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SHORTER COMMUNICATIONS

MECHANICAL PREPARATION OF THIN SECTIONS

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In 1970 the Geology Department at Dalhousie University installed mechanical equipment for preparation of thin sections of rock. The technique was developed in Holland, and is not widely known in this country. This note reports upon our experience in the hope that it may be helpful to others.

In the past, mechanical preparation of thin sections has encountered problems because of the extreme thinness of the sections and the small tolerances allowed in them. Some years ago, this problem was solved by the technicians of the Agricultural University (Landbouwhogeschool) at Wageningen, Holland. For work on soils, they learned to make, on a routine basis, very large sections, 10 × 20 cm) with a uniform thickness of 15 microns. Their technique has been borrowed, with only insignificant changes, for manufacture of: (1) large thin sections of rocks, and (2) simultaneous production of 12 normal petrographic sections (27 × 46 mm). The machine has also been used for manufacture of discs for measurement of thermal conductivity of rocks, for preparation of flat rock slabs for display purposes, and for sections of biological material, such as teeth.

The machine used is a high precision horizontal-spindle surface grinder. That is, the cutting is done by a diamond-impregnated wheel which runs at high speed in a vertical plane. The work is held upon a horizontal table that slides back and forth beneath the wheel, which is lowered toward the table as cutting proceeds. The table can be moved crosswise, to bring the entire table area within reach of the wheel. The reciprocating motion of the table is hydraulically powered, but all other control motions are mechanical. Once set, the control motions are repeated automatically by the machine.

Details of the surface grinder and its equipment are as follows:

Manufacturer and model: Churchill Machine Tool Co., Manchester, England. Model NB, 18″ × 6″ × 9″ surface grinder, horizontal spindle.

Standard equipment: Grinding wheel, balancing-type wheel collets, wheel-balancing arbor, wheel truing bracket, motors and control gear.

Extra equipment: Wet-grinding equipment and swarf separator; 18″ × 6″ magnetic chuck, wheel-truing diamond, automatic vertical feed to whee', dial dead-stop to table, air-bearing head (which requires about 6 c.f.m. air at 100 p.s.i.).

Substitution: Diamond wheel, 8″ × 1″ × 1¼″, D-150-N-75-M-11-⅛″, substituted for that normally supplied.

Working accuracy of machine: Manufacturers' specification is that machine will grind work plane parallel within 0.012 mm per metre.

Preparation of normal thin sections (27 × 46 mm)

To be practical, a machine for mechanical thinning of rock sections must be capable of handling several at one time. On many machines this is difficult because the machine

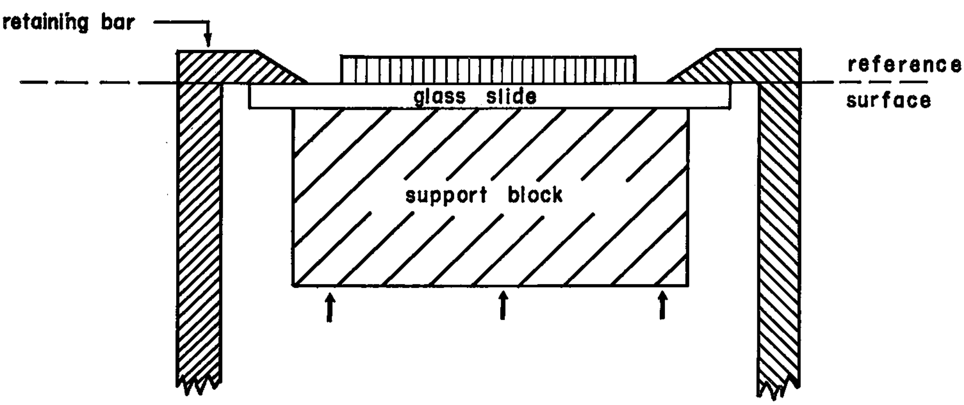

FIG. 1. The section is held firmly against the retaining bar, and supported against bending, by a thick metal support block which is lifted mechanically beneath the slide.

grinds toward a reference surface which is the *back* of the glass slide. A.S.T.M. Specification E 211-63T, for petrographic slides, permits a variation in glass thickness of ± 0.1 mm, which is more than three times the thickness of the finished rock slice. In consequence of the variation, uniformity of section thickness is difficult to attain mechanically in such machines, even though the variation in glass thickness in a given box of slides is much less than the maximum quoted above.

In the present case the problem of glass thickness is avoided by making the reference surface the surface of the glass in contact with the rock. This is accomplished in a jig, made by Cutrock Engineering Co., Ltd., of London, England, the principle of which is shown in Figure 1. The glass slide is solidly supported from beneath to prevent bending and is held tightly against the undersurface of the retaining bars. It is to this surface of the retaining bars that all grinding measurements are referred, and the thickness of the glass is of no consequence. The jig holds six slides; to use the full size of the work table, Cutrock made a matched pair of jigs, which are used end to end (Fig. 2). This requires that the variation in height from one end of the pair to the other (a distance of about 40 cm) be not more than one micron, but there is no trouble whatever on this account. Twelve sections can thus be cut simultaneously.

The only practical difficulty with the jig comes because even a very tiny grain of dirt between glass and retaining bar will cause cracking of the glass and loss of the slide. Provided the operator is scrupulously careful about cleanliness on this interface, there is no trouble.

The rough slices from the diamond saw are cemented with Lakeside 70 to a 1/8″ steel plate the full size of the work table of the grinder. Up to about 100 can be accommodated. Strength of bond-not uniformity of bond thickness-is all that matters here. The whole batch is then ground on the machine until there is a flat surface on the full area of each rock slice. Warming the plate will release the rock slices, which are finished by hand, using 600 Carborundum powder on glass. The slice can then be mounted on the microscope slide in the usual way; the warm slide is smeared with Lakeside 70 cement and the warm rock slice lowered into it, pressed down with forceps, and allowed to cool on paper. The steel plate must be cleared of accumulated cement about every two weeks.

The above grinding operation is automatic, except for the finish. The maximum depth of cut is usually 0.003 inches (about 75 microns). Under manual control, the initial finishing cut is about 0.002 inches, followed by another at 0.001, and a final one without further downfeed.

Thinning of the mounted rock slides is also automatic, in large part. Twelve slides are mounted in the jigs, which are in turn held by the magnetic chuck of the grinder. The grinding wheel is one inch thick, which makes it possible to deal with most sections by the technique known to machinists as "plunge grinding". That

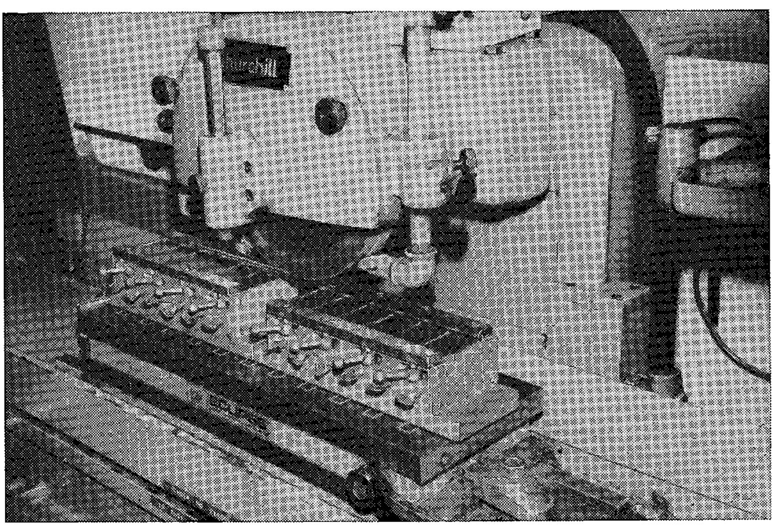

FIG. 2. The two jigs hold six sections each, and are held by a magnetic chuck, shown beneath them. The retaining bars and the support blocks are controlled by the levers and wing nuts on the front of the jig. The whole assembly slides back and forth beneath the grinding wheel.

is, there is no cross-feed of the table and the cutting wheel can be lowered on each alternate reversal of the longitudinal motion of the table. This reversal occurs about once per second and thinning is very rapid, because about 50 microns (0.002″) can then be removed every two seconds. The automatic cutting is continued to within about 40 to 50 microns of the final thickness, and the last few cuts are then made under manual control.

There is no problem about thickness measurement. Because the reference surface on the jigs (and therefore on all slides) is always at the same fixed distance from the table of the machine, the micrometer dials on the down-feed of the grinding wheel allow the operator to stop the grinding at any thickness his experience tells him is suitable. In addition to the micrometer controls, the technician's educated forefinger has been found to be a useful gauge.

The last stage of machine grinding is always done with rather light cuts. The machine can make a single cut as shallow as 0.0001 inch (2 microns), but there is, of course, considerable mechanical stress on the rock. The experience and judgement of the operator are of great importance here. Some rocks can be taken to within 1 or 2 microns of the finished thickness; on weak rocks, on the other hand, it may be necessary to stop the cutting with 10 or 15 microns still remaining.

The minimum thickness attainable by machine is not known. By accident, basalt was once thinned without difficulty to first-order grey of olivine (14 microns).

The final stage of grinding is done by hand, using 600 Carborundum powder on glass, in the ordinary way. This usually involves removal of from 1 or 2 microns up to 10 or 15 microns, and ordinarily takes a very short time. Because of the uniformity of thickness produced by the machine, there are usually no thick spots requiring special adjustment.

Time required to prepare normal thin sections:

Table 1 shows the average time consumed, per section, for each step in the technique. The figures are based upon 215 sections. Those parts of the operation that are automatic free the technician for other parts of the procedure.

Table 1.

Time Required to Prepare Normal Thin Sections.

1. Slabbing and trimming on diamond saw	4.73 minutes
2. Mounting upon steel plate	0.63
3. Grinding of initial surface and frosting of glass slides	3.35
4. Hand finishing of initial surface	0.88
5. Cementing section to glass slide	1.60
6. Cleaning prior to machine grinding	1.77
7. Mounting on jigs, set up and adjust machine, thinning of section	3.90
8. Adjust thickness and final finishing by hand grinding	4.96
9. Cleaning of section	1.67
10. Mounting of cover glasses	1.88
11. Trim excess cement, final cleaning	2.11
	27.5

Giant sections — 10 × 20 cm

This is the major product for the Dutch technicians, but our experience is limited to a few experimental slides only.

The giant slides mut be made one at a time. The rather thick rock slice (about 5 mm) is mounted directly upon the magnetic chuck and held in place by strips of sheet iron. The initial flat surface is then cut by the machine and finished with 600 Carborundum on a glass plate. The rock slice is mounted upon the microscope slide with this flat face against the glass, the slide is returned to the machine and thinning is continued. This is automatic, once started.

Uniformity of thickness in the rock sections depends upon parallelism of both rock surfaces with the top of the magnetic chuck. This requires that both the cement layer and the glass slide should be uniform in thickness. The glass must have parallel surfaces and be free of ripples or other surface irregularities. The entire surface of the glass is supported from beneath by the magnetic chuck, but it is imperative that there be no intervening dirt — such would produce a high spot on the glass and a thin place in the section.

We have found that, as they are cut by the machine, the ends of the giant slides are slightly thicker than the central portion. We have been assured by expert machinists that this is normal and is also always encountered when grinding metals. They ascribe the effect to unrelieved stresses and to heating caused by the grinding. Very light finishing cuts, with a pause for cooling between them, certainly help, but we have not yet developed a satisfactory routine procedure to eliminate this: our Dutch colleagues say they have never had this problem.

Flat surfaces for display specimens

Preparation of large display surfaces obviously merely involves cutting a flat upon a slab of the rock. In theory, the size limit is set by the working area of the work table. In practice, the maximum size is probably that at which the inertia of the specimen causes vibration when the longitudinal motion of the table reverses.

Discs for thermal conductivity measurement

Heat flow in rocks obviously depends upon their thermal conductivity. Colleagues involved in this work measure the conductivity of their samples in a steadystate apparatus that requires a thin disc of the rock. The disc is cut from diamond drill core, is about 6 mm thick and must have the opposite faces flat within one micron and parallel within the same limit.

It has proven very simple to produce such discs on the surface grinder. Rough discs, about 8 mm thick, are cut off the drill core with the diamond saw. These are then arranged upon an oiled glass plate. A wall about 1/4 inch high is built around them, using strips of 1/4 inch perspex. A bonding agent is then poured into the space within the wall and between the discs and allowed to harden. This produces in effect, a slab with the discs embedded in it; the surface formed against the glass is smooth enough to be placed against the chuck of the grinder. The rough top surface of the cast slab is then cut flat by the grinder, the slab is inverted, and the other surface is cut flat and finished. It is advisable to invert the slab once more to put the finish upon the first surface. When final thickness and finish are achieved the discs can be broken out of the slab without difficulty.

The same technique has been used for sections of teeth.

The best bonding agent is "dental stone", but it has a serious drawback. The slab is tough, fine-grained, cuts very easily, hardens quickly, holds the discs firmly, is stronger than plaster of Paris and separates easily and cleanly from the finished discs. The fluid used to cool the cutting wheel is water, to which is added a rust-preventing oil that forms an emulsion with the water. Unfortunately, plaster of Paris is the basis of the dental stone and sufficient sulphate goes into solution in the cooling water to cause separation of the emulsion. Replacing the coolant is an especially messy job because the swarf from the dental stone is very fine grained and almost gelatinous. Alternative coolants, such as di-methyl phthallate, would probably be the solution to this problem, if much work of this type were to be done.

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