This vibrator was originally designed with a transport spiral to feed out screws and similar items; for the present purposes the transport spiral is removed and the stand holding the cup (Figs. 2, 4) is placed directly onto the vibrator. The important feature of this vibrator is the circular motion given in the horizontal plane which accompanies the overall vibration effect. This circular vibration effect is produced by a trigonal arrangement of three steel bands and an electromagnet working on them. The circular motion helps the mineral powder to float into the specimen cup and diminishes the tendency of fine powders to entrap air. The cup is filled by fixing it in the stand and placing the stand onto the vibrator; when charging the powder, the stand is lightly tapped to get the powder firmly packed. A smooth and planar surface is achieved, and similarly packed cups are produced by different workers, showing that operator dependence is eliminated at this point.

Mr. H. Johansson carried out the machine working of the cups and his contribution to the development of the present models is gratefully acknowledged. Mrs. Ulla Bokén gave technical assistance which was supported by a grant (1959–61) from the Swedish Natural Science Research Council. The English of this manuscript was kindly revised by Dr. M. J. McNamara.

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THE PREPARATION OF THIN SECTIONS OF FRAGMENTAL MATERIALS USING EPOXY RESIN

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Introduction

Techniques of preparing thin sections of fragmental materials, such as sand grains, drill cuttings and mill products, either have required lengthy procedures (Bell, 1939; Brison, 1951) or have utilized embedding materials from which the grains tend to be pulled out during grinding of the section (Gibbs and Evans, 1950). Dillinger and Sclar (1960) used epoxy resin for preparing polished sections of milligram amounts of finely divided samples of opaque minerals. They suggested that epoxy resin might be suitable for preparing thin sections of particulate materials, but did not actually prepare any sections. This paper shows that epoxy resin can be used to prepare thin sections of standard thickness (0.03 mm) of particulate mineral samples.

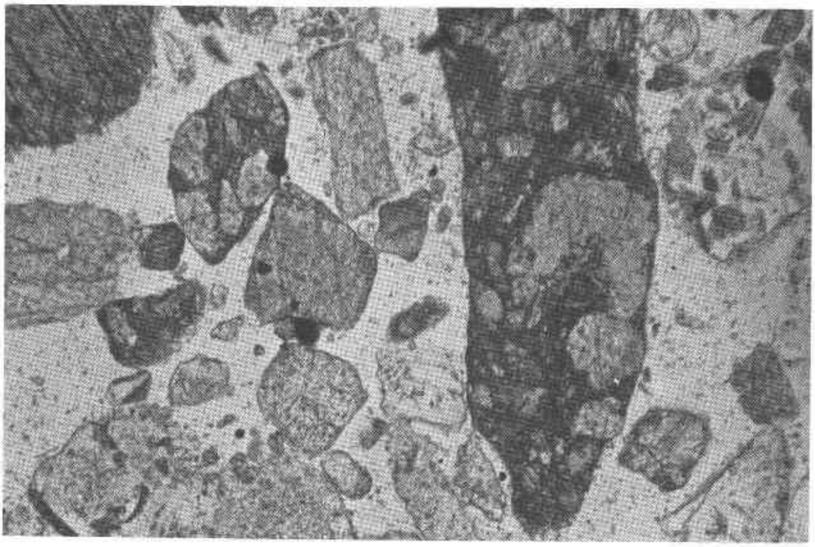

FIG. 1. Photomicrograph showing churn drill cuttings in a thin section. Note the organic (crinoidal fragments) structure in some of the limestone fragments (×23).

Epoxy resin, which securely molds fine particles, can be used to prepare standard thin sections, 0.03 mm thick, of such materials. The use of epoxy resin has the advantage over liquid bakelite (Bird, 1935) and thermoplastic resins (Barringer, 1953) in that it is easier to handle and requires no heat treatment. Epoxy resin recently has been utilized for related purposes, viz, preparation of polished sections of opaque and nonopaque particulate mineral samples (Dillinger and Sclar, 1960; Sclar and Dillinger, 1960; and Taylor and Radtke, 1965), mounting mineral grains on a glass slide (Langford, 1962; Sanders and Kravitz, 1964), and impregnation of soils for sectioning (Wells, 1962).

Epoxy resin was first used in the Ore Microscopy Laboratory at the University of Missouri at Rolla to prepare thin sections of fine churn drill cuttings from the Tri-State district for adequate microscopic examination (Fig. 1). In these studies it was desired to determine the degree of recrystallization of limestone in cuttings from areas of possible zinc-lead mineralization (Hagni and Saadallah, 1965). Subsequently the technique has been used to prepare thin sections of magnetite and hematite concentrates in order to reveal the presence and identity of transparent impurity minerals (Fig. 2) and to prepare thin sections of phosphate concentrates.

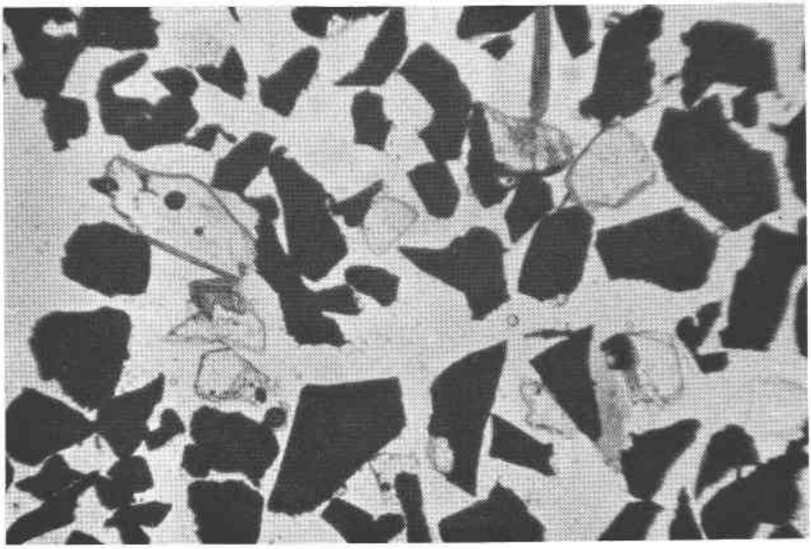

FIG. 2. Photomicrograph showing transparent grains of quartz, orthoclase, garnet and biotite in a thin section of opaque magnetite concentrate (×23).

METHOD

The technique is rapid and consists of three simple steps: (1) embedding fragments in epoxy resin, (2) sawing cured resin to form a slab and mounting slab on glass slide, (3) thin cutting and grinding the mount to final thickness.

The embedding procedure begins with the preparation of watch glasses by covering each with aluminum foil[1] to prevent the epoxy resin from coming into contact with the glass to which it would form a strong bond (Fig. 3). As large a group of watch glasses as desired may be prepared at the same time. Into each of the covered watch glasses the mixed liquid

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[1] Sclar and Dillinger (1960, p. 865) described the use of aluminum foil for casting epoxy resin.

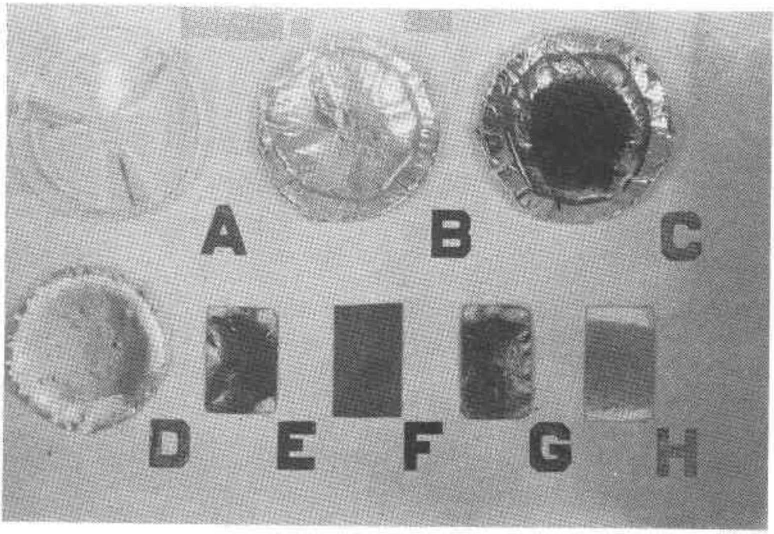

FIG. 3. Stages in the preparation of a thin section of fragmental materials: A. Uncovered, three inch diameter, watch glass; B. Mixture of epoxy resin and catalyst poured into aluminum foil-covered watch glass; C. Layer of dark sand grains settled to the bottom and center of the resin-filled watch glass; D. Cured resin mold removed from watch glass and with aluminum foil peeled off; E. Sawed resin slab; F. Slab ground flat on one side (sand-rich side); G. Slab mounted on standard petrographic glass slide (flat, ground side down); H. Thin section (uncovered) of sand grains ground to a thickness of 0.03 mm.

epoxy resin (at room temperature) and catalyst (10 parts Epon No. 828[1] and 1 part triethylene tetramine[2]) are poured. A light sprinkling of the fragments to be embedded are allowed to sink to the bottom of the watch glasses and this is followed by additional particles until sufficiently thick layers of material are built up on the bottom of the watch glasses to cover the major portions of standard petrographic slides. Stirring with a glass rod or toothpick will free trapped bubbles from the accumulated layer of particles and insure the absence of holes from the completed thin sections. The resin cures in an hour or two at room temperature but the writer prefers to allow overnight curing to insure that it becomes thoroughly hard and ready to saw.

The hardened resin molds are sawed with an ordinary diamond blade to the size of a standard petrographic thin section (27×46 mm) and ground flat with the Ingram grinder. The cutting fluid should be blotted

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[1] Obtained from the Shell Chemical Corporation, P.O. Box 2392, Church Street Station, New York, New York 10008.

[2] Available from the Union Carbide Corporation, Chemicals Division, P.O. Box 6112, Cleveland, Ohio.

from the slabs immediately and their ground sides mounted to the frosted sides of petrographic glass slides within a short time to curb the tendency for unmounted slabs to curl. The writer finds the same resin to be very satisfactory for this mounting because the resin promotes rapid mounting of a large number of slabs, and because its fluidity facilitates the removal of bubbles between the slabs and the glass slides. The fluid nature of the resin also greatly aids in positioning the slabs perfectly flat upon the glass slides, and the strength of its bond to the glass slides greatly exceeds that of Canada balsam or thermoplastic cement—two properties which are extremely important to the success of rapid thin section preparation with the Ingram saw and grinder.

The mounted slabs are processed in the same manner in which ordinary rock slabs are prepared with the Ingram saw and grinder. The slabs are thin-cut with the Ingram Cut-Off saw to a thickness of about 0.5 mm, and then ground to 0.03 mm with the Ingram grinder. Although some thin sections require completion by hand using alumina abrasive on a glass plate, most sections can be finished by the grinder alone.

Cover slides may be placed over the ground thin section again using the epoxy resin or any cold-setting cement. Epoxy resin is convenient to use for it does not require reheating the slide and it allows ample time to remove bubbles trapped beneath the cover slide.

ADDITIONAL COMMENTS

Cured epoxy resin in completed thin sections is clear and isotropic. Dillinger and Sclar (1960) report that the index of refraction of cured Epon No. 828 to which the catalyst triethylene tetramine has been added in the ratio of 10 resin to 1 catalyst is 1.591 ± .002. However, narrow, first order gray, birefringent rings may form at the margins of some fragments. These very narrow, weakly anisotropic, bands do not have a crystalline appearance and do not hinder the examination of the mineral fragments. No cracking of the hardened epoxy resin has been experienced in the preparation of several hundred thin sections.

Thin sections of very fine fragments invariably contain some fragments which will not be cut by both surfaces of the section and some care must be excerised in the study of such fragments. Most larger fragments are cut by both surfaces of the section and they produce birefringent colors normal to the standard thin section.

It is not the purpose of this paper to discuss the details of the preparation of polished thin sections. Yet the techniques which have been applied to the preparation of polished thin sections of rocks and ores are equally applicable to thin sections of fragmental materials. The completed, uncovered, thin section may be polished as described by Grondijs and

Schouter (1931), Kennedy (1945) and Amstutz (1960). Or alternatively the sawed slab may first be polished and then thinned by the techniques described by Donnay (1930), Rankama (1941) and Cadwell and Weiblen (1965). For most studies of fragmental materials it is simpler and generally satisfactory to prepare standard polished sections in addition to thin sections.

Conclusions

The significance of this technique lies in the simple and rapid procedure whereby thin sections of fragmental materials can be prepared so that the transparent minerals show birefringent colors which are those exhibited in conventional thin sections of rocks. Epoxy resin grips mineral fragments tenaciously and bonds strongly to the petrographic glass slide. The resin is inexpensive, readily available, easily handled and does not require elaborate equipment.

Acknowledgment

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