MICROSCOPICAL STUDIES OF TASMANIAN ROCKS.

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The delicate methods of modern microscopical petrology have added greatly to our knowledge of igneous rocks. Very little work of this description has hitherto been attempted in Tasmania, but the present studies, undertaken in connection with the Launceston Microscopical Club, have been entered upon in the hope of throwing additional light upon the genesis and intimate structure of our eruptive rocks. It is proposed to continue the descriptions from time to time as materials and opportunity permit, and as they must at first necessarily partake of the nature of preliminary work, remarks upon their classification will be withheld till sufficient progress has been made to justify generalisations. A glance at the current literature of our science suffices to show that the microscope in petrology is each year enlarging the boundaries of its conquests, and it is hoped that the present contributions will prove helpful to the stratigraphical geologists of this island.

I. The Dolerite [= Diabase of Authors] of the Cataract Gorge, Launceston.

The samples of rock selected for slicing were taken from the quarry near the Cataract Bridge. Microscopically, the stone is dark, granular, doleritic-looking, studded with glistening needles of felspar, and black or dark-green spots representing a ferro-magnesian mineral. Its specific gravity, as determined by the use of a Walker's balance, ranges from 2·9 to 3, showing that we are dealing with a basic rock.

From a microscopical examination of their sections, we learn that the essential mineral components are a plagioclase felspar, augite, and a little iron oxide. I have not found any olivine in my sections, but further examples will have to be examined with respect to this point.

FELSPAR.

The sections presented are lath-shaped, columnar, with a few tabular forms. They are tolerably even in size ; at all events, there is not that disproportion of size which would suggest two generations. Though there are a few Carlsbad twins, the felspars are mostly twinned on the albite plan, and by choosing sections out of the zone perpendicular to the brachypinacoid (010), we can obtain the extinction angle proper to the species represented. With this method of determination not many visible sections are useful, as it is essential that they be cut perpendicular to the twin lamellæ. The maximum angle ascertained is the one to be taken, and this in the present instance is 42°. The felspar therefore belongs to the labradorite-anorthite group. The individuals polarise in the neutral tints of the first order of Newton's scale. At their terminations they are frequently turbid, and this turbidity makes it difficult to say whether there is or is not any small occurrence of glassy base between the ends of some of the prisms. There are rods of apatite in a few of the crystals, and inclusions—sometimes fluid cavities—are numerous.

AUGITE.

This is in groups of large ill-defined crystals or plates with irregular boundaries, moulding themselves, as it were, upon the felspars, and at times enclosing them, after the type known as ophitic. This structure is prevalent in gabbros, so-called diabases, and dolerites, and indicates that the augite crystallised out later than the felspar, which it wraps round and sometimes wholly encloses.

The ordinary order of crystallisation is now understood to be (1) iron ores, etc., (2) the ferro-magnesian crystals (olivine, augite, hornblende, biotite), (3) felspars, (4) quartz. But in these ophitic rocks the felspars precede the augite; accordingly they have the most perfect symmetry of form, having been free to crystallise without interference from adjacent crystals. The large masses of augite, on this assumption, are not analogous to lava phenocrysts brought up to the surface ready made, often corroded, dislocated, and senile. Some of them measure $\frac{12}{100}$in. in length, and though their component crystals are far from being idiomorphic, a few, out of the prism zone, are twinned, and have the modification of zonal structure known as the hour-glass form. The augite is monoclinic and non-pleochroic, colourless to light brown. Extinction angle 41° to 50°. On the whole they are not fresh, decomposition processes having commenced, and in some plates schillerisation has set in.

Iron oxide (magnetite) occurs in scattered grains, but is not abundant, the iron having apparently been used up in the augite, which from the marginal colouring we may infer to be highly ferriferous.

Viridite or chlorite exists as a greenish, radiately fibrous decomposition product, derived probably from disintegration of the augite. Its strong pleochroism helps to discriminate it from serpentinous matter. It evidently belongs to the chloritic group, and gives rise to the name greenstone.

There is no base actually determinable as such. The felspar crystals abut closely upon each other, as can be clearly seen by employing a quarter-inch objective.

With regard to the genetic history of this rock, its microscopical structure shows that it cannot in any sense of the word be described as a lava poured out at the surface in ancient times and cooled under atmospheric conditions. We do not find the glass which results from rapid surface chill imparted to flowing lava streams, and the crystallisation indicates its formation below the earth's surface.

Again, in most lavas, besides the large crystals brought up from intra-telluric reservoirs, there is a generation of smaller ones (generally felspars) springing into existence in the moving vitreous magma at the moment of eruption. But in our rock these two generations do not exist. There never was a surface phase in its history, and though it happens to be at the surface now, it is so only as the result of extensive denudation. Moreover, the incipient traces of schiller enclosures in the bisilicate tell us that we are dealing with no superficial rock, for these signs of hydration only characterise rocks which have formed under pressure at considerable depths.

The rock therefore agrees thoroughly with what is called the intrusive type—intermediate between the plutonic rock masses and volcanic lavas emitted at surface. To define the conditions under which it has come to occupy its present position belongs to the province of the field geologist.

The German petrographers postulate geological age as a classificatory principle for igneous rocks. This is not admitted in England, and is responsible for considerable confusion in the references to authors' descriptions. Thus in Germany the same rocks would be called diabase and dolerite, porphyrite and andesite, melaphyr and basalt, according to the age of each pair. Within a limited area this plan is to some extent applicable, but when we attempt to apply it universally we find that it fails. Gabbros, dolerites, and basalts may be found to shade into one another, presenting a continuous series of one and the same basic rock substance with textural modifications, ranging from the coarse granite structure of the gabbros to the glass of basalt lavas. Dolerite is on this theory a holocrystalline plagioclase-augite rock intermediate in texture between the gabbros and basalts, and the only use left for the term diabase is in designating those dolerites in which extensive chloritic and other alterations have supervened.

II. The Zeehan White Rock, a Vesicular Basic Lava = Melaphyre.

This rock varies in appearance according to the degree of decomposition and to its condition as an ancient ash or a tuff or a lava flow. The pieces prepared for examination were from a hard greenish-grey stone with conchoidal fracture, emitting sparks under the chisel, dotted with black spots (filled vesicles) from the size of a pin's head upwards. The specific gravity was 2·8. The stone was obtained from the Silver Queen Mine through Mr. W. F. Petterd, who informs me that he is now quite satisfied that it is interbedded with the slates. Mr. Alex. Montgomery, M.A., Government Geologist, has shown me looser descriptions, one of which looked like an agglomerate or brecciated tuff, but my remarks will have reference to the compact variety.

The slides prepared show a glassy ground mass devitrified by globulites and felspar microliths, many of the latter with curved, abortive, and ragged forms. A few of the larger crystals show simple, rarely multiple twinning. The microliths are crowded with inclusions which give them a corroded appearance. The structure is what Rosenbusch calls hyalopilitic, a felted mass of felspar microliths with interstitial glass.

I have applied Levy's method of determining the nature of the small felspars, viz., obtaining the extinction angle as from the longitudinal axis of the microlith. I find this to go as high as 30°, though quite a group collects round 24° and 26°. This indicates labradorite of average composition, the most common type of felspars of the ground mass in basaltic rocks.

The most striking feature in the sections consists of the numerous steam pores or cavities originally of gas bubbles, irregular in size and shape, but often elongated in the direction of flow, filled sometimes entirely with a chloritic substance, sometimes with calcite or with calcite bordered by chlorite, and sometimes containing carbonate of iron and a little quartz. The calcite effervesces on the application of acid and polarises brilliantly, contrasting strongly with the border of feebly refracting chlorite. This chloritic substance occurs as spherular aggregates filling the vesicles. Where the section is sufficiently thick its colour is a yellowish green, between crossed nicols it is steel blue and shows faint interference crosses. The characters of delessite approach those of the other chlorites so nearly as to render its absolute determination difficult, but the indications are those of this mineral, *e.g.*, the colour is from colourless to greenish yellow, according to the thickness of the slice; the arrangement of the fibres is radial from the centre with concentric interruption lines, through which they pass occasionally without a break, and its occurrence in vesicles is eminently characteristic of delessite. It is sometimes faintly dichroic. Where the section is thin the delessite filled vesicles are thoroughly colourless, and single-refracting. Calcite veins traverse the rock, presumably after consolidation. The crystalline calcite of the vesicles, showing characteristic twin structure and intersecting cleavage lines, appears to have crystallised out synchronously with the delessite, judging from its optical continuity notwithstanding interruptions by delessite.

Grains of iron ore, probably the carbonate, white in reflected light, are plentifully scattered through the base, and often tend to collect round the outlines of the cavities. There is an admixture of iron oxide, and some quadrate forms are presented by small cubes of pyrites, distinguishable by their brassy lustre. The granular substance of the siderite is discernible with a high power ($\frac{1}{8}''$).

I can find no augite, and the chloritoid mineral is not pseudomorphic after augite, but that mineral cannot have been far off. We thus see that this rock has as its essential constituents :—Glass with crystallites in the form of globulites ; felspar crystals of the base, labradorite ; iron oxide, probably magnetite. And as secondary and accessory constituents :—Crystalline calcite occupying vesicles and veins ; delessite in the vesicles ; quartz in vesicles ; carbonate of iron in the base and also in the vesicles. This is evidently an alteration product from the oxide.

From the triclinic nature of the felspar and the specific gravity (2·8) we infer that the rock belongs to the basic division. Its light colour seems to be due chiefly to the calcite and carbonate of iron, and masks its basic relations.

We are thus led to include it among the glassy melaphyres. Melaphyre is regarded by English petrologists as altered basalt, and in this sense the Zeehan stone is the vesicular form of old basaltic eruptive material = altered vesicular basalt = vesicular melaphyre. Its microscopical characters therefore teach us that it is an old lava, and Mr. W. F. Petterd says that in one of the adits of the Oonah Mine it can be distinctly seen lying between the silurian slates and following their stratification. Its European equivalent is the vesicular spilite of Nassau, the so-called lime diabase.

Since the preparation of this paper, Mr. Petterd has had some slices cut from the more solid rock met with at a greater depth, viz., from the 120ft. level of No. 3 shaft in the Silver Queen Mine. These show only a few vesicles, but have pale green chloritic materal diffused abundantly through the base. The felspars are larger than in the surface variety, but the same curved and distorted forms prevail. There is carbonate of iron scattered over the field in grains, as well as what I take to be titaniferous iron bordered by its white alteration product leucoxene, sometimes in wedge-shaped crystals, or pseudomorphic after felspar (and apatite ?) and apparently so after olivine. The latter is the nearest approach which I can find to any porphyritic constituent.

My attention has been drawn to a paper on the geology of the Zeehan and Dundas silverfield, read Nov. 20, 1895, before the Institution of Mining and Metallurgy at the Jermyn-street Museum in London, by Mr. W. F. Thomae, who has, I notice, correctly diagnosed this white rock as a melaphyre, and refers to its occurrence as favourably affecting the richness of the silver-lead lodes near Zeehan.

III. Picritic Basalt from Mount Horror.

There is a small class of rocks composed of the ferro-magnesian silicates and containing little or no felspar. These are the ultra-basic rocks, the specific gravity of which is higher than 3, and as high as 3·2, 3·3. By the addition of a felspathic constituent and its increase the specific gravity is reduced. Olivine no longer occupies an exclusive place, but augite and hornblende come in and eventually become the dominant ferro-magnesian silicates. When this happens the rock becomes a picrite, augite, or hornblende-picrite, as the case may be, and the picrite itself is liable to go on varying in the same direction until the augite-picrite may finally merge into olivine dolerite, or even into olivine basalt.

In Tschermak's original type rock picrite (1869) olivine constituted one-half of the rock, the remaining constituents being diallage, hornblende, and biotite. Gümbel described a few years later a palæopicrite from the Fichtelgebirge, an olivine-augite rock. In 1880 Dr. (now Sir A.) Geikie described augite-picrites from Scotland, in Inchcolm and at Blackburn, the latter with glass and abundant felspar, being a plagioclase-augite-olivine rock. Prof. Judd, in 1885, published observations on picrites from the island of Rum and the Shiant islands. We need not here concern ourselves with the extension of the name to the hornblende-picrites by Prof. Bonney, but restrict our remarks to the augite division of the group as represented by a rock from Mt. Horror in Tasmania.

The rock is a dark looking, almost black, crystalline stone, with large crystals of augite porphyritically set in the matrix, with smaller grains of olivine visible with a hand magnifier. Its weathered surface is rusty brown, with numerous protruding augite crystals. It is excessively tough, and its weight when taken in the hand prepares one for its high specific gravity. Determinations by Walker's specific gravity balance gave for different samples 3·11, 3·14, 3·16, 3·163, 3·169. To the last specimen I applied the liquid process, using Klein's tungsto-borate of cadmium solution of 3·28 density. Floating the fragments upon this dense fluid and diluting it until they remained suspended in any given position, their specific gravity was found to be 3·18. Tschermak's and Gümbel's picrites are 2·93 to 2·96*.

The Inchcolm picrite = 2·81. The sp. gr. of the non-felspathic picrites of Rum is stated by Judd† as about 3·20. The hornblende-picrite from Anglesey, described by Prof. Bonney,‡ has a sp. gr. of 2·88. Accordingly the sp. gr. of the Mt. Horror rock is high enough for a picrite containing some felspar.

The most important mineral is the augite, and not the mono-silicate olivine as in the more basic peridotites. It is present in large sections more or less oblique to the vertical axis. Its tint in plain light is light purplish, deepening to a dark mauve shade at the edges. A feeble pleochroism is perceptible where the purple shade is most pronounced. The purple colour (according to Knop) results from the presence of titanic acid ; this colouration is well seen by transmitted light and a hand lens in thin section of the rock. In some of the crystals traces of the cleavage cracks parallel to the prismatic surfaces are visible. Zonal lines are very marked and frequent. The low extinction angle indicates that the pyroxene is not very ferriferous. There are inclusions of colourless grains of olivine after the manner which gives rise to lustre-mottling or poicilitic appearances. In gabbros and diabases we find felspars included in the bisilicate in this way ; the characteristic inclusion in ultra-basic rocks is the mineral olivine.

The augite is repeated in the ground mass in the form of small crystals, often with defective ends ; many of these crystals show sections out of the prismatic zone. There is a tendency to grouping, and then a somewhat granular condition of augite prevails. This augite of the ground mass is of the same colour as the large phenocrysts, slightly pleochroic when deeply tinted. The extinction angles of vertical sections vary from 28° to 40°.

The next constituent is olivine in grains and defective crystals with rounded corners, at once distinguishable in the sections by its freedom from colour. Its fissures are filled with yellow serpentine, sometimes showing minute honeycomb structure. It is filled with enclosures containing bubbles and opaque grains (chromite ?) ; besides these, there are large glass cavities with inclusions.

The felspars are narrow, long, lath-shaped, and by their extinction angles may be referred to the labradorite-anorthite group. They are tolerably fresh and altogether play a minor role in the constitution of the rock.

* Teall, British Petrography, p. 103.

† Q. J. Geol. Soc., 1885, p. 392.

‡ Q. J. Geol. Soc., 1883, p. 256.

Rods of apatite with transverse jointing are numerous, and there are one or two narrow laths of a dichroic mineral which I suspect may be hornblende.

The presence of glass in some of the picrites, their porphyritic character and their varying quantities of felspar, all tend to show that their present classification is not final. Manifestly the holocrystalline gabbroid varieties ought not to be ranked with porphyritic ones. This difference is accompanied by a difference in their geological occurrence, the one division being plutonic, the other a lava. The occurrence at Mt. Horror is probably a basic segregation in the Tertiary basalt there.

I do not detect much vitreous base, but there is a considerable quantity of a clear substance containing, besides apatite and glassy belonites, minute colourless needles of what is usually considered to be secondary hornblende (grammatite, tremolite). This substance permeates the sections in all directions, and gives in bladed aggregates the feeble re-action on polarised light characteristic of hydrous silica. It clearly has no original place in an ultra-basic rock. I cannot establish for it a pseudomorphous character ; the impression conveyed is that it veins the rock generally. It may be seen too in some of the hand specimens as white veins. I suggest that it is the hydrous ferro-magnesian silicate, serpentine, formed by the hydration of the olivine, which, upon this assumption, formed once a larger proportion of the rock.

It is worthy of note that needles of tremolite have been observed in the olivine pseudomorphs and serpentinous substance of English picrites*, and Rosenbusch regards similar cases of their occurrence as associated with the alteration of olivine. I do not see any traces of the mutual intersection of belonites in the serpentine, regarded by Bonney as suggestive of enstatite†.

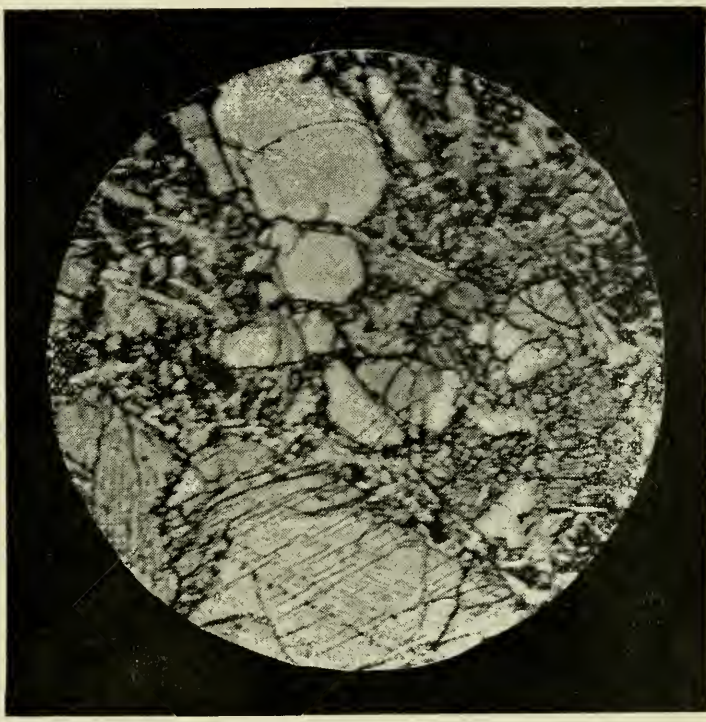
From the above description the nature and affinities of the Mt. Horror rock may be approximately gleaned. Its texture is coarser than that of a dolerite, and by its constitution it is an augite-olivine-felspar rock. Its relations are evidently with the olivine-basalts, while it is connected with the ultra-basic rocks by its high sp. gr., indicating a low $Si O_2$ %, and by its excess of ferro-magnesian silicates. These remarks may serve to direct attention to this instance of a very basic kind of basalt in Tasmania and elicit the communication of further occurrences.

* Teall, Brit. Petrogr., p. 86.

† Q. J. Geol. Soc., 1883, p. 255.

Note.—In plate for picrite and augite picrite read picritic basalt.

PICRITE FROM Mt. HORROR.



W. H. TWELVETREES, Photo-micro.

EXPLANATION OF FIGURE.

AUGITE-PICRITE from Mt. Horror, x 45. Transmitted light. At the bottom of figure is part of a large augite crystal with lines of inclusions marking zonal growth. The large rounded white crystals are olivine. The narrow laths are the felspars. The rest of the field comprises the smaller augites and serpentinous substance.