THE AMERICAN MINERALOGIST, VOL. 53, NOVEMBER-DECEMBER, 1968

PREPARATION OF POLISHED THIN SECTIONS

GROVER C. MORELAND, *Department of Mineral Sciences, Smithsonian Institution, Washington, D.C.*

ABSTRACT

Techniques are described for the preparation of polished thin sections suitable for examination in reflected and transmitted light and electron microprobe analysis. The techniques are designed to economize on irreplaceable material such as meteorites. Uniform polished surfaces of heterogeneous material containing silicates, sulfides, and metal particles are attained by three stages of polishing with diamond and alumina-abrasive cloths.

INTRODUCTION

A polished thin section is much more useful than a standard thin section or polished section. A single section can be examined in both reflected light and transmitted light and used for electron microprobe studies.

This discussion will deal with the preparation of polished thin sections of stony meteorites, minerals and rocks.

CUTTING THE SPECIMEN

A 5″×0.015″ diamond saw blade is generally used because the cut is considerably smoother than can be obtained with the usual 5″×0.055″ blade, and, in addition, use of a thin blade conserves material. This is often a very important consideration, especially in meteorites. The cut wafer should be about 1/8″ thick with flat parallel surfaces, and about one inch square.

IMPREGNATION

Some specimens are porous, fragile, or water soluble. In this case a binder is added. First the specimen is dried for approximately 30 minutes at 200°F, and after cooling immersed in the impregnating media under vacuum. It is helpful if the vacuum is occasionally broken and restored. The inrushing air will help to force the impregnating solution into the pores and cavities. Two to three hours of immersion should give adequate impregnation.

The following impregnating solution is used: equal portions of epoxy resin and hardner (Araldite AY105 and Hardner 935F)[1] are mixed. This freshly prepared mixture is dissolved in three parts of toluene, with occasional stirring. About an hour at room temperature is sufficient for complete solution, and the impregnating mixture is now ready for use. The curing time is about one hour at 200°F or 15 minutes at 300°F.

[1] Chemical and Engineering Co., Inc., 221 Brooke St., Media, Pa. 19063.

This impregnation medium has given excellent results on very friable materials, such as carbonaceous chondrites and decomposed granite. It also has a favorable index of refraction of 1.55.

Mounting

The side of the specimen which is to be cemented to the glass is ground to an optically flat surface, using a water slurry of 600 aluminum oxide on a 850 rpm 12″ cast-iron lap.

The specimen is then placed on a 200°F hot plate ground side up, with the glass slide numbered side down. After 30 minutes, equal portions of Araldite AY105 and Hardner 935F are mixed in a small aluminum dish on the 200°F hot plate and stirred until it becomes clear (40 seconds). The plastic thus prepared must be applied immediately as it thickens in three to five minutes. A thin even coat is spread on the flat side of the specimen with a wooden spatula. The glass slide is then slowly lowered on the specimen from a 45° angle. Any trapped air bubbles are immediately removed by rubbing the back side of the glass with a soft object such as a sharpened wooden dowl. The slide is then turned over, the specimen quickly positioned, and left on the hot plate for 30 minutes to completely cure. After removing from the hot plate and allowed to cool, traces of the plastic sticking to the glass are gently removed with a razor blade. Note, that in mounting the section no toluene is mixed with the plastic.

Sawing and Grinding

For reduction in thickness and conservation of material an Ingram Model 103 thin section cut-off saw[1] is used to saw the specimen to a thickness of 0.020 inches. The slice removed can be reserved for future use. The section is further reduced on an Ingram Model 303 thin section grinder,[1] using a diamond wheel. The microscrew adjustment on the grinder is positioned so that the specimen barely touches the wheel. The specimen is then slowly advanced against the wheel, and from time to time examined under the microscope to determine its thickness until a thickness of 40 microns has been reached. The slide is now ready for the next grinding step.

Further grinding is done by hand, first on a 850 rpm horizontal lap using a slurry of 600 aluminum oxide and water. The slide is held with one hand, while the aluminum oxide-water slurry is applied sparingly and evenly to the rotating lap with the other hand. When the slurry that has been applied to the lap reaches a semi-dry condition (a few seconds), grinding is started with light pressure. After 15–20 seconds the slide is

[1] Ingram Laboratories, Griffin, Ga.

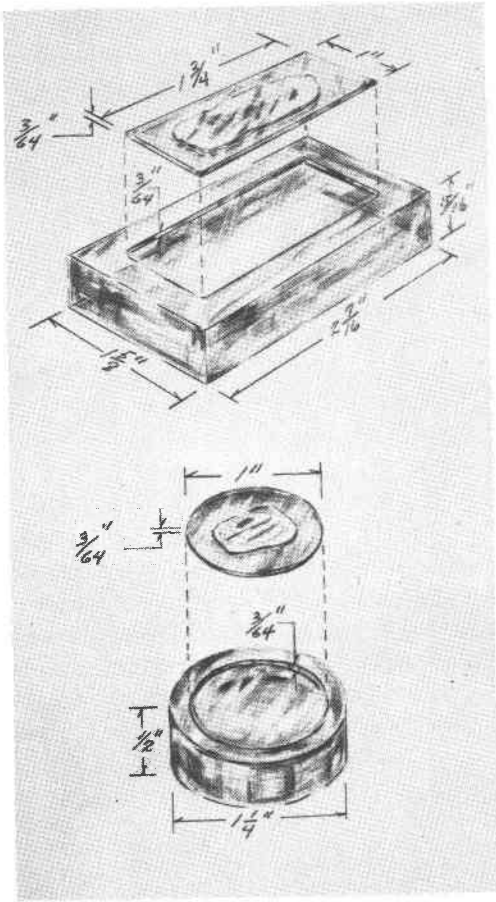

FIG. 1. During the polishing operation the thin section is best held in plastic holders as shown in the above sketches: (top) for standard petrographic sections; (bottom) for circular microprobe sections. A drop of water is placed between the slide and the holder to hold the slide in place.

rinsed with clear water and examined under a polarizing microscope to check its thickness. This step must be repeated until the desired thickness is obtained.

The last step in the grinding process is done on a glass plate with a water slurry of 1500 aluminum oxide. The hand grinding step provides excellent control over final thickness. Standard thickness is 30 microns, but thickness down to 10 microns can be obtained by exercising extreme care, and after considerable skill has been acquired. Another advantage of the hand grinding is that plucking is almost entirely eliminated.

Polishing

Most meteorite and rock specimens contain both opaque and non-opaque minerals. Because the polishing characteristics of opaques differ from nonopaques, special polishing media and techniques are needed for each.

The first step in the polishing operation is designed to rough polish the opaques; the second step is to polish the nonopaques. If both types of minerals are found in a specimen, then both steps are needed. The third step removes the pits and ultra-fine scratches. This step is used to prepare both opaques and non-opaques as well as specimens containing a mixture of the two types of minerals.

The first step is to provide a rough polish for opaques. For this AB Texmet[1] lap cloth impregnated with three micron diamond abrasive is used. The lap is lubricated with a one to one mixture of Buehler[1] 40–8140 mineral spirits and 40–8142 polishing oil. Apply enough of the lubricant to give the cloth a slightly damp appearance. Since the lubricant does not evaporate, one application should last several days. In this step the lap should turn at 600 rpm. The specimen is placed on the lap and moved in a circular direction opposite to the rotation of the lap. Using moderate pressure on the specimen, polish for approximately $1\frac{1}{2}$ minutes, then rotate the specimen 180° and polish for an additional $1\frac{1}{2}$ minutes. The objective of this step is to remove the fairly coarse pits and scratches.

After completing each step the specimen should be carefully cleaned with water and liquid soap using a soft (camel's hair) brush. If the specimen is partly soluble in water, clean it with alcohol.

The objective of step two is to polish the non-opaques. In this step Polytex Supreme lap cloth[2] is used. The polishing media is Linde grade 0.3A Alumina abrasive. A light slurry is prepared by sprinkling a small amount of the abrasive on the lap, adding water or alcohol if needed, and mixing with one's fingers. While polishing in this step it is important to keep the lap wet. A dry lap will produce scratches. As in step one the wheel should turn at 600 rpm.

Use light pressure and move the specimen in a circular motion opposite to the direction of rotation of the lap. After two to three minutes rotate the specimen 180° and continue polishing for another two to three minutes. If the specimen begins to grab during any part of this step, stop polishing and add more water. Periodic inspection under a microscope equipped with vertical illumination will indicate whether most of the

[1] Adolf Buehler, Inc., 2120 Greenwood St., Evanston, Ill.
[2] Geoscience Instrument Corp., 110 Beekman St., N. U., N. Y. 10038.

scratches and pits have been removed. When this condition is reached, wash the specimen and go on to step three.

For final polishing AB Microcloth[3] and Linde Type 0.05B High Purity Alumina Abrasive are used. In contrast with steps one and two, the wheel should turn slowly (163 rpm). As in step two, prepare a light slurry on the turning lap using water or alcohol and the abrasive. After applying the slurry use a laboratory wiping cloth to remove most of the abrasive solution. During the final polish the lap should be almost dry. This condition provides good polishing characteristics while minimizing relief. After applying the specimen to the lap with the specimen holder, move the specimen slowly in a circle (1–1.5 seconds per revolution) opposite the direction of rotation of the lap. Do this 15 times; rotate the specimen 180° and repeat. For most specimens this will provide satisfactory polish. If objectionable pits or scratches remain, repeat the process.

After achieving a satisfactory polish the specimen should be carefully washed with soap and water (or alcohol) and then cleaned in a sonic cleaner, first with warm soapy water (or alcohol) and then clear water. It is then carefully dried.

As with most techniques and skills, the most important ingredient for mastery is experience. There are, however, some basic principles that should be remembered. The objective of a high polish is to produce a surface in which random refraction of light due to surface irregularities is minimized. In general the finer the polish the better the resolution. There is another factor which should be kept in mind. A long polishing operation increases the probablility of losing softer minerals in a specimen, for example at a soft grain boundary. Unless care is taken it is quite possible to polish away important information contained in a specimen. It is important, then, to balance the desire for an ultra-fine polish against the chance of losing material at soft grain boundaries, or small soft inclusions in the section. Another point to remember in removing pits is that some pits may be natural. New pits appearing after the polishing action has removed some of the surface of the specimen, or old pits enlarging, probably results from a natural pit and should not be removed.

Acknowledgement

The author is indebted to the following persons for much encouragement and technical assistance: Mrs. P. R. Brenner, Dr. K. Fredriksson and Mr. D. J. Ortner.

[3] Adolf Buehler, Inc., 2120 Greenwood St., Evanston, Ill.