NOTES AND NEWS

GRAIN-THIN SECTIONS AND OTHER TEACHING AIDS IN OPTICAL MINERALOGY

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In an effort to make it possible for a student in optical mineralogy to study all of the optical characteristics of a mineral in a thin section, a method has been developed for making thin sections containing an ample number of grains of the same mineral in random orientations, in which each individual grain is completely surrounded by Canada balsam. The materials commonly used in the optical mineralogy laboratory for studying the optical properties of one particular mineral usually consist of:

(1) mineral grains or powder between 150 and 200 mesh for the immersion method,
(2) slides containing these grains, mounted in Canada balsam,
(3) a set of thin sections of a large piece of mineral at random orientation, usually showing only one orientation,
(4) thin sections of rock, containing among other minerals some grains of the mineral under consideration, and
(5) oriented slides containing one small piece of mineral at one special orientation.

The importance of the immersion technique is generally recognized and should be mastered by all serious students of rocks, minerals, and ores; nevertheless, it does not enable the student to observe all of the optical properties without going to considerable trouble if the mineral grains have a tendency to lie in a preferred orientation due to cleavage. As reference material in connection with thin-section work the use of grains is limited. Grains mounted in Canada balsam are of value for the transition from the immersion technique to thin-section work and acquaint the student with the relief of the particular mineral. Thin sections of one large piece of mineral at random orientation are of doubtful value, since the one orientation shown is seldom sufficient for the determination of the mineral, and if the appearance of the mineral under consideration in this one orientation becomes fixed in the mind of the student it is even misleading. As reference material a set of these slides is useless. Thin sections of rock containing the mineral have the advantage of showing the particular mineral among associated minerals, but in studying the optical properties the student spends much time in locating the few grains of the mineral in question present in the section, sees the mineral mostly in contact with other minerals, and as in the case of schists and gneisses, the mineral will occur only in one preferred orientation. The oriented slides are intended mainly for studying interference figures and are seldom of correct thickness. To be of real value these slides should be properly labelled, show some indication of the crystal orientation, and be of correct thickness. The ideal thin section for showing what the three last mentioned slides are intended to show would consist of a thin section containing around 200 grains of a certain mineral at random orientation, mounted in Canada balsam, and showing the crystal outline or orientation. The grains should be closely spaced to make comparison between grains of different orientation easy and impressive. All grains should be of correct thickness and large enough to give clear interference figures. The new slide reaches this ideal in some cases, but falls short in the following respects: (1) Only minerals which are not affected by salt water, and which break up in nearly equidimensional grains can be prepared by the new method. For this reason sections of gypsum, most micas, and fibrous minerals cannot be prepared. (2) In crushed material the crystal orientation can be determined only when the mineral has cleavage. It is seldom possible to obtain a large enough number of individual, well developed, small crystals between 9 and 60 mesh in size to make a slide. Another disadvantage of crushing the mineral is that since the twinning plane is often a plane of weakness, much twinning is eliminated in crushing. (3) The strength of the mineral to resist the grinding action varies with orientation and therefore, although the mineral grains are at random orientation in the blank grains in certain orientations are liable to be plucked out in the grinding operation. For this reason basal sections of amphibole and pyroxene are rather rare in a slide. (4) It is difficult to obtain mineral material which is absolutely pure. If the impurities occur as separate grains and in negligible amounts, these foreign grains can easily be removed from the slide before covering. On the other hand, if these impurities occur as inclusions, not much can be done about it. However, in general, one can say that as long as these impurities are characteristic associated minerals and do not occur in such quantities as to obscure the mineral under consideration, little harm is done by their presence.

Method of Preparation

In order to prepare thin sections of more than one particle on one slide, the individual pieces have to be mounted in some material which will permit the preparation of one common plane surface, and hold this surface at the elevated temperature of the hot plate while cementing to the glass slide. Secondly, since the abrasive action is severe on the edges of hard particles imbedded in a soft matrix, a cement stronger than Canada balsam should be used.

For a mounting medium thermosetting plastics have the disadvantage that the plastic cannot easily be removed after the section is prepared and the index of refraction of the transparent varieties does not match the index of Canada balsam. Thermoplastic plastics neither match the index of Canada balsam nor hold a sufficiently plane surface on the hot-plate. Although lucite has been used for making sections of pebbles, it has been found less advantageous in grinding properties and more difficult to use than plaster of Paris. In the preparation of grain-thin sections, plaster of Paris is used. The crushed and sieved grains—best results are obtained with grains between 9 and 60 mesh—are mixed dry with plaster, then water is added until a creamy paste is formed and the mixture poured into a mould 22×22 mm. and ¼″ deep. Since the consistency of the mixture is of utmost importance, particularly the amount of water, the exact measurements for quartz (and most other minerals) are here given for 6 blanks of the above given size: 12 cc. dry washed grains, 20 cc. plaster, and 7.5 cc. $\pm .2$ cc. water. With some minerals the amount of water may be slightly different. The mineral grains inside the blank are at truly random orientation. If a preferred orientation is desired the moist grains can be arranged on a glass plate and the plaster poured over it.

After the blanks are set, thin sections of them are prepared in the usual manner except that instead of Canada balsam, Lakeside No. 70 transparent cement is used.* The finished thin section contains the grains in a matrix of plaster of Paris. Plaster is soluble in small amounts in water, but to dissolve the thin layer present required up to 48 hours. Adding salt (NaCl) to the water speeds the process to 1 or 2 hours. As soon as all plaster is dissolved, the scum left on the slide is washed off in water and any dirt caused by grinding is cleaned off with xylene. The sections are then covered in the usual manner, using a slightly larger amount of balsam to fill the space between grains.

Additional Special Slides

In addition to grain-thin sections, four additional slides have been made for the purpose of studying interference figures and relief. The idea behind these slides was that it is an advantage to see objects for comparison with each other, either simultaneously or in quick succession. For this reason a relief scale was made containing 6 grains of the following minerals: fluorite, orthoclase, quartz, beryl, apatite, and garnet, mounted in the form of a star. The grains are sufficiently close together to make it possible to bring the center of the star with all six minerals simultaneously into the field of the 16 mm. objective. The star is located in a hole of a thin paper mask bearing the names of the minerals. This makes it easy to find the mount on the slide. For interference figures a slide with a mask with 6 holes is used. Each hole contains an oriented plate of mineral

* Properties of Lakeside #70 cement are discussed under the heading "Notes on Lakeside #70 Transparent Cement" by the author.

and the different interference figures can be brought into view by sliding the section from hole to hole without refocusing. The slide contains the following orientations: quartz, perpendicular to *c* for uniaxial positive; topaz, perpendicular to Bx_a positive; muscovite, perpendicular to Bx_a negative; epidote, optic axis; barite, perpendicular to Bx_0; and topaz cut halfway between optic axis and Bx_a so that one emergence point and the center of the Bx_a are simultaneously in the field. This orientation demonstrates the mechanism of the isogyres in a spectacular manner. All plates are cut to a thickness to show the interference figures to best advantage and selected minerals of extreme clearness are used for the purpose.

To enable the student to get acquainted with the appearance of the isogyres for different values of 2V, a similar slide has been prepared containing plates perpendicular to the Bx_a of the following minerals: phlogopite 7.5°, aragonite 18°, muscovite 40°, topaz 60°, orthoclase 70°, andalusite 84°. Since the optic axis angle of most of these minerals is variable, a simple device for measuring the optic axis angle was constructed with which the angle can be determined to $\pm 1°$ directly from the interference figure. This device consists of a $\frac{3}{8}'' \times 1'' \times 2''$ brass plate to which are attached sheet-brass legs by which it can be held on the stage of the microscope by the stage clips, and a protractor which is fastened to one $\frac{3}{8}'' \times 2''$ side. Through the center of the protractor half-circle, a $\frac{1}{8}''$ hole is drilled, which is extended through the width of the plate. A shaft which passes through this hole carries on the protractor side an arm with a pointer; on the other side a thin plate 32 GA$\times \frac{3}{8}'' \times \frac{1}{2}''$ which has a $\frac{1}{4}''$ diameter hole in the center. A friction spring holds the shaft in any desired position. From the mineral crystal a plate is cut approximately perpendicular to the Bx_a and mounted on an 8 mm. square cover glass. One-fourth inch diameter glass hemispheres are cemented to the cover glass and over the mineral plate in such a way as to form a complete sphere. These hemispheres are made by melting the end of a glass rod, sawing off the rounded end, and grinding the flat side to form a hemisphere. With a small blocking tool for grinding, these hemispheres can be made quickly and the curvature is sufficiently accurate for giving a sharp image when the hemisphere is used as a lens. The mounted mineral plate is now inserted into the $\frac{1}{4}''$ hole in the metal plate, the interference figure is obtained with the medium power objective without throw-out condenser and with the substage at its highest position. The cover glass is turned until the optic plane is parallel to the plane of the protractor. Then the stage of the microscope is set to the 45° position, and the protractor arm turned until the emergence point of one optic axis is lined up with the cross-hair. After the angle has been read, the arm is turned until the other emergence point is in line. The angle between the two measurements is 2E of the mineral against the index of the hemispheres. When the index of the glass of the hemispheres is known, the angle 2V can be computed. This device can easily be made and can be used in class for giving a vivid demonstration to clarify the relation of the optic axis figure to the Bx_a.

Since most beginning students have difficulty in distinguishing the Bx_a from the Bx_o for large optic axis angles, a fourth special slide is provided, with two holes in the paper mask. In one hole a plate of andalusite 84° Bx_a is mounted, while the other hole has a plate of the same mineral cut for Bx_o. With this slide the student can observe quickly the difference in appearance between the two figures.

It is believed that a set of these mineral slides in connection with the monomineralic grain-thin section will eliminate much waste of time in the laboratory and give the student a vivid and complete conception of the optical properties of the different minerals. The same set could be used to advantage as a reference set in further studies in petrography.†

Grain-thin sections have been used for the following purposes other than teaching aids: (1) in sedimentary problems for the identification of mineral grains in fractions coarser than 100 mesh; (2) for control of nonmetallic coarse concentrates in the concentrating process; (3) for examination of churn drill sludge.

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NOTES ON LAKESIDE NO. 70 TRANSPARENT CEMENT

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Since Lakeside No. 70 cement is rapidly taking the place of Canada balsam as a mounting cement for preparation of thin sections, a few

† Sets of 40 mineral grain-thin sections and the four special slides are obtainable through Ward's Natural Science Establishment, Rochester, N. Y., or through the author.