ON MESOZOIC DOLERITE AND DIABASE IN TASMANIA.

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The following Notes lay no claim to be an exhaustive description of our familiar "diabase" or "dolerite" rock, which plays such an important part in the geology and physical configuration of our Island. The present object is rather to place upon record some inferences drawn from the examination of numerous microscopical sections of specimens collected or received from all parts of Tasmania. It is by accumulating the results of observations that stepping stones are formed to more complete knowledge. A glance at Mr. R. M. Johnston's geological map of Tasmania, issued by the Lands Office, will show the share this rock takes in the structure of the Island. It occupies the whole upland area of the Central Tiers. On the northern face of the Tiers—the Western Tiers as they are here called—there is a tongue of the rock prolonged northwards past Mount Claude. At their north-west corner it forms or caps mountains, such as Cradle Mountain (the highest in Tasmania), Barn Bluff, Mount Pelion West. Eldon Bluff forms a narrow western extension. Mount Sedgwick is a western out-lier; Mount Dundas another. In that part of the island it is also found at Mount Heemskirk Falls, and on the Magnet Range, two miles north of the Magnet Mine. Mounts Gell and Hugel are also western out-liers. Its south-west boundary is Denison Range, with Mount Field West, Mount Mueller, and Mount Picton. Southerly we find it in the Hartz Mountains; the rock goes down to the south as far as the Rivers Huon and Esperance, and even further south it is found on the isolated peaks of La Perouse and Adamson's Peak, and a narrow fringe of it runs along the coast-line south of the Huon to South East Cape and South Cape. On Bruni Island it is present in a very massive form. It is found on Tasman's Peninsula, and in the whole of the south east of the Island it cuts up the sandstones and shales of the Permo-Carboniferous and Trias-Jura country. Mount Wellington and other heights near Hobart have summits composed of this rock. From the eastern side of the Central Tiers it is continued to the Eastern Tiers and the hilly ground from Swansea northwards to St. Mary's. Ben Lomond, the Mount Nicholas Range, Tower Hill, Mount Victoria, and Mount Saddleback are north-east out-liers fringed with Permo-Carboniferous and Jura-Trias. The northern extension passes under the sands and clays of the Launceston Tertiary basin, and re-appears along both sides of the River Tamar. It extends to Mounts Barrow and Arthur and Ben Nevis. There is an isolated patch of it at the mouth of the Mersey and at Port Sorell. On the East Coast it abuts on a fringe of granite on Maria Island, Schouten Island, and Freycinet's Peninsula.

A peculiar feature is the almost invariable association with it of Permo-Carboniferous and Trias-Jura beds. The whole periphery of the area forming the Central Tiers is fringed with a narrow zone of these beds, and the same holds good in the case of all the isolated peaks. How can this association be explained? It has been suggested that dolerite capping has protected underlying sediments, and that the latter do not merely hang on the flanks of the igneous table-land, but actually lie beneath the eruptive capping, as the lower formations would do in the case of a sill. The few boring trials which have been made in different parts of the Island lend no support to this suggestion. They have been made through the Permo-Carboniferous and Trias-Jura beds, and traversing these, have penetrated into the dolerite below. On the other hand, no trial has been made of boring through the dolerite at surface with a view of reaching the coal measures: as a matter of fact, we do not know whether the rock on the Tiers is a denuded intrusive sheet, concealing sedimentary rocks below it, or whether it is a vast eruptive mass *in situ*. The thickness in other parts of the island makes it difficult to believe that it is an intrusive sill. The thickest sill we can find mentioned in geological literature is the sill of basic rock in the Shiant Isles, off Scotland, described by Sir Archibald Geikie* as showing a sea-wall 500 feet high. But even this surprising thickness falls below the development of the massive rock which occupies the upper part of Mount Wellington. At the same time numerous minor intrusions in the form of dykes penetrate the Permo-Carboniferous and Trias-Jura sedimentary beds, so that we have two rather clear types

* Quarterly Journal Geo. Soc., 1896, p. 375.

of occurrence. Mr. R. M. Johnston places the geological horizon of this rock at the close of the Trias-Jura system, and we have no doubt in this his opinion is approximately correct. The rock has never been found *in sitû* in any of our Tertiary beds, which, however, do contain included fragments of it. The microscopical appearances of specimens from widely distant parts of the island also support the inference that the rock all over the Colony belongs to one and the same geological age. In one instance we have noticed microscopical fragments of the dolerite (diabase) included in Tertiary olivine-basalt. This occurs near Bothwell, where the basalt probably has entangled in its flow loose pieces of the older rock.

Its mineralogical constitution is rather simple, as will be seen from the following list of constituents :—

Essential.	*Accessory.*	*Secondary.*
Plagioclase.	Olivine.	Chlorite.
Augite.	Apatite.	Serpentine.
	Ilmenite.	Actinolite.
	Magnetite.	Scolecite.
	Pyrite.	Calcite.
	Mica.	
	Quartz.	
	Oligoclase. (?)	

Microscopical Characters.

Plagioclase-Felspar.—The sections are lath-shaped, in short or long laths, sometimes in tabular forms. Of course, it must be remembered that these sections only give us a view of one particular plane, and convey to the mind, merely inferentially, the image of the solid crystal. The felspars could not be called lath-shaped ; lath-shaped sections are all that is meant. Out of so many sections it is surprising to find how few are available for measurements of the extinction angle. For this purpose only such twins can be selected as give approximately symmetrical extinctions on opposite sides of the trace of composition plane. The twin forms are Carlsbad and Albite. We have seen none on the pericline type. If we take the haphazard sections of felspars in this rock, we shall find some giving low, some high, angles. The low-angled ones are probably those parallel to the base ; the high-angled ones parallel to 010, and the maxima of extinctions are given by the latter. The highest angle we have noticed is 42°, but, as a rule, angles of 30°, 32° are obtained. From this the felspar may be inferred to be labradorite and labradorite-anorthite.

Augite.—The augite crystallises after the felspars, sometimes enclosing them, sometimes wrapping them partially round or moulding itself on their ends. This gives rise to the structure called ophitic or diabasic. The structure has been surmised to have originated in rocks which consolidated under hydrostatic pressure, for instance, beneath the ocean; but this is purely hypothetical, and does not account for the same structure in the middle of thick subaerial lava flows. The augite is nearly colourless, or of an extremely light-brown tint; never the violet tinge which characterises the augites of Tasmanian Tertiary basalts. This colour character is occasionally rather useful in distinguishing the mesozoic from the Tertiary dolerites. Where the augites are fragmentary and small and the felspars much reduced in size, and the rock assumes an intersertal structure, as at Killafaddy, Tasman Peninsula and some other localities, doubt sometimes arises, on inspection of microscopical slices, as to whether we are looking at dolerite or basalt. In such cases the absence or rarity of olivine, which at most only occurs sporadically in the Mesozoic rock, is a useful guide. The Tertiary basalts of the island invariably contain a plentiful amount of olivine.

The augite has not been converted into diallage. Twin crystal sections, parallel to the clinopinacoid, exhibit fine oblique striæ, which must be parallel to the basal plane, and not the orthopinacoidal lamination of diallage. In sections parallel to the orthopinacoid the striæ are at right angles to the vertical axis.

Olivine.—This is not an abundant accessory. From most parts of the rock it is entirely absent. When it does occur, as at Killafaddy, Ross, Hobart, Bothwell, West Devonport, &c., it appears to be idiomorphic. It is then one of the early minerals in the rock, most likely second in point of time only to the apatite and iron ores. It appears preferentially in the finer grained varieties and those which show an approach to intersertal structure.

Apatite.—Occurs as slender needles in the felspars and in the unindividualised groundmass when this is present.

Ilmenite and Magnetite.—The iron ores in most diabases are ilmenite and titaniferous magnetite. Ilmenite cannot be recognised in our rock in any definable forms, though many of the shapeless grains may be that mineral. On the other hand the forms of magnetite can be discerned very well. In a section of the interesting rock at the Hobart Railway Station, which is of a porphyritic nature, a very fine magnetite cross is visible. This is an embryonic crystal with two axes at right angles to each other, neatly marked out by octahedral grains of magnetite growing end to end and forming a cross of singular symmetry and beauty. The iron ore is very plentiful in this variety, forming skeletal crystals everywhere. It is, as a rule, abundant in the varieties which possess any interstitial groundmass. In the holocrystalline descriptions it is present in larger grains or crystals, but in very small quantity, and from the ferriferous borders of many of the augites, it is reasonable to suppose that the iron in the rock has been largely utilised in that way.

Quartz.—This is an unexpected mineral in rocks of this class, but we have found it microscopically intergrown with felspar (granophyric intergrowth), in a piece of dolerite from the top of Mount Faulkner, kindly furnished by Mr. R. M. Johnston. Under such circumstances it must be an original constituent.

Mica.—A very little light brown biotite occurs in the Launceston dolerite at the Cataract Gorge, and at the place on the Elphin Road where the rock crops out opposite Mr. Thomas Corbett's grounds. The mineral is not associated with any chloritic products, and appears to be original.

Actinolite.—Needles of this mineral are to be found in the rock at the Railway Station, Hobart, and this is the only locality where we have observed it. It is rather strange that no hornblende is noticeable in any of our specimens, as it is not at all uncommon in the Swedish Hunne diabase, which structurally resembles many of the Tasmanian occurrences.

Chlorite.—This substance is now universally admitted to be only a secondary constituent of diabase, and to be of no value in classification. Rosenbusch traces it to the weathering of the augite mineral. Many Tasmanian dolerites are perfectly fresh, but others contain a green chloritic mineral between the felspars, and even in the felspars themselves. In some the augite has been entirely replaced by fibrous chlorite, and the rock would be called diabase by many English petrographers. Still this chloritised dolerite is not a separate geological unit, but forms part of the mass of the fresh rock, and has doubtless received its character from the purely local action of ordinary meteoric agencies. This fact suggests the old question of dolerite versus diabase. Dogmatism is inadmissible here. The consensus of petrographical opinion must be allowed to prevail.

Calcite.—This occurs in small quantities, *e.g.*, in the Organ-pipes of Mount Wellington.

Serpentine.—There is a little yellow serpentine in the olivine-dolerites, resulting from the decomposition of olivine.

Scolecite.—This zeolite is occasionally found coating the joint planes and faces of the rock at the Cataract quarry, Launceston, in white radial aggregates. It is a hydrous aluminium and calcium silicate, which has been reported from cavities and fissures of widely differing rocks, basalts, dolerite, granite. It is of no particular importance as a rock-forming mineral, but forms interesting specimens from the mineralogist's point of view. It is apparently a decomposition product originated by the access of meteoric waters.

Groundmass.—This occurs sparsely in most varieties between the angles of the felspars, and sometimes forms irregular patches in the rock. In the Hobart Railway Station rock it is in sufficient quantity to produce a porphyritic facies. It mostly forms an imperfectly individualised mass, comprising skeletal and embryonic felspars, magnetite grains, &c. Its character is well displayed in Mr. Teall's figure of sections of the High Green plagioclase augite dyke, Q.J., Geol. Soc., 1884, p. XIII., Fig. 2.

Some of the small felspars in the groundmass of the Hobart rock, and that of Ross, give straight extinctions, and may be oligoclase. The groundmass is holocrystalline felspathic, and has not a basaltic facies. It would appear to indicate that the rock did not consolidate subaerially, but, on the other hand, not very far below the surface. This felspathic groundmass is plentiful in some of the dolerite near Bothwell. The main mass of the rock between Bothwell and The Lakes, despite its general coarseness of grain, has a little of it, and it is not wholly absent from the coarse ophitic dolerite at the dam on St. Patrick's River. It is abundant in a fresh coarse dolerite near Mount Claude, which is also remarkable for containing allotriomorphic felspar. In some varieties the green chlorite has wandered into the groundmass, as at Mount Direction (south), where the rock cotains some olivine.

Besides the ophitic structure, we have another modification found chiefly in the finer grained varieties of this rock, namely, one in which an incompletely individualised or otherwise indistinct groundmass exists in the interstices of the small crystals of felspar, and round the granules or small fragments of augite which are distributed in those interstices. This is the intersertal structure of Rosenbusch. Both ophitic and intersertal structures are met with in basalts. Intersertal basalts are common all over the world : ophitic ones have been described by Judd, from the Western Isles of Scotland. Gabbros also are sometimes ophitic. It would be interesting to know whether the two modifications are characteristic of different geological occurrences ; if so, one would expect to find the ophitic structure prevailing in the larger masses of rock, and the intersertal in narrow dykes. The most can be said of the Tasmanian occurrences is that the intersertal structure is confined to the close-grained varieties.

Parts of this dolerite become converted into diabase by the chloritisation of the augite. Thus a diabase on the Blue Tier (Gould's Country) is a typical occurrence, the whole of the augite, which is ophitic, being changed into chlorite. Some of the occurrences of diabase in the island may possibly be older, but evidence of their age is not yet available. It may yet be shown that some of these altered dolerites are of Palæozoic age ; for instance, there is a dyke of diabase near the Hampshire Hills, and near the Bridge on the Arthur River, Heazlewood, is a porphyritic diabase, with ophitic chloritised augite, and a little light brown biotite. The diabase occurring at the Blue Tier may belong to the older series. On the Corinna Road, 8 miles from Waratah, is what appears to be a diabase with intersertal structure. The felspars in it are smaller than usual, and grains of augite occupy the interstices. Both calcite and chlorite are present ; possibly this is a melaphyre.

The European types with which the Tasmanian Mesozoic dolerite may be compared, micro-structurally, are the Hunne-diabase of Sweden, and the Kinne-diabase from the Kinne-kulle of that country. The latter rock, as exemplified by one of our slides, exactly corresponds with our typical coarse-grained dolerite. In Sweden it covers Silurian rocks in the form of a sheet. The Hunne-diabase of the Hunneberg, in the same country, and in the same geological position, contains a little bronzite, biotite, quartz, and hornblende, but in structure closely resembles some of our fine-grained varieties.

Many people look at our bold escarpments and rugged faces of "greenstone" and believe that some stupendous eruption ejected the mass from below and poured it over the land in an overwhelming flood. In view of the preceding remarks it is hardly necessary to say that these rocks were never in the form of a lava over-spreading the land in the presence of the atmosphere. They have been undeniably produced by the crystallisation of a magma which was injected or intruded into strata lying below the surface. They have not crystallised rapidly, but under the pressure of superincumbent rocks, which we seem compelled to believe have been carried away by subsequent denudation. There is absolutely nothing to show that they ever succeeded in establishing communication with the surface. If, however, they did, both the pipes by which the magma ascended, and the basaltic flows in which that ascent finally resulted, have been wasted, without leaving a trace behind. The entire absence of mesozoic basalts in the island suggests that these dolerites always were subterranean, and that the faces and cliffs which we now see are subterranean sections lifted for our inspection by one or other of the earth movements, which geological science so often reports.

The names by which this eruptive rock is known are not constant, and the discussion of them introduces us to controversial petrology. The rock is that which is called diabase in Europe and America, and dolerite by most English petrographers. It is a plagioclase-pyroxene rock, with the ophitic (and intersertal) structure which so eminently characterises diabase that it has given rise to the term "diabasic structure." The rocks related to it are, on one side, ophitic gabbros; on the other, intersertal basalts. In former days, if the rock was of pre-tertiary age, it was called "diabase": if more recent, "dolerite." European geologists, however, reserved the term "dolerite" for the coarse interior part of thick lava sheets. This term is not much used now-a-days by Continental petrographers, and the instances in which it is applicable are considered by them as local and unimportant. But the habit of attributing much importance to geological age as a factor in rock nomenclature has now died a natural death, even in Germany, and the only question at issue is that of convenience. Some general agreement is desirable as to whether the present group should be called dolerite or diabase. English petrographers (with the exception of Mr. Harker) use the group name dolerite, and keep diabase for altered varieties of the same rock. This usage was established by the late Mr. Allport, and has been followed by Judd, Teall, Hatch, Rutley. Mr. Harker alone retains "diabase" for massive sills, dykes, laccolites, &c., and applies dolerite to the less important intrusions of similar rocks. Rosenbusch states that diabase, when fresh, is undistinguishable from tholeites and dolerites: Professor Lacroix, in France, upholds the term diabase as the group name. Looking at the present practice of petrographers all over the world, we see that there is a preponderance of agreement in favour of the term "diabase." The future will show whether English petrologists will agree to surrender their somewhat isolated though thoroughly logical use of "dolerite," and fall into line with their colleagues in other countries. All that can be done at present is to observe the trend of petrological opinion, and if one or other of the terms becomes obsolete, it will be necessary to adopt the one which gains general recognition. Meantime we venture to adhere to the English practice, and call this rock dolerite in its fresh condition and diabase in its chloritised state.

The tertiary basalts of Circular Head, Table Cape, Lefroy, &c., often exhibit a coarse intersertal or slightly ophitic structure, and would correspond with what goes under the name of dolerite in Germany. In point of coarseness such basalts are dolerites. They may be distinguished from our mesozoic dolerite by their abundant olivine, glassy base, and greater freshness.

The discovery of a little auriferous wash in the first and second basins of the South Esk at Launceston has led a few people to believe that the mesozoic dolerite might be gold-bearing; but the fact is that the sand which was obtained contained, besides small flakes and water-worn pellets of gold, grains and crystals of quartz, zircon, sapphire, and ilmanite, all minerals of the granite and slate country in the upper reaches of the river, and must be referred to that source. No useful minerals have yet been found in this rock, and the lodes and reefs of our various mines are all of earlier date. The experience of our miners in this respect has been so uniform that search for ore deposits in the dolerite is invariably regarded as useless.