check that PD of polarizer and analyser are at 90° .
7. Check that cross hairs are parallel to PD of polarizer and analyser.
8. Calibrate the micrometer ocular using a stage micrometer.
9. Select one thin section from the set provided and use it to familiarize yourself with the microscope.