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No. 6.

NOTES ON A COLLECTION OF IGNEOUS ROCKS FROM LORD HOWE ISLAND.

BY

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NOTES ON A COLLECTION OF IGNEOUS ROCKS FROM LORD HOWE ISLAND.

Introduction.—The collection comprises about twenty specimens, collected by Mr. R. Etheridge, junr., and Mr. Alexander Morton.

Classification.—All the hand specimens examined belong to the basalt group. They appear to belong to three leading types.—

1. *Basalt with olivine.*—These are chiefly dense dark greenish-gray rocks, for the most part little affected by decomposition, some of them probably being of comparatively recent origin.
2. *Basalt without olivine, lateritic.*—This is a lateritic rock, of a dull brick-red colour, soft, earthy and amygdaloidal; passing in places into scoria. This lava may be partly submarine.
3. *Basalt, diabasic.*—A hard dense pyritous rock of a greenish-gray colour, and resembling an andesitic dolerite; it has undergone extensive alteration, and is probably of considerable geological antiquity.

Detailed Description of Specimens.—Type 1. *Basalt with olivine* [Slide No. 1], from the "Gulch" North Cliff, is a dark-gray cellular basalt, having its joints and steam-holes partly filled with calcite.

On weathered surfaces the rock has a very fresh aspect, and has suffered less, perhaps, from decomposition than any of the other specimens. It outwardly resembles the vesicular basalt No. 6, or (30 a. and b.) north of Ned's Beach, at the Point.

Under the microscope the rock is seen to consist of a microcrystalline base of magnetic iron and granular augite, enclosing micro-porphyritic grains of olivine, occasional zeolites, and a good deal of glassy interstitial material.

The felspars, chiefly triclinic, occur in minute lath-shaped crystals never micro-porphyritic.

Magnetite is abundant, though not present in sufficient quantity to make the base opaque, as in the succeeding section. Ilmenite is also recognizable. Augite is present, only in very minute grains of a pale purplish-brown colour.

The olivine grains are in striking contrast to the rest of the rock constituents. They are much decomposed and of very irregular shape and uneven size, most of them having the appearance of fragments broken off larger grains. All the grains are surrounded by a zone of a reddish-brown decomposition mineral, and the cracks traversing the grains are lined with similar material. Green serpentinous matter is also observable towards the centre of the olivine grains.

The absence of any sign of decomposition or fracture in the rest of the rock, as compared with the much decomposed and fractured state of the olivine, argues a derivative origin for this mineral.

Specimen No. 23 [Slide 2], exact locality unknown.—This is a dense basalt, of a blackish-gray colour on weathered surfaces, very little decomposed, and rendered slightly porphyritic by crystals of augite and grains of olivine. The rock consists of a blackish-gray, rather opaque microcrystalline base of triclinic felspar, and abundant magnetic iron, with porphyritic crystals of augite, felspar, and olivine.

The base contains so much magnetic iron as to be nearly opaque, excepting at the thin edges of the section, and it appears to be wholly devitrified.

The felspars seem to belong to two generations.

The lath-shaped microcrystals with ragged ends in the base were evidently formed during the cooling of the magma, but the porphyritic crystals, to judge from their broken and corroded appearance, were probably formed previously. The latter are colourless and clear.

The augite occurs in minute granules, as a constituent of the base, and also in large well-formed eight-sided prisms bounded by sharp edges. Some of the augite crystals are corroded at the edges and fractured.

The large crystals of augite are not penetrated by the felspar, but completely invest or are moulded on to the grains of olivine.

The large crystals are of a pale-straw colour nearly colourless, with yellowish-brown streaks along the cracks.

The olivine is in rounded grains, partly serpentinized along the cracks into a bottle-green fibrous mineral, rather strongly pleochroic.

The olivine was evidently formed before the consolidation of the base, as proved by its enclosure in the large perfect crystals of augite, which must have formed contemporaneously with the base. In one part of the slide a little secondary actinolite (?) is visible.

Specimen No. 1 [Slide No. 3], from Observatory Point.—This is a dense basalt of a dark greenish-brown to black colour and flakey fracture; it is rich in olivine, the olivine grains bring from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch in diameter.

The specific gravity is 3·05.

In microscopic sections the rock is seen to consist of a micro-crystalline ground-mass of triclinic felspar, granular augite, and dendritic aggregates of magnetic iron, and grains of olivine and crystals of augite and triclinic felspar occurring porphyritically.

The grand-mass appears to be wholly devitrified, with the exception of one oval patch in part of the section, which contains a little glass.

The less-decomposed parts of the rock are gray, while those more affected by decomposition are of a reddish-brown colour.

The triclinic felspar in the ground-mass occurs in minute lath-shaped striated crystals.

The larger porphyritic fragments of felspar are much broken and corroded. One of them is moulded on to the side of a large grain of olivine, and in one case some crystals of triclinic felspar are completely invested by a large crystal of augite.

The augite occurs in the ground-mass in microscopic granules, and also porphyritically. The large augite crystals have been much eaten away, like the large felspars. Magnetic iron occurs in the base in black crystalline aggregates, and also in single crystals, showing as opaque black squares and triangles.

Ilmenite is also present, in well-marked rhombohedral sections.

The olivine in this basalt is quite clear and transparent, and remarkably free from decomposition, excepting along the cracks, and around the margins where it has decomposed into a reddish brown mineral, which has lent a similar colour to the rock, when viewed in thin sections by transmitted light.

This reddish-brown secondary product is probably formed partly from the magnetic iron, but its presence is most marked close to the olivine grains.

A little greenish decomposition mineral is also observable in the gray parts of the base. This probably results from the alteration of the granular augite into chlorite.

Specimen 35, from north-east point of Ned's Beach, is a cellular basalt slightly porphyritic by augite. The gas-pores are lined or completely filled

with a white transparent zeolite. The weathered surfaces of the rock show that it is composed of a greenish-brown ground-mass speckled with rust, (formed by decomposition of magnetite) and containing black crystals of augite from $\frac{1}{8}$ inch to $\frac{1}{4}$ inch in length, a few crystals of striated triclinic felspar $\frac{1}{2}$ inch long, and reddish-brown, partly decomposed, grains of olivine.

The zeolite has a hardness of about 4, and a specific gravity of about 2·16.

Before the blow-pipe it whitens, crumbles, and swells up considerably into white semi-transparent beads.

It probably belongs to the Chabazite Group, and resembles phacolite.

Type 2: *Basalt without olivine. Specimen* 25 [Slide No. 4 *a*.], from North Point, Ned's Beach.—This rock is a much decomposed lateritic amygdaloidal basalt, of a reddish-purple colour. The rock is soft enough to be cut with a knife without much difficulty. The amygdules consist chiefly of a pale greenish-gray aragonite.

The rock, examined in thin sections under the microscope, is seen to consist of a microcrystalline ground-mass of lath-shaped felspar too cloudy to polarise, a feebly translucent brown mineral, a pyroxenic decomposition product filling in the spaces between the microscopic felspars, and crystalline aggregates or individual crystals of hæmatite pseudomorphous after magnetic iron. Crystals of a mineral resembling nosean (though possibly a variety of pyroxene), $\frac{1}{16}$ inch to $\frac{1}{8}$ inch in diameter, are plentifully distributed throughout the ground-mass.

The sections afforded by this mineral are generally six-sided, and occasionally quadratic.

Most of the crystals are bounded by an opaque zone of hæmatite, and the greater part of the space so enclosed is reticulated with pseudomorphs of hæmatite after magnetite. One crystal in particular shows the characteristic zonal grouping of the enclosures remarkably well.

Between the opaque hæmatite grains in the nosean (?) crystals is a semi-translucent yellowish oily mineral, which has evidently resulted from the alteration of the nosean (?).

Small and large amygdules also occur of a mineral somewhat similar in appearance, of a pale greenish-yellow colour. The large amygdules have a hardness of about $3\frac{3}{4}$, are infusible before the blow-pipe, and effervesce briskly in hydrochloric acid. They are evidently aragonite.

The advanced state of decomposition of the only small specimen of this rock available for examination precludes the possibility of the certain determination of the nosean-like mineral.

Specimen No. 10 (34), from the west side of Thompson's Beach, is a purplish-red scoria, perhaps a scoriaceous representative of the preceding rock.

Type 3: *Diabasic basalt. Specimen* 24, [Slide No. 5 *a*], from beach below Robbins' House.—This is a hard, dense, dark greenish-gray rock, irregularly jointed. The weathered surfaces are pitted with small hollows, and in places small beads of chalcedony $\frac{1}{16}$ inch in diameter form minute excrescences. White and dark-green spots are visible on freshly-broken surfaces. Some of these white spots are very soft, and effervesce strongly in hydrochloric acid; others are hard, and cannot be scratched with a steel penknife. The dark-green spots are aggregates of iron pyrites and epidote. Iron pyrites is present in crystals and crystalline aggregates disseminated through the mass of the rock, and also lining the irregular rock-joints, in films $\frac{1}{50}$ to $\frac{1}{20}$ of an inch thick. At times calcite takes the place of this interstitial pyrites in the joints, as pointed out to me by Mr. F. Ratte, Mineralogist to the Australian Museum.

The specific gravity of this rock, taken in water at 80° Fah., is 2·822 for average specimens, and 2·838 for the more pyritous.

Under the microscope the rock is seen to be holocrystalline and composed of a microcrystalline ground-mass doleritic in places with microporphyritic crystals of augite and amygdules of chalcedony and calcite. The ground-mass is formed of lath-shaped triclinic felspar, granular augite, a grass-green secondary mineral, chiefly epidote, magnetic iron, and secondary iron pyrites. The structure of the felspar and granular augite is subophitic, and decidedly ophitic in the case of the microporphyritic crystals of augite.

The felspars, with few exceptions, are sufficiently free from decomposition to show distinct multiple-twinning. They penetrate the augites deeply without interfering with the orientation of the crystal. In one part of the slide they exhibit a zonal tangential arrangement around a microporphyritic crystal of colourless multiple-twinned felspar.

A few microporphyritic crystals of felspar are observable, several of which have been fractured in situ, and the broken pieces considerably displaced with regard to one another. The augite in the ground-mass is of a pale yellowish-gray tinge, inclining in places to pale purplish-brown. Towards the margins most of the augites are decomposed into a grassy-green epidote. The microporphyritic augites are intercrystallized with the lath-shaped felspars. They show no signs of decomposition, and polarise brilliantly. One large crystal, however, is in striking contrast to the others, being almost wholly decomposed into a greenish mineral. The green secondary minerals probably result from the decomposition of the augite, as shown by the gradual merging of the latter mineral into the former, and the ophitic structure of this green mineral with the felspars. Tested with the single nicol most of the green mineral shows pleochroism, but not so strongly as hornblende. In a few instances this green mineral is somewhat fibrous, and shows a strong parallel cleavage in one direction. Acicular crystals of actinolite (?) traverse some of the green patches, and sometimes show a radiate arrangement. Chlorite is not definitely recognizable, and there is no evidence of the existence of primary hornblende.

Magnetite is present in the base and in the microporphyritic crystals of felspar and augite. A few large grains of ilmenite are recognizable from the fact that they are surrounded by rings of cloudy pale yellowish-gray leucoxene.

Opacite is plentiful, occurring in elongated shapes.

Summary.

The chief conclusions to be derived from the preceding observations would appear to be the following:—

(1.) All the igneous rocks of Lord Howe Island (so far as represented by the collection examined) belong to the Basalt Group.

(2.) A vast period of time must have elapsed between the eruption of the diabasic basalt and that of the comparatively recent olivine basalt.

(3.) All the basalts, with the exception of the diabasic types, are probably not earlier than Tertiary, and some may be Post-Tertiary.

(4.) The diabasic basalt is probably Pre-Tertiary, and may be Palæozoic.

T. W. EDGEWORTH DAVID.

[Plates.]

Sydney: Charles Potter, Government Printer —1889.

ERRATA.

Page.		Line.					
4	...	16	...	for	Admirallty	read	Admiralty
7	...	45	...	„	Inlets	„	Islets.
7	...	46	...	„	Zig-Zaged	„	Zig-Zagged.
8	...	6	...	after	Lord	„	Howe.
8	...	25	...	for	Haliaster	„	Haliastur.
			and	„	lucogaster	„	leucogaster.
10	...	16	...	„	Philipp	„	Phillip.
12	...	7	...	„	Galinula	„	Gallinula.
20	...	29	...	„	Hoplodactylus	„	Haplodactylus.
21	...	50	...	„	decrease	„	decreasing.
23	...	42	...	„	was	„	were.
25	...	24	...	„	Brazeri	„	Brazieri.
26	...	31	...	„	arter	„	after.
33	...	44	...	„	Actœa	„	Actæa.
35	...	8	...	„	Huegellii	„	Huegelii.
36	...	18	...	„	chebrus	„	chabrus.
36	...	19	...	„	leolophus	„	leiolophus
36	...	29	...	„	Huegellii	„	Huegelii.
39	...	13	...	„	breviceps	„	brevipes.
40	...	29	...	„	Cœloria	„	Cæloria.
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77	...	21	...	„	Lidgbird	„	Ledgbird.
88	...	36	...	„	tibia	„	tibiae.
95	...	47	...	„	pubesccnee	„	pubesence.
101	...	34	...	„	spec	„	speck.
105	...	8	...	„	shorther	„	shorter.
113	...	40	...	„	Promotory	„	Promontory.
117	...	38	...	„	debris	„	débris.
117	...	38	...	„	dessicated	„	desiccated.
124	...	26	...	„	mergeance	„	mergence.
130	...	78	...	„	grand-mass	„	ground-mass.
	Plate i.		...	„	Phæton	„	Phaëton.

N.B.—Plates iv. and v.:—The figures on these plates have been reversed.