ON AN ENSTATITE-AUGITE BEARING DIABASE FROM TASMANIA.

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As an annex to W. Wahl's interesting investigations of enstatite-augite in diabases, (²) the author here describes a diabase from Launceston, Tasmania, which he has received from Professor F. W. E. David, of Sydney. According to Johnston's geological sketch-map of Tasmania, (³) greenstones (diabase, otherwise dolerite) have a very wide distribution in this island; they compose in particular a considerable part of the mountainous land of the centre, and spread also to the northern, eastern, and south-eastern coasts. Their occurrence is always associated with Carboniferous and Mesozoic sedimentaries, with which apparently they alternate as intrusive masses. Twelvetrees and Petterd (⁴) give a general petrographic description of them, and see in them close relationships to the Hunne and Kinne diabases. F. P. Paul (⁵) has described a konga diabase from the neighbourhood of Hobart, in the southern part of the island. The rock contains, always in parallel intergrowth, two pyroxenes of somewhat different colour and of different optical axial angle; closer information respecting the size of the latter is not given.

Further information respecting the geological occurrence of the diabase now to be described is not in the author's possession.

It is a medium-grained, very fresh rock, of grey colour, with macroscopical pyroxene and lime soda felspar; the former forms irregularly bounded grains or thick (up to 6 mm.) long rods of bright greenish-grey colour. Ophitic structure is not developed. Under the microscope also the diabase appears to be very fresh, and composed essentially only of felspars and pyroxene; amphibole and mica are altogether absent. The plagioclase has quite the habit of andesite felspars. Crystographically it is always very well developed, in thick plates parallel to (010), and then elongated in the direction of the a axis. Sections show the combination (010) (001) (110) (1̄10) (101) (2̄01). Twinning lamellation, according to the albite law, is probably present in every individual; and is frequent according to the pericline and Carlsbad laws. Zonal growth is universal, and this appears

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(¹) Central blatt für Mineralogie, Geologie, und Paläontologie, 1907, No. 23, pp. 705–711.

(²) W. Wahl: Die Enstatitaugite, Mineral. petr. Mitteil, 26, p. 1.

(³) R. M. Johnston: Systematic Account of the Geology of Tasmania, 1888.

(⁴) W. H. Twelvetrees and W. F. Petterd: On Mesozoic Dolerite and Diabase in Tasmania. Proc. Roy. Soc. of Tasmania, 1898–9.

(⁵) F. P. Paul: Beiträge zur petrographischen Kenntniss einiger foyaitisch theralitischen Gesteine aus Tasmanien. Mineral. petr. Mitteil. 25, p. 267.

particularly in sections parallel to (010). A basic centre is surrounded by an acid envelope, which is sometimes furnished with a narrow, more acid, marginal band. The boundaries of these zones are generally sharp. The following measurements were taken on (010), observing crystallographic contours and orientating for uniform brightness:—

Centre.	Envelope.	Marginal Band.
$-33\frac{1}{2}° = Ab_{11}\ An_{89}$	$-18\frac{1}{2}° = Ab_{46}\ An_{54}$	
$-29\frac{1}{2}° = Ab_{25}\ An_{75}$	$-21\frac{1}{2}° = Ab_{42}\ An_{58}$	
$-34\frac{1}{2}° = Ab_{7}\ An_{93}$	$-23\frac{1}{2}° = Ab_{40}\ An_{60}$	
$-33\frac{1}{2}° = Ab_{11}\ An_{89}$	$-22° = Ab_{41}\ An_{59}$	
$-35° = Ab_{5}\ An_{95}$	$-19° = Ab_{46}\ An_{54}$	$-12° = Ab_{55}\ An_{45}$
$-30° = Ab_{24}\ An_{76}$	$-20° = Ab_{44}\ An_{56}$	$-13° = Ab_{54}\ An_{46}$

Accordingly, the centre is basic bytownite-anorthite, the envelope is labradorite, and the narrow outer band is basic andesine

Under the microscope the pyroxene is very brightly coloured. In thin mounts the larger grains are, as a whole, nearly colourless, only on the edges a more intense grey-brownish tint is apparent. Small grains have also the same colouration. Pleochroism is scarcely perceptible, even in very thick slices and isolated grains. Crystallographic boundaries are infrequent, and confined to the prism zone. As a rule well-defined felspars pierce the larger pyroxene grains, and small grains of augite with irregular forms are squeezed between the felspars. Obviously, the crystallisation of pyroxene began before that of the felspars, but that of the latter lasted longer than that of the former. On this account, and also in consequence of the presence of a felspathic mesostasis, the structure deviates from a purely ophitic one. Besides a prismatic cleavage there is one parallel to (010), apparent by means of infrequent, but clean and continuous, cracks. Parting parallel to (001) can be recognised only in places. The cracks corresponding to this face are always crowded together in spots, and never traverse an entire pyroxene section. A twinning connected with these striæ is not shown. Frequently the parting proceeds from large prismatic cleavage cracks, and at the same time there begins an alteration of the pyroxene to green decomposition products; according to this it is certainly to be regarded as secondary.

The augite acts as a host for numerous inclusions of small dimensions. The smallest of these are colourless, rounded, and frequently carry a moving gas-bubble. The larger ones are cloudy, sometimes scarcely translucent, apt to be drawn out in tubular form, and constitute in places a complete network. Apparently these also are fluidal inclusions. Their decomposition is irregular; they collect in swarms, so that with a low magnifying power their host appears as if traversed by irregular cloudy zones. With striking frequency these zones occur in the vicinity of large cracks, so that for these inclusions also a secondary origin is probable.

Grains of pyroxene are often intergrown with one another polysomatically, as can be seen even in ordinary light along the course of the cleavage cracks. In polarised light, however, another phenomenon appears: Grains of uniform cleavage, which in ordinary light, both in respect of colour and refraction, appear perfectly homogeneous, fall into generally two, rarely

several, individual parts, which differ by reason of a slight dissimilarity in the strength of double refraction or position of the directions of vibration. The boundaries of these individuals are always sharp, and are irregular, as is their mutual relation, so that any difference in age is not apparent. Each of the individual parts can extend to the margin of the entire section, and assume there a deeper colouration. Sometimes the whole phenomenon recalls such as is shown by strongly-squeezed and shattered quartz grains; a similar feeble undulose extinction declares itself. Nevertheless, secondary pressure is here certainly not the cause. The rock, moreover, shows no trace of pressure effects, and the course of this phenomenon in neighbouring pyroxene individuals cannot be referred to any common direction of pressure.

The optical differences are best seen in weakly birefringent sections. With a favourable section approximately normal to the acute bisectrix, one kind of these individuals (for brevity named pyroxene *A*) shows a grey polarisation colour, while the other (pyroxene *B*) remains completely dark. In convergent light *A* gives the figure of a biaxial crystal with a moderate, but in different grains, a somewhat variable axial angle; with *B*, on the other hand, the cross either does not open at all, or only slightly, and in a plane normal to the axial plane of *A*. One can best convince oneself of the latter by choosing a spot in the neighbourhood of the boundary between two individuals, *A* and *B*, and placing the mount at 45° push it. Just as the boundaries of *A* and *B* appear sharp in parallel light, so here also the passage from one position of the axial plane to the other is immediate and with a leap. The position of the bisectrix *C* is apparently exactly identical in both individuals. Since their intergrowth, as is shown by the coincidence of both systems of cleavage cracks, is parallel, one of them must have a normal-symmetrical axial position. From the angle of the cleavage cracks, and in the case of twins on (100), from the position of the twinning plane it is seen that *A* has symmetrical, *B* normal-symmetrical, axial position. This is a further instance of normal-symmetrical axial position in pyroxene, as described by Wahl in the augites of the diabase of Richmond and the eucrite of Juvinas. Unfortunately very few sections were suitable for measuring the axial angle. In a very thick slice two intergrown grains were measured with a Klein's lens: *A*, 2E = 45 − 46°; *B*, 2E = 12°. Accordingly, for a monoclinic pyroxene, *A* has a strikingly low value, which, according to Wahl, is characteristic of diabase augites poor in lime.

With increasing birefringence the optical differences between *A* and *B* diminish, and sections on (010) allow only slight differences in polarisation colour to be noticed, but none in the extinction. The latter amounts to C : C = 45 − 46°. On cleavage flakes on (110) the extinction was found varying between 31° and 35°, but it was impossible to determine whether it was different between *A* and *B*.

The attempt to separate the pyroxenes *A* and *B* by means of heavy solutions was unsuccessful. In the Rohrbach solution, in which epidote of 3·47 sp. gr. just sank, the augite began also to sink, and the microscope showed this to belong to the dark marginal zone. The clear grains sank within a very small interval of dilution, and the irregularly distributed fluidal inclusions evidently exert a greater effect on the specific gravity of their hosts than the anticipated chemical differences of *A* and *B*. Nothing remained therefore but to analyse the clear pyroxene by itself, *i.e.*, as a mixture of *A* and *B*. The analysis (by Professor Dittrich) gave the following results under I. Under Ia. are the corresponding molecular quotients:—

	I.	II.	III.	Ia.
SiO_2	51·87	51·30	50·36	0·8588
TiO_2	0·21	0·72	0·80	0·0026
Al_2O_3	2·02	2·36	2·49	0·0198
Fe_2O_3	3·50	2·22	2·35	0·0219
FeO	8·98	18·83	18·15	0·1249
MnO	0·18	0·57	0·56	0·0025
MgO	16·26	16·56	11·37	0·4029
CaO	15·70	6·96	13·97	0·2797
Na_2O	0·16	0·21	0·26	0·0026
K_2O	0·09	0·37	0·19	0·0010
H_2O	1·20	1·00	0·55	
	100·17	101·15	101·09	

II. and III. are quoted for comparison. Under II. is the composition of a pyroxene from the diabase of Källsholm, Föglö (with 0·05 Nio). According to Wahl the apparent angle of the optic axes varies between 36° and 26°; the average is 30°. Under III. is the composition of a pyroxene from a coarsely granular quartz diabase from Schtscheliki (with 0·04 NiO), with 2E between 73° and 40°, greater therefore than that of II. In both occurrences the greater and smaller values are, contrary to our pyroxene, connected by transitions in one and the same individual.

The low lime content, as well as the optical characters, prove that our pyroxenes, *A* and *B*, belong to the enstatite-augite series of Wahl. According to the optical relations a still lower content was to be expected. Strikingly low is the percentage of FeO. Wahl found the proportion CaO : FeO + MgO in various enstatite-augites to be very nearly 1 : 6, and sees in this diminution of CaO as against the total of the other two oxides the factor which mainly conditions the small axial angle. At all events, that is correct. Still, the proportion of FeO : MgO, as in rhombic pyroxenes, must also exert a not unessential influence on this angle, respecting the importance of which we are still quite in the dark. In Analysis I. the proportion CaO : MgO + FeO is nearly as 1 : 2. Alkalies and sesquioxides vary so little in the analyses given that their influence on the axial angle seems to be inconsiderable. Owing to entire ignorance of the proportions of their admixture, nothing further, of course, can be established as to the chemical differences between the *A* and *B* pyroxenes of the Tasmanian diabase.

The high water content in Analysis I. is striking. Before the water was determined, which was done by Penfield's method, the powdered mineral was dried two hours at 105°. Hygroscopic water to the extent of 1·20 per cent. is therefore excluded. Hydrous decomposition products could not be determined microscopically in the powder, and only traces of them are recognisable in slides of the pieces of rock used for isolating. It is questionable whether the plentiful, but very minute, fluidal inclusions can be made responsible for this amount of water. Perhaps one might suppose a primary]-(content in the pyroxene.

As already mentioned, the structure of the rock is not typically ophitic, notwithstanding the very late age of the pyroxene. A mesostasis occurs in areas of meshwork, which, as can be seen in thin slides, consists of two colourless minerals, distinguishable by somewhat differing refraction and double refraction. The mineral with stronger refraction and double refraction forms either radiating aggregates or irregularly outlined spots, which, as a rule, have uniform optical orientation in one meshed area. It agrees in refringence and birefringence with the acid margin of neighbouring plagioclase crystals, and attaches itself to these with identical orientation. According to this, it is andesine. The other mineral, in which this andesine is embedded, might, in harmony with the not inconsiderable potash content of the rock, be orthoclase. Quartz appears to be entirely absent.

The sparse iron oxide is attracted by the magnet; but according to the titanic acid content of the total analysis, which considerably exceeds that of the pyroxene, it must be titaniferous.

The analysis of the diabase, also by Professor Dittrich, gave as follows:—

	I.	II.
SiO_2	52·49	56·14
TiO_2	0·62	0·49
Al_2O_3	16·44	10·35
Fe_2O_3	2·60	—
FeO	5·30	6·81
MnO	trace	—
MgO	6·18	9·92
CaO	11·71	13·42
Na_2O	2·06	2·13
K_2O	1·09	0·74
H_2O under 110°	0·15	
H_2O under 110°	1·42	
P_2O_5	trace	
	100·06	

From the molecular ratios given in column II. (all iron calculated as FeO) results follow as under:—

s	A	C	F	a	c	f	n	m	k
56·5	2·87	7·48	22·67	2	4·5	13·5	7·4	7·4	1·03
58·	3·38	6·39	22·34	2	4·	14·	7·7	8·6	1·05

In the bottom row the corresponding values are quoted from Wahl; for the diabase already mentioned from Källsholm on Föglö. On the whole the figures for *A*, *C*, and *F* are very similar. The silica coefficient of Föglö is somewhat higher than that of Launceston; the former rock contains some quartz. In Launceston the lime soda felspar, with a very little basic andesine, is essentially labradorite, with bytownite, down to anorthite; in Föglö it is labradorite, with only sporadic grains of bytownite. This finds expression in the ratio A : C, and also in the values *a* and *c*. The pyroxene of Föglö contains only 7 per cent. CaO, compared with that of Launceston, 15¾ per cent. Therefore, *m* in the former is considerably higher than in the latter. The alkali ratio (*n*) is nearly the same in both rocks, therefore one should expect some orthoclase also in that of Föglö.