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A RAPID, ECONOMICAL METHOD FOR POLISHING THIN SECTIONS FOR MICROPROBE AND PETROGRAPHIC ANALYSES

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ABSTRACT

Polished thin sections suitable for microprobe and microscopy are prepared in routine fashion using a semi-automatic polisher, rough polishing with diamond abrasive and finishing with alpha-alumina.

INTRODUCTION

The production of high quality polished thin sections has long been recognized as more of an art than a simple technique (Cameron, 1961), yet not only are high quality polished sections a necessity for electron microprobe studies but they are increasingly important for routine petrographic analyses. In this note the authors discuss the many advantages of polished thin sections and the effect of different degrees of polish on microprobe work. A polishing method is described which is being used successfully in their laboratories and has resulted from the development of a semi-automatic polisher designed especially for thin sections.[1] This method: (1) requires very little experience to follow, (2) is relatively inexpensive, (3) is rapid with an average of nine sections per hour, and (4) requires little variation in technique for materials of various hardnesses.

POLISHED THIN SECTIONS—ADVANTAGES

There are many advantages of a polished thin section over a covered petrographic thin section, and a partial list of these are summarized as follows: 1) The ability to observe the petrographic relations of both the opaque and transparent minerals in one section. 2) The areas to be studied with the microprobe can be located during routine petrographic analyses. 3) The section is readily available for microchemical techniques and some of these (*e.g.*, staining, etching) are much more successful on polished surfaces. 4) Oil immersion lenses can be used optimally only on an uncovered polished thin section. 5) The reflectivity of transparent minerals can be used as a characteristic for identification since

[1] Buehler "Petro-Thin® Polishing Attachment."

reflectivity is directly related to refractive index. 6) The minerals are directly available for testing of microhardness, and polishing relief can be directly observed.

Polished thin section surfaces of most common rocks are very durable and even if marred can be repolished with relative ease. Thus, in this respect, polished sections compare favorably with covered sections for petrographic use.

The nature of the surface becomes highly important in some types of microprobe work (Long, 1967; Sweatmen and Long, 1969). For reliable quantitative data it is necessary to have a polished surface which contains a minimum of pits and scratches and is free from relief. Detailed studies of chemical homogeneity across grain boundaries can be affected by relief between adjacent grains.

There are many variables that affect the amount of relief and pitting, and we have found that two of the most important factors, (and most easily controlled) are the choice of polishing cloth and the hardness of the abrasive. The main purpose of this study is to evaluate these variables and determine the optimum conditions for producing a high quality polished section in minimal time.

Preparation of Polished Thin Sections

Preparation of polished thin sections involves three separate stages—slabbing the specimen, grinding the thin section, and polishing. This note is concerned only with the polishing, as standard textbooks adequately cover the other stages (Cameron, 1961). It should be emphasized, however, that proper grinding prior to polishing is critical to producing quality polished thin sections. The authors do offer one suggestion in this respect—that the use of resin bonded diamond grinding discs are superior over wet, loose abrasive techniques in terms of time, convenience, and resulting surfaces.

The semi-automatic polisher (Fig. 1) that has been developed for polishing thin sections, holds from one to three samples, either standard petrographic sections or circular sections (one or one and one-quarter inches in diameter). The polisher rotates the samples on a rotating polishing lap and applies equal pressure individually to each of the sections. This pressure can be adjusted depending on the nature of the samples.

The operator controlled variables that were evaluated in this study were: the type of polishing cloth, amount and types of abrasive, amount of lubricant, wheel speed, and pressure applied to the specimens. Samples used in determining the best polishing techniques were common igneous and metamorphic rock specimens such as granites, gabbros, basalts,

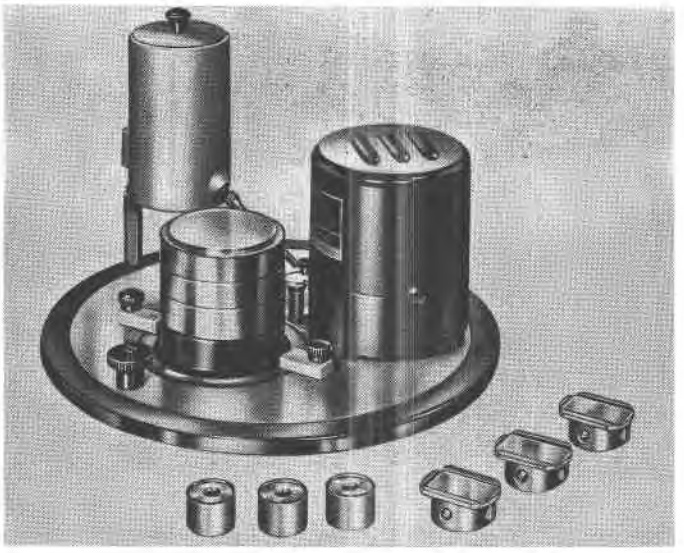

FIG. 1. Photograph of AB Petro-Thin Polishing Attachment, courtesy of Buehler Ltd.

amphibolites, and various schists. Nearly all common rock forming minerals have been encountered in this study.

The factors that tended to produce intergranular relief were a thick, resilient or high nap cloth. However, these types of cloth also produced better surfaces with respect to scratches and pits. Obviously these variables must be adjusted depending on the type of minerals in the sample.

TABLE 1. DETAILS OF POLISHING THIN SECTIONS

	A	B
Rough polishing		
	6 micron diamond paste	6 micron diamond paste
	Lapping oil	Lapping oil
	Nylon cloth	Texme® cloth
Final polishing		
a.	Alpha alumina, 0.3 micron	Alpha alumina, 0.3 micron
	Distilled Water	Distilled water
	Nylon Cloth	Texme® cloth
b.	Gamma alumina, 0.05 micron	Gamma alumina, 0.05 micron
	Distilled water	Distilled water
	Microcloth®	Silk cloth

A) Routine igneous rocks in which relief is not a serious problem.

B) All rocks having minerals with great variations in hardness, where relief is of major concern.

Table 1 summarizes the details of the polishing method that is suggested for use with the semi-automatic polisher. Where relief was not normally a serious problem, procedure A in Table 1 was the standardized method and the emphasis was placed on removing pits and scratches. In the case where the minerals have great variation in hardness, procedure B in Table 1 was used. Emphasis here was placed on keeping relief at a minimum, and possibly at the sacrifice of leaving some pits and scratches.

Diamond abrasives were found to be superior over all other types for rough polishing (to remove large pits and scratches), but fine aluminum oxide was found to be more satisfactory for the final polishing step; and in every case, relatively small amounts of lubricant were used with the abrasive (*i.e.* only enough to wet the entire surface of the cloth). This resulted in a faster cutting rate and also was an important factor in lowering relief, especially in the last stage (Fig. 2). In certain instances where aluminum oxide might be trapped in pores and thereby give erroneous microprobe results, one-quarter micron diamond paste was used as a final polishing medium. In order to prevent loss of abrasive and lubricant and to keep frictional heat build-up to a minimum, polishing wheel speeds were kept at approximately 160 RPM. Although full pressure of seven (7) lb was found to be optimal for most materials, with soft materials very light pressure was applied during the final touch-up stage.

The various polishing steps in Table 1 could be accomplished in 10 minutes for the rough polishing, 5 minutes for the intermediate final polishing, and 2 minutes for the final polishing step. This was true when using a new cloth and charge, full pressure, wheel speed of 160 RPM, and with samples measuring approximately $\frac{3}{4}'' \times 1\ \frac{1}{4}''$. These times varied, naturally, with different materials, worn cloths, and different sized samples.

Figures 2a, 2b, and 2c show how some samples used in this study appeared after the various polishing stages. It was our experience that if each sample showed no more pits and scratches than seen in these photomicrographs, we could easily proceed on to the next stage.

One important factor that is often neglected is sample cleaning. This can cause serious scratching and plucking and erroneous probe pick-up (or analysis), due to abrasive carry-over from preceding steps. Ideal cleaning should include light scrubbing with a soft brush and soap solution, followed by ultrasonic cleaning.

Polished Thin Sections—Electron Microprobe

Since special skills are not required to prepare polished thin sections using this technique, the two factors necessary for evaluation are time of

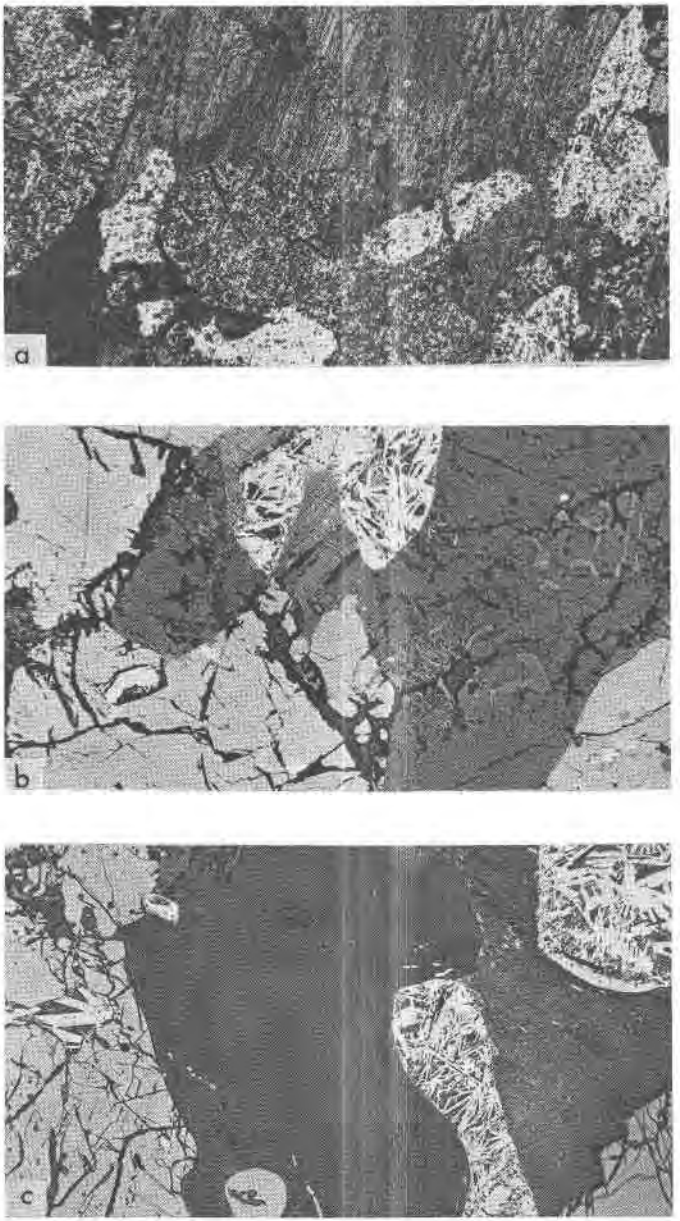

FIG. 2a, b, c. Photomicrographs showing section surfaces at various stages of preparation. These correspond to the stages in Table 1.

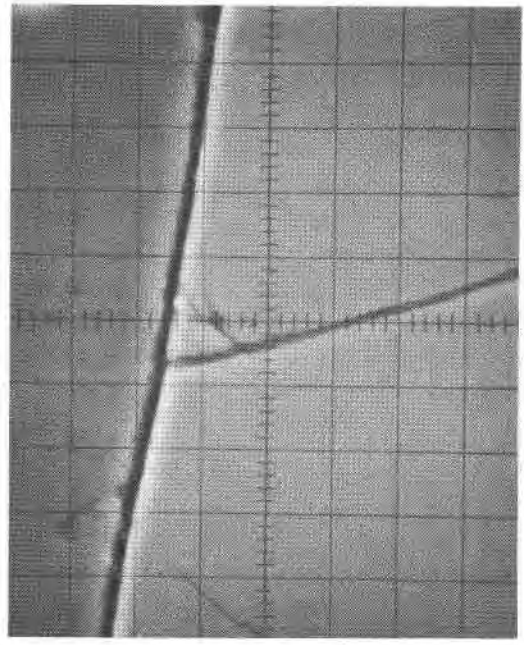

FIG. 3. Secondary electron image of garnet-plagioclase boundary. This section was specially polished to produce relief. (10 microns equal one large division.)

preparing the polished surface and the quality of the surface. The quality of the polished surface was evaluated by producing polished surfaces on identical specimens, varying time, polishing cloths and abrasives. Some factors were varied to especially produce relief so that this effect on microprobe analyses could be evaluated. Operating conditions of the microprobe for these tests were: 25 kV, 0.02 mA and a beam diameter between 0.2–0.5 micron. It was surprising to observe that relief affected chemical analyses only when there were large differences in relief present. Figures 3 and 4 show the effect of 0.5 micron relief of garnet over plagioclase (measured with an interferometer), which was specially produced by abnormally long periods of polishing with a high nap cloth. Figure 3 is a photograph of the secondary electron image of the boundary between plagioclase (dark) and garnet (light) which shows high relief at the boundary. Figure 4 is a trace of the Na($K\alpha$), FeK(α), and Mg($K\alpha$) X-ray radiation over this boundary. The relief effects of the boundary are noticeable over a distance of 4.2 microns and give a pattern that could be confused with grain boundary diffusion.

By reducing polishing times and changing other variables, relief was

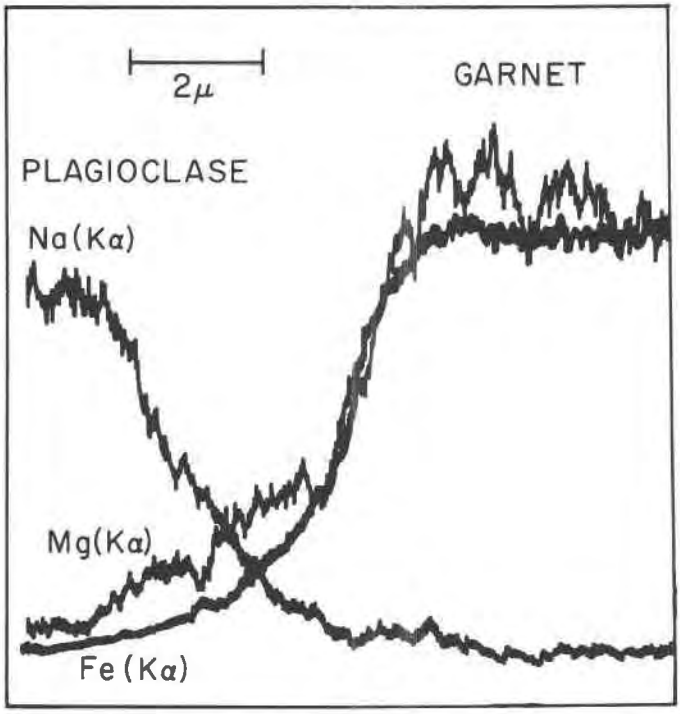

FIG. 4. Trace of Na(kα), Fe(kα), and Mg(kα) X-ray radiation over same garnet-plagioclase boundary, as shown in Figure 3. The slopes of these curves are due to the relief of garnet over plagioclase.

reduced considerably and the change in counting rate across plagioclase-garnet grain boundaries was decreased until the boundary effects were less than two microns (*i.e.* due to the boundary was less than two microns). Under the microprobe operating conditions that were used, this range is negligible, since the effect of non-vertical boundaries is generally larger than this. Therefore, since only in extreme cases is relief an observable factor in microprobe analyses, it is possible to arrange polishing variables to minimize pits and scratches rather than to control relief (Table 1).

SUMMARY

The principal advantage of preparing polished thin sections using the technique described above is that a technician with relatively little experience can, quickly and inexpensively, produce a high quality polished thin section.

Acknowledgments

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