GY-343 Petrology
Petrographic Microscope Laboratory

Introduction to the Petrographic Microscope

In this laboratory you will be using the petrographic microscope to analyze thin sections of various types of igneous rocks. You will be assigned a thin section with which you will determine the mineral percentages by point counting the mineral grains in the thin section. As a final step you should choose the most appropriate ternary classification diagram(s) (IUGS) in your lecture text and plot the position of the sample to classify the rock. You will have two weeks to complete the lab. You should count a minimum of 100 points in the thin section to get valid results. If you can mount one on your assigned microscope, you should use a counting stage to tally the 100 point counts.

Elements of the Microscope

The petrographic microscope is much like any other microscope with the exception of a few additional attachments that are necessary for optical mineralogy determination. Figure 1 contains a diagram of a petrographic microscope similar to the type that we have in the lab. Below is a brief explanation of the more important parts of the microscope:

1. Eyepiece: this is the lens that you look through at the top of the microscope.

2. Analyzer (upper nicol): this is a polarizing filter that can be inserted or removed from the field of view with a lever on the eyepiece tube. The polarizer is oriented parallel to the East-West direction in the field of view.

3. Objectives: these are the lenses that are mounted on the turret in the middle portion of the microscope. These lenses are usually labeled in terms of their magnification power such as 10X, 40X, 100X, etc. The larger numbers provide a higher degree of magnification.

4. Stage: this is the flat circular area directly below the objectives where the thin section will rest when you are observing it. The stage rotates through 360 degrees and has a vernier scale to measure angular rotations.

5. Fine and Coarse Focus Adjustment: the large and small circular adjustments on the lower portion of the body of the microscope are used to rack the stage up and down thus changing the focus of the objective lens in use. This adjustment should be used to focus the thin section.

6. Lower Analyzer (lower nicol): polarizing element below the stage. Thus when light is transmitted from the light source to the thin section it passes through the lower analyzer and is plane polarized in a North-South plane relative to the field of view.

7. Iris (aperture diaphragm): this is an adjustment nearest the light source that allows more or less light to be transmitted to the stage.

8. Condensing lens: located with lower analyzer. Must not be engaged for our lab.

Optical Mineralogy Terminology

The below terms describe or define important properties of minerals that you will use to identify minerals in the thin section:

Anisotropic mineral: an anisotropic mineral possesses different optical properties in different crystallographic directions. Anisotropic minerals are members of the triclinic, monoclinic, orthorhombic, tetragonal, and hexagonal crystal classes. Since most silicate minerals are members of these classes, most minerals in common igneous rocks are anisotropic.

Birefringence (Interference Colors): when both analyzers (nicols) are inserted (nicols crossed) any anisotropic material will produce colors based on the thickness of the grain and on the optical properties of the mineral. Although this color does not directly identify the mineral it does narrow the possibilities considerably. The colors will change on a mineral grain as the stage is rotated. At two positions 90 degrees apart the mineral grain displaying birefringence will become totally dark (extinction position).

Cleavage: hairline fractures or traces that are crystallographically controlled. In many grains the cleavage is parallel to well developed faces. Some combinations of cleavage directions are diagnostic, such as the 120 and 60 degree intersections in amphibole hornblende.

Crossed analyzers (crossed nicols): when the upper analyzer is inserted the microscope contains crossed analyzers since the lower analyzer is oriented N-S and the upper analyzer is oriented E-W.

Extinction: a mineral grain is "extinct" when it is totally black under crossed analyzers. This will occur at two positions 90 degrees apart if the mineral is anisotropic (uniaxial or biaxial). If the mineral is isotropic it will remain extinct through 360 degrees of stage rotation under crossed analyzers.

Extinction angle: the angle that some crystallographic direction, such as a crystal face, makes with the extinction position of the grain.

Isotropic mineral: minerals that possess the same optical properties for transmitted light in all crystallographic directions are termed isotropic. All isotropic minerals are members of the isometric class. An example is garnet.

Plane Polarized Light: the microscope is in this mode when the bottom analyzer is inserted (it will always be inserted) and the upper analyzer is not.

Pleochroism: the property of a mineral to show a play of colors when the stage is rotated in plane polarized light (upper analyzer out). Examples include biotite and hornblende.

Relief: refers to the "height" or distinctness of the grain boundary relative to adjacent grains. If the crystal outline is very distinct and the mineral seems to visually rise above the adjacent grains, it has high relief. Grains that seem to be very thin and lie lower than surrounding grains have low relief.

Twinning: twin planes divide volumes of the mineral grain that have different crystallographic orientations, therefore, twinning is very evident under crossed analyzers because the individual twins show different degrees of birefringence. In some twinned crystals, especially plagioclase, one set of twins will be extinct while the other is not. This greatly enhances the ability to identify the polysynthetic twinning in plagioclase. Microcline usually has a characteristic "grid" twin pattern. The twinning properties of the feldspars makes them rather easy to identify under crossed analyzers.

Undulose extinction: a characteristic of extinction peculiar to quartz where the extinction sweeps through the grain rather than covers it entirely at a single stage position.

<u>Optical Characteristics of Common Igneous Minerals</u>

Biotite: one direction of perfect cleavage and brown-red pleochroism. Mottled birefringence also characteristic.

Clinopyroxene: Colorless to pale green to bright green in plane polarized light. Birefringence is rather strong and ranges up to a maximum of upper second order. Twinning is common. Maximum extinction angle varies from 37 to 44 degrees. Usually occurs as short prismatic crystals that are 4 or 8 sided.

Feldspathoids: very similar to quartz in properties but usually occurs as short prismatic euhedral crystals. May also be mistaken for K-feldspar but does not have the grid twinning.

Hornblende: strong green to brown pleochroism under plane polarized light. Most crystals will display the two cleavage directions at 60 and 120 degree angles. Grains are usually euhedral to subhedral with bounding faces parallel to the cleavage traces. Birefringence ranges up to middle second order but the strong absorption cause the colors to be anomalous.

K-feldspar: usually microcline in phaneritic rocks. Low birefringence is 1st order gray to white, somewhat less than that of quartz. Usually displays "grid" twinning that is very diagnostic.

Muscovite: one direction of perfect cleavage, colorless to pale green in plane polarized light, mottled birefringent colors under crossed analyzers. Maximum birefringence is upper 2nd order.

Olivine: colorless in plane polarized light. Usually crossed by numerous fractures that may be altered. Relief is fairly high. Birefringence is strong and ranges up to upper second order colors. Resembles diopside but diopside has oblique extinction whereas olivine has parallel extinction.

Orthopyroxene: two directions of cleavage at right angles. High relief with birefringence ranging up to pale yellow of first order. Parallel extinction. Hypersthene may have pale red or green pleochroism.

Plagioclase: birefringence is low, about 1st order gray to white. Most characteristic is the polysynthetic twinning.

Quartz: usually anhedral in form since it forms late in crystallization sequence. 1st order white birefringence and undulose extinction is diagnostic.

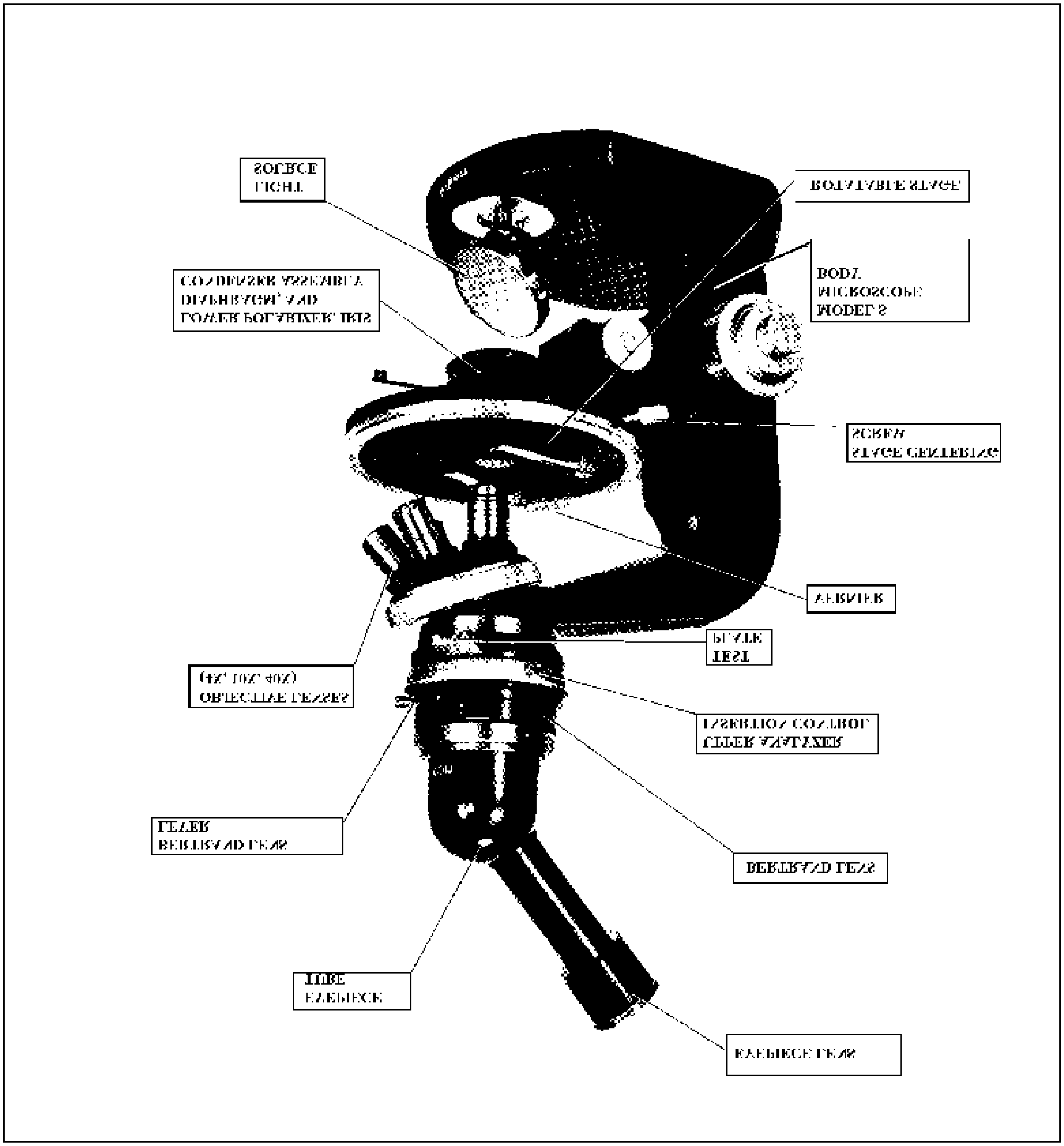

Figure 1. Diagram of petrographic microscope.