Observations on the Preparation of Mineral and Rock Sections for the Microscope.

By John Ernest Ady.

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DURING the past few years the study of the minute structure of minerals and rocks has received the attention of so many able geologists, that microscopical mineralogy and petrography may now be regarded as a fairly established means for the identification and diagnosis of inorganic species. As a special instance, I may point to Heddle's researches on Amazonstone,* where the discrepancy of its chemical constitution from normal orthoclase, and its aberrant crystalline form, are accounted for under the microscope, with polarised light, by minute structural peculiarities which support the view that it is composed, not of orthoclase and albite, as has been supposed, but of orthoclase and a paragenetic constituent, allied to, if not identical with, oligoclase.

I propose to confine my remarks to the preparation of hard substances which do not require any special previous or after treatment to enable them to withstand the mechanical methods to which they are subjected. There are many trifling details of manipulation, the neglect or observance of which suffice to draw the line between failure and success. By the term failure I intend to imply that slovenly habit of securing a thin fragment of a section and mounting it anyhow, with clinging particles of dust and dirt, to which such errors of observation as a detailed description of rough surfaces, rugosities, striæ, cavities filled with unknown products, and a variety of other conflicting evidences, are to be attributed; whereas a successfully prepared section, in the hands of a faithful recorder, can only contribute to the advancement of science.

Although my present communication will not involve any novel principles, I trust that, by a formulated outline of the best known methods, divested of all unnecessary and extravagant details, and supplemented by practical notes, to place before the Society the most noteworthy results of my experience.

* *Trans. Roy. Soc. Edin.*, Vol. XXVIII. p. 197 *et seq.*; *Min. Mag.* Vol. V. 1883, p. 160 *et seq.*

The first operation in the preparation of sections is to secure a slice of the mineral or rock. In the former case, it is obvious that for purposes of investigation a definite series of sectional planes should be selected; in the latter instance, especially in very finely-textured rocks, without any natural or superinduced peculiarities, such as occur in finely laminated examples, slates, schists, &c. or the presence of specially developed and local particles, the plane of section is immaterial, and a chip taken with a hammer may often suffice. The process of slicing by hand, with emery powder and a toothless tenon-saw, is both tardy and extremely laborious. The employment of a slitting machine, fitted with a diamond-charged disc of soft iron (the so-called block tin), is an accomplishment which requires considerable practice, and indeed is not worth while adopting for the production of a few occasional slices, except to gratify the whim of the worker, since they can be both efficiently and inexpensively cut by any good working lapidary.*

The reduction of the slice may be accomplished by hand, or with the aid of a grinding bench. In either case, the processes are essentially the same; the result to be aimed at is, a section of the desired thickness, which shall be perfectly even and free from superficial scratches. The tenuity of the preparation must of course be regulated by the special requirements of each case; as a rule, however, the thinner a slice can be made, the more valuable it becomes to the general investigator, especially with high powers of the microscope; minute endomorphs, cavities, and traces of fluidal structure may thus be revealed, and inferences often of great importance deduced therefrom. Sections of finely textured and dark rocks, such as the majority of the basalts, dolerites, &c., may be roughly gauged by placing them over a sheet of ordinary printed matter; if the typographical characters can be readily distinguished, the specimen may be regarded as sufficiently thin. Another somewhat more reliable ready expedient is, to hold the preparation near to the eye between it and a window or other object illuminated by diffused light; if the outlines of the window-frame and bars can be easily distinguished, the section may be taken to be adequately thin. Translucent and transparent minerals, or rocks composed of a large proportion of such constituents as quartz, clear felspar, or calcite, may be reduced until the darker minerals with which

* I usually mark my mineral specimens with lines of ink, to which a little mucilage has been added, to indicate the directions along which I desire to have them sliced. Rocks and dark opaque minerals may be marked with a fine camel's hair brush dipped in artist's oil-vermilion, reduced to a suitable consistency with benzol.

they are generally associated, *e.g.* hornblende, mica, schorl, augite, &c. become almost transparent. In themselves, however, the intensity of chromatic effect, when viewed with polarised light under a low power of the microscope, is a sufficient test. A basalt thus examined ought to reveal the intimate structure of its interstitial groundmass, and the granular condition of its augite ought also to be clearly defined; whilst the closely aggregated patches of dark spicular schorl in the variety Luxulianite should be resolvable into stellate groups, each with distinct radii. The individual grains of limestones and sandstones ought to lie in a single layer, so as to avoid interference phenomena, and the fluid cavities of milky quartz admit of coming into focus under the highest magnifying powers that are of any use.

The mode of preparing hard sections is briefly as follows :—The slice or chip must be ground absolutely level and perfectly smooth on one side ; it is not necessary to polish the face. The smooth facette may thereafter be firmly cemented on to a suitable piece of glass, and the other side then reduced until a sufficiently thin section is obtained. To do this by hand, a few soft metal plates, preferably of pewter, zinc, copper, or lap-metal, each about 12 inches square, and $\frac{1}{4}$ inch thick, three sizes of emery powder, and one or two Water-of-Ayr hones, are in reality all that is necessary. Glass plates are not to be tolerated, since they rapidly wear away irregularly unless extreme care is taken. For the final operation of grinding, flour emery which has been used and washed, or mirror-polishers' powder, is to be preferred.

(I.) Oakey's No. 60 hole emery powder with a little water should be used upon one of the soft metal plates, and the slice may by a small circular motion over each quarter of the plate, and a gradual transition into a greater circular motion thereafter around and towards the centre of the plate, be ground coarsely level on one side, and prevent the plate from wearing away into hollows. This operation should be repeated on another plate with No. 80 hole emery, and then on another with flour emery ; care should be taken to wash the section thoroughly each time before using emery of a different size.

To produce a perfectly flat face upon the slice, the surface of the plates should be slightly raised at their centres so as to be somewhat convex. This may be produced by heating the central part over a spirit or Bunsen flame, when the four corners of the square will tend to bend slightly downwards, and give the desired degree of convexity to the upper grinding surface. The plate may then be fixed upon a support of wood

covered with a layer of plaster of Paris, so as to prevent a springing motion during the process of grinding.

(II.) The use of flour emery will secure a tolerably smooth surface, free from any serious scratches or roughness; but it is advisable to make use of a Water-of Ayr hone, with a plentiful supply of water, in addition, to ensure success. Indeed, *two* hones may be advantageously employed, and their surfaces are to be specially prepared beforehand thus:—The first hone, about 6 inches long and 1½ inches in breadth, is to be rubbed rapidly from end to end, longitudinally in one direction, upon a level slab of fine sandstone. This will develop a slightly convex surface upon the hone. The second hone, of similar proportions, must be treated in the same way, but it should in addition be further rubbed upon a slab of fine marble, so as to secure a smoother surface also slightly convex. The value of a convex grinding or polishing surface where the pressure is applied by the hand has long been known to practical mechanicians, for it is upon this principle that the so-called engineer's file is constructed. To the neglect of this item may be traced the cause of those inequalities which result in a section thick towards the centre and thin at the edges.

(III.) In fastening the smoothened surface of the slice to a piece of glass, the best cement substance I have found for the purpose is that made of an admixture of Venice turpentine and orange shellac. The turpentine should be heated in a sand or water bath, and enough shellac ought to be added to it to produce on cooling a thoroughly hard yet tough solid; it may be tested from time to time by the removal of a small portion. The advantages of this cement are manifold: it is not prone to imbed particles of emery during the processes of grinding, its adhesive properties are exactly suited to the requirements of the case, and it is perfectly soluble in ordinary methylated spirit. By surrounding the edges of the slice with a small quantity of the cement, the borders of the latter will be perfectly protected.

The slice ought to be fixed on to the small preliminary square of glass, with the fastening substance melted upon it over a spirit or Bunsen flame; it should be firmly pressed upon the glass slip (which, by the way, is all the better for being made of the best flattened plate glass, about ¼ inch thick, and 1½ inches square) to the entire exclusion of air-bubbles.

(IV.) The process of reduction may be carried on with Nos. 60 and 80 hole emery powder, until in dark specimens, *e.g.* basalts, &c., the slice becomes translucent. Flour emery may then be used, and the final touches given upon the Water-of-Ayr hones. During the latter stages, the specimen ought to be repeatedly examined under the microscope.

(V.) All that is necessary now is to remove the finished section from the preliminary slip of glass. This may be best accomplished by soaking it in a saucer full of methylated spirit. The slice ought to float off of itself in the course of a few hours; it must not any account be forced off. After detachment, it should be transferred to a dish of clean spirit for an hour or so, and gently washed therein with a fine camel's-hair or sable pencil.

(VI.) From the clean spirit the slice should be removed by means of a special lifter (a fine brush or stout needle will do), and placed between slips of clean white tissue paper, where they will dry rapidly and be ready for mounting.

(VII.) The best mounting fluid for rock sections is a filtered solution of equal parts of Canada balsam and gum damar in pure benzol. Hardened Canada balsam dissolved in benzol and filtered may also be used. A drop of the solution ought to be placed upon a clean warmed slip of glass, the section placed therein covered with another drop, and laid aside for about 10 or 12 hours in a dust-proof box, or under a bell glass. This process, which I have described elsewhere as the "*exposure method*," permits the medium to assume a suitable consistency before the cover glass is applied to the preparation. After exposure, a fresh drop of balsam may be placed upon the section, and a gently warmed cover glass lowered upon the whole.

I may state that balsam prepared in the manner indicated, and used after the method I have described, will enable the operator to cleanse his preparation of all superfluous balsam *immediately* after he has placed the cover glass thereon, by simply rubbing it with a rag dipped in methylated spirit. Air bubbles and vacuoles, moreover, may be disregarded, as the nature of the medium is incompatible with their persistence.

The labour of grinding sections of minerals and rocks for the microscope by hand is so tedious, that few persons would follow that process where they could resort to a suitable grinding bench. Many instruments have been devised for this purpose, the best one in the English market being that of Messrs. Cotton and Johnson, and called the "Amateurs' Lapidary Machine." There is room, however, for vast improvements in instruments of this kind; those that are now made for scientific inquirers are either too expensive or mere toys; whilst working lapidaries use benches which require almost a term of apprenticeship to enable one to manage them. What is wanted by the petrologist is a thoroughly good machine with a horizontally disposed fly-wheel, treadle action, firm steady bearings, and the entire system so arranged as to admit of the ready change of laps, and the cleanly application of emery with the greatest possible utility.

I am glad to be able here to describe a machine which fully meets all the wants I have just enumerated, and which has hitherto remained unnoticed. With its aid several hundreds of sections of the most perfect description were prepared in illustration of my journal on microscopical petrography.

The vertical treadle motion is modified into a powerful horizontal one by means of a strong cord passed over a pulley, and attached to the crank of a fly-wheel. A connecting strap transfers the motion of the fly-wheel to a small horizontally placed spindle-bearing wheel. The lower end of the spindle works upon a fixed iron bearing, whilst its upper extremity is free and slotted to receive the central attachment pins of the grinding discs. The circular grinding discs are provided with cylindrical rod-like attachment pins screwed into the centres of their lower faces at right angles thereto; they are simply allowed to slide into the receiving slot of the spindle-head, and can therefore be readily changed; their weight, and the pressure applied to their upper surfaces during the process of grinding, are sufficient to maintain them firmly. The fly-wheel works between two metal bearings supported by a strong framework, which can be made to slide forwards or backwards in the body of the bench by working a large adjustable wooden screw; thus, when the connecting strap becomes somewhat slack, it can be speedily tightened by merely turning the screw-head.

Before placing the lap into the slot of the spindle-head, the waste emery box must be placed around the latter, and over this a protecting metal cup-shaped cap is slid to prevent the possible passage of dirt to the working parts of the instrument.

Lastly, the subjoined figures with explanatory notes and measurements will show the details of this new lapidary's lathe far better than any verbal description alone. It may be taken as a working plan.

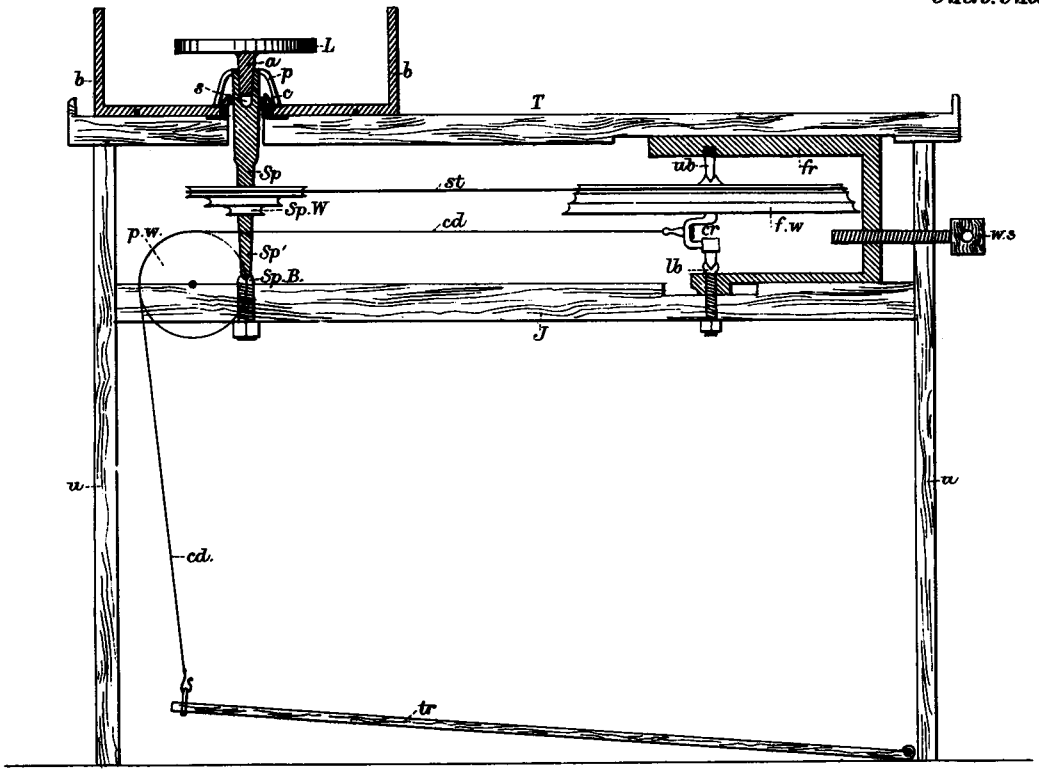
EXPLANATION OF PLATES.

Plate III.—Diagrammatic Sectional Drawing of Lapidary's Lathe for Petrographical Work. *T.*, Top of table; *u.u.*, upright supporting legs; *J.*, middle joist; *tr.*, treadle; *cd.*, cord of treadle passing over pulley wheel *(p.w.)* to crank *(cr.)* of fly-wheel *(f.w.)*; *st.*, strap from fly-wheel to spindle-bearing wheel *(sp.w.)*; *Sp.*, upper end of spindle; *Sp.* 1, lower part of spindle resting on bearing *(Sp. B.)*; *u.b.*, and *l.b.*, upper and lower bearings of fly-wheel, sunk in sliding-frame *(fr.)*, which can be regulated by wooden screw *(w.s.)*. The lower bearing, along with the inferior arm of the sliding frame, move in a limited groove in the joist *(J)*, which is specially morticed at this part.

Plate IV.—Enlarged Diagram of Grinding Apparatus. *i.*, Circular brass ring bordering aperture for upper end of spindle *(Sp.)*; it is provided with an upward projecting rim. The brass cap *(c)* acts as a steadying bearing to the spindle head *(Sp.)*; *i'.*, circular metal ring with upward projecting rim fastened on edge of central aperture of waste emery box *(b)*; the brass protecting cap *(p)* comes over the edge of this rim, and is apposed above to the free extremity of the spindle-head, thus effectually preventing the entry of dirt to the bearing *(c)*; *i".*, iron pegs for securing box *(b)* in its place. *L.* lap, or grinding disc; *a.*, attachment pin of lap, is somewhat conical, and does not quite fill the slot *(s)*; thus providing a grip which tends to become more firmly fixed during the process of grinding.

WORKING MEASUREMENTS.

Table	Height	38 inches.
	Length	40 inches.
	Width	20 inches.
Distance of joist *(J)* from top of table		6 inches.
Distance of spindle from nearest supporting leg *(u)* ...		5 inches.
Diameter of fly-wheel		16 inches.
Diameter of spindle-bearing wheel		6½ inches.
Diameter of pulley wheel		5½ inches.
Length of arms of sliding frame *(fr)*		10 inches.
Side of square waste emery box (*b*)		12½ inches.



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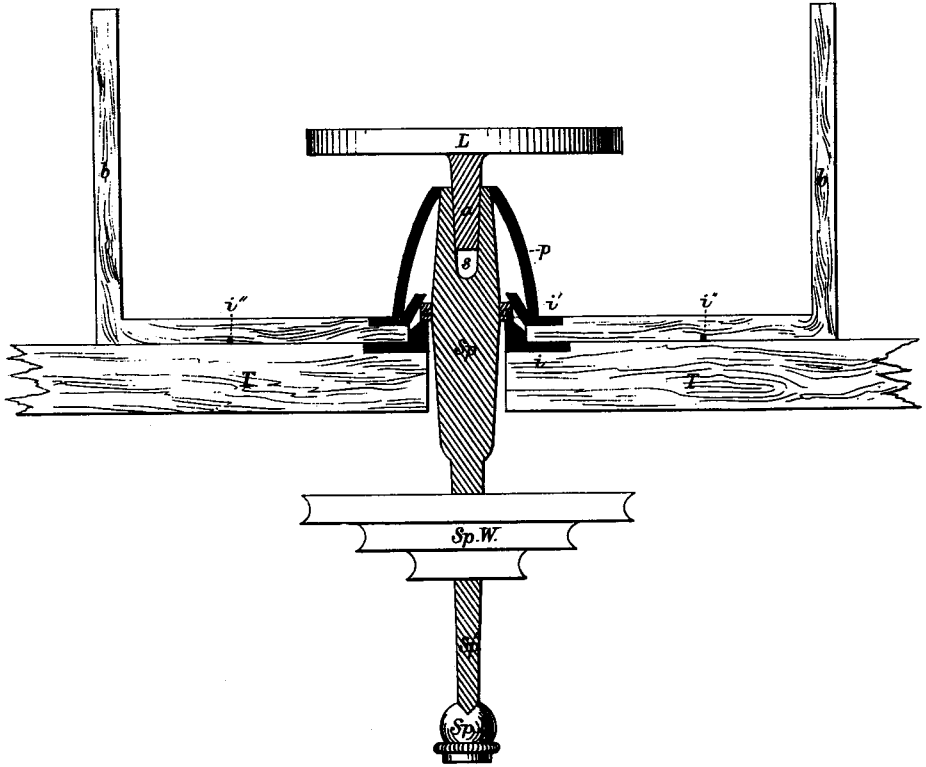
Diagrammatic section & drawing of Lapidary's Lathe.



Enlarged diagram of Grinding Apparatus.

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