Chapter 25 Sheets exclusive of cone-sheets: south-west Mull. Loch Scridain petrology

Introduction

Before proceeding to detail in the matter of classification, it is necessary to state clearly how the types tholeiite and augite-andesite are distinguished in this memoir. In both cases, the essential minerals are plagioclase-felspar and augite, and there is, in addition, a residuum of glass, or such finely crystalline material as is commonly spoken of as a devitrification-product. Where the glass, or its devitrification-product, is seen as a fairly continuous matrix, it constitutes in Rosenbusch's vocabulary a ground-mass; where, on the contrary, it is relegated to more or less angular interstices between the crystalline elements it serves as amesostasis; and mesostasis characterizes what is known as intersertal structure. The distinction between ground-mass and mesostasis is of necessity arbitrary, and we find it convenient to add that, in typical intersertal structure, the mesostasis has a patchy distribution. Olivine-free and olivine-poor plagioclase-augite rocks with intersertal structure are classed by Rosenbusch as tholeiites;<ref>Rosenbusch admits both non-porphyritic and porphyritic tholeiites. In the course of the present memoir the name tholeiite is employed in the restricted sense of non-porphyritic tholeiite; while some such description as I orphyritic basalt with tholeiitic ground-mass is applied to porphyritic tholeiites. This practice is adopted for its local convenience, and does not clash with Rosenbusch's classification. </ref>- plagioclase–augite rocks with a definite groundmass are, generally speaking, augite-andesite. One can readily see that, in general, such a difference in structure as is here relied upon for distinguishing tholeiite from augite-andesite has a chemical foundation, for the glassy residuum of any particular rock is relatively acid as compared with the early crystalline elements. We have found by experience in Mull that the term intersertal is of great convenience in describing the structure of rocks with somewhat less than 55 per cent. SiO_2, while it ceases to be applicable to rocks with more than that amount. The analyses, upon which this statement is based, are given in (Table 2) and (Table 3) (pp. 17, 19). Moreover, our local experience in this matter seems to agree with that of other workers elsewhere, for Messrs. Eyles and Simpson<ref>V. A. Eyles and J. B. Simpson, Silica Percentages of Igneous Rocks, Geol. Mag. , 1921, p. 437, have found that there is a consensus of opinion that the names dolerite and andesite meet in their application to rocks having 55 per cent. SiO_2.

It may be asked, how does increased crystallization affect the structural distinction between tholeiite and augite-andesite? The answer, so far as Mull petrology is concerned, is that coarse-grained tholeiite passes over to quartz - dole rite (Chapters 28 and 29), whereas coarse-grained augite-andesite, if non-porphyritic, or only slightly porphyritic, becomes craignurite (Chapter 19), and, if markedly porphyritic, it becomes porphyrite.

While 55 per cent. SiO_2 is taken, in this memoir, as the basic limit of augite-andesite, 70 per cent SiO_2, is taken as the acid limit, thus including rocks which, as far as composition is concerned, have their analogues among the dacites. True dacites, if porphyritic quartz is regarded as an essential feature, are absent from Mull.

The subject-matter is grouped in the sequel under four main headings: Augite-Andesite, Basalt and Dolerite —including Tholeiite, Felsite, and Composite Sills.

Augite-andesite

(Anals. (Table 3), p 19; and (Table 11), p. 263)

The augite-andesites of Mull are for the most part non-porphyritic rocks belonging to a type to which the name leidleite has been given, after Glen Leidle in the Loch Scridain area. A relatively small number are porphyritic, and belong to another type which has been called inninmorite (p. 282), after Inninmore Bay near Loch Aline.

Leidleite

Rocks of this type are dark-grey andesites, varying in texture from finely crystalline (S14605) [NM 5238 2514], (S14625) [NM 5298 2228], (S14632) [NM 5324 2302], (S14639) [NM 5313 2333], (S15997) [NM 5021 2337], (S17246) [NM 5057 2261] to glassy (S15996) [NM 5021 2337], (S17243) [NM 5018 2359], (S17245) [NM 5057 2261]. The silica-percentage ranges from 55–70. The constituent minerals are plagioclase, augite, hypersthene, and magnetite, to which glass, or its devitrification products, serves as a groundmass. In the more stony types, the ground-mass is largely composed of an ill-defined crystallization of alkali-felspar and quartz; whereas, in the glassy varieties (pitchstone), it is in large measure glass. In some of the stony leidleites, closely allied to the tholeiites, the stony texture is due to relative abundance of early crystal-elements, rather than to a devitrification of the matrix (S17244) [NM 5018 2359].

The felspars are generally acid labradorite or andesine. They occur as narrow laths with somewhat ill-defined edges and ends, and are simply twinned and somewhat zoned. Skeletal growths are prevalent in the more glassy varieties.

The augite is a pale-yellowish green non-pleochroic variety, with an extinction of about 45°. It occurs in narrow blades and laths elongated parallel to the vertical axis, and in habit and dimensions agrees closely with the felspar. While often the augite-crystals are independent of each other, they are commonly grouped in a roughly stellate fashion, or form sheaf-like growths co-operating with the felspar to give rise to a subvariolitic structure (S15996) [NM 5021 2337]. Skeletal growths, of the type so often described from variolites, are sometimes well-developed (S14540) [NM 5131 2639], (S17243) [NM 5018 2359].

Hypersthene accompanies the augite, at any rate in many of the slides showing fresh material (S15996) [NM 5021 2337]–(S15997) [NM 5021 2337], (S17243) [NM 5018 2359], (S17245) [NM 5057 2261]. In habit and appearance, it agrees so exactly with the augite that it is difficult to obtain an idea of the relative proportions of the two; and we do not regard its occurrence as an essential feature of the type. It is distinguished only by its straight extinction and its definite, though weak, pleochroism.

The magnetite occurs, either as strings embedded in, or fringing, the pyroxene-crystals, or else, in the matrix, as rods made up of a series of adherent octahedra.

In typical leidleites, fluidal and perlitic structures on a microscopic scale are wanting, and so also is recognizable intergrowth of quartz and felspar.

The minerals of the stony leidleites are relatively decomposed compared with those of the glassy varieties. Another point of interest is the merging of stony leidleite, with increasing crystallization, into craignurite, a type also exemplified in the sills of the district (S14600) [NM 5272 2462], (S14627) [NM 5321 2328], (S14878) [NM 5301 2647]. One of the craignurites is worth special mention for the beautiful examples it affords of vesicles occupied, without loss of form, by residual magma (S14600) [NM 5272 2462].

Inninmorite

Rocks of this type when fresh are generally dark-grey or brown, and range in texture from finely crystalline to glassy. An essential feature is the occurrence of few, or many, minute porphyritie crystals of basic plagioclase and uniaxial augite in a ground-mass that closely reproduces the characters of the leidleites as defined above. It is naturally difficult to compare in detail two types, which themselves show a considerable range of variation, but it seems that the ground-mass of the inninmorites tends to differ, from the bulk-crystallization of comparable leidleites, in a much more restricted development of moderately basic plagioclase and, also, in a practical want of hypersthene. The result is that augite, often in skeletal curving growths, is the most characteristic mineral-development in the ground-mass of inninmorite (S14591) [NM 5112 2543],(S14593) [NM 5091 2444], (S14603) [NM 5157 2530]; in keeping with this, a completely glassy ground-mass is frequently met with (S14590) [NM 5113 2547], (S14662) [NM 5395 2264], (S14671) [NM 5444 2214], (S15989) [NM 5077 2552], whereas completely glassy leidleites have not been definitely recognized.

The range of silica-percentage for the type is taken as from 55–70.

The felspar-phenocrysts rarely exceed 3 or 4 mm. in length. The characteristic habit is a stumpy prism with somewhat rounded angles. In composition, the felspar approximates to anorthite. Zoning is uncommon. Twinning is invariable, and usually follows the carlsbad and pericline laws; albite-twinning, though sometimes conspicuous, is perhaps less universal.

The augite-phenocrysts are rounded crystals generally less than 1 mm, in diameter, and are nearly always untwinned. The mineral is very susceptible to alteration, and yields serpentinuous pseudomorphs resembling those after hypersthene or olivine. In the field, little cavities are frequently found in place of the pseudomorphs. The uniaxial nature, and the mode of alteration of the augite, rendered a closer study desirable. This was undertaken by Mr. Hallimond.<ref>A. F. Hallimond, Optically Uniaxial Augite from Mull, Min. Mag., vol.xvii., 1914, p. 97.</ref> The following is a summary of his results, based upon material separated from an inninmorite (S15900), Anal. V., (Table 3), p. 19):

- Crystals rounded, unzoned, and having uniform extinction.
- Optically uniaxial, or nearly so.
- Refractive indices for sodium light: ■ 1'714;ε 1.744.
- Birefringence: 0.03.
- Pleochroism: ■ smoky brown; ε pale yellow.
- Extinction on the cleavage (110) 30½°, and on the plane of symmetry approximately 41°.
- Chemically a ferromagnesian metasilicate (Anal. I , (Table 9), p. 34).
- Specific gravity 3.44.

Such uniaxial augite agrees with the enstatite-augite of Wahl.

Very occasionally (S14664) [NM 5365 2283], hypersthene is found among the phenocrysts of the inninmorites, playing exactly the same role as the uniaxial augite.

The devitrification of the inninmorites leads to a development of ill-defined quartz and alkali-felspar, with concurrent decomposition of the early-formed minerals (S14593) [NM 5091 2444], (S14599) [NM 5245 2542], (S14603) [NM 5157 2530]. Where crystallization has proceeded more slowly, and a porphyrite has resulted, the phenocrysts, even enstatite-augite, may, in large measure, remain fresh. Such a porphyrite is illustrated by specimens from Port na Croise, Loch Scridain (Sheet 43), where oligoclase, with micrographic fringes, figures largely in the ground-mass (S20795) [NM 4266 2640]. All the most maturely crystallized inninmorites of Mull are not classed as porphyrites, since their porphyritic structure may tend to be obscured, and, as pointed out in Chapter 19, it is often convenient to group them as craignurites.

Basalt and dolerite, including tholeiite

(Anals IX., (Table 2), p. 17; and I., (Table 6) p. 24).

Tholeiite

It has already been explained that tholeiite, as used in this memoir, denotes a non-porphyritic olivine-poor or olivine-free augite-felspar rock with intersertal structure and a silica-percentage less, than 55. The tholeiites of the Loch Scridain district continue, in the basic direction, the less variolitic development of the leidleites (and to a very minor extent of the inninmorites too), Corresponding variolitic rocks may he called variolites of tholeiitic affiinity, and are well-represented.

In Mull, three main types of tholeiite are distinguished:

The Talaidh Type (Anal. IX., (Table 2)) approaches leidleite in the absence, or extreme rarity, of olivine, and in the frequent tendency to elongation of the augite. The Talaidh Type of tholeiite (and quartz-dolerite) is particularly strongly developed among the Lath Basic Cone-Sheets, and is accordingly described more fully in Chapter 28. The type is represented at Loch Scridain by a few slides (S14663) [NM 5365 2283], (S15993) [NM 5371 2277], (S17170) [NM 5238

2024], and its close approach to the basic leidleites of the district is illustrated by comparison with (S14914) [NM 5202 2628], (S15993) [NM 5371 2277], (S17244) [NM 5018 2359], (S17246) [NM 5057 2261].

The Brunton Type also lacks olivine, but the tendency to elongation on the part of the augite is lost; instead, this mineral segregates along with the felspar into crystalline groups, partly in contact with one another, and partly separated by mesostasis. The Brunton Type will be returned to in Chapter 34, devoted to the dyke-rocks of Mull. Here, one may enumerate a few slides of Brunton Type among the Loch Scridain Sills, namely (S14532) [NM 5323 2163], (S14633) [NM 5324 2302], (S14637) [NM 5087 2506], (S16055) [NM 4890 2415], (S16056) [NM 4918 2236], (S17119) [NM 4804 3334], (S18518) [NM 4754 3220].

The Salen Type is characterized by olivine as an essential, though minor, constituent, while the amount of mesostasis is often greatly reduced. The Salen Type of tholeiite is particularly well-developed among Mull dykes, and will be dealt with again in Chapter 34. Only occasional examples have been met with among the Loch Scridain sills (S14541) [NM 5033 2607].

In the account of the lath Basic Sheets of Talaidh Type (Chapter 28), it is pointed out that variolitic deve1opments are often encountered. In the same way, the Loch Scridain Sills, not infrequently, include variolites, in which the crystallization of plagioclase and augite so nearly occupies the whole slide, that it is safe to presume that the composition of the rocks is tholeiitic rather than andesitic (S14543) [NM 5203 2623], (S14545) [NM 5240 2548], (S14581) [NM 5347 2227], (S14656) [NM 5324 2162], (S14852) [NM 5366 2307], (S16061) [NM 4941 2140], (S17276) [NM 5029 2889], (S17279) [NM 5212 2951]. There is often an obvious resemblance between these variolites and those described in Chapter 10 as occurring among the Central Lavas.

A few rocks in the tholeiite-assemblage are perhaps best described as spherulitic tachylytes. They have consolidated with a well-marked spherulitic structure, in which clearly defined crystals take no part. A slice is divided up into rounded, or polygonal, areas, within which there are radiating crystalline fibres (probably associated augite and felspar) with an aggregate refractive index well-above that of balsam (S16066) [NM 5032 2358], (S17277) [NM 5171 3027], (S18515) [NM 5050 2333], (S18527) [NM 4759 2805]. Similar rocks are described as constitutiing the Cruachan Dearg Type of Late Basic Cone-Sheet in Chapter 28, and, in two analysed specimens, have been found to contain less than 55 per cent. of SiO_2 (pp. 304, 305).

Other basalts and dolerites

A small proportion of the Loch Scridain Sills are olivine-basalts, or dolerites, that are not conveniently grouped with the tholeiites. In several cases, they are of olivine-poor varieties characterized by porphyritic felspar (S14622) [NM 5374 2472], (S16645) [NM 5332 3763], (S14669) [NM 5393 2229], (S16737) [NM 5666 2520], and indistinguishable from the porphyritic Central Types of lava described in Chapter 10, except that, occasionally, the olivine is fresh (S14611) [NM 5317 2337]. In a few of the porphyritic sills, crystallization has proceeded further than is common in the case of the lavas (S14880) [NM 5279 2765], (S15994) [NM 5356 2253]. In the analysed specimen (S15994) [NM 5356 2253], Anal. I., (Table 6), p. 24), slightly zoned basic labradorite, or bytownite, occurs in two generations, distinguished only by a little difference of size, and the matrix is furnished by augite and olivine (often fresh) crystallized together. Another specimen from the same sill (S14666) [NM 5356 2253] shows a little residuum with skeletal crystallization. Altogether this rock greatly resembles the small-felspar basalt of (Figure 23) (p. 163), but is fresh.

Non-porphyritic olivine-basalts, or fine dolerites, are scarcely represented in the Survey collection of sills from the Loch Scridain area. There is one slice (S14621) [NM 5255 2390] which approaches olivine-tholeiite in character, and another (S14865) [NM 5326 2137] indistinguishable from olivine-rich Plateau Types of basalt-lava (Chapter 10). Both of these slices contain fresh olivine.

Felsite

(Anal. I.; (Table 4), p. 20).

At the acid end of their range of variation, the leidleites and inninmorites join hands with closely related felsites and rhyolites—or acid pitchstones. The arbitrary limit of silica-content, which has been chosen to bound the application of the names leidleite and inninmorite, in this direction, is 70 per cent. The analysed rock (S18464) [NM 5361 2259], (S14661) [NM 5361 2259] is just on the acid side of this limit, and may be described as a felsite of inninmorite-affinity. It has occasional little phenocrysts of felspar (albitized), and of uniaxial augite (represented as characteristic pseudomorphs), set in a felsitic ground, in which skeletal growths of augite (also pseudomorphed) are less abundant than in typical stony inninmorites. The interior of the Rudh' a' Chromain Sill (S14894) [NM 5237 2027]–(S14895) [NM 5237 2027] is of similar character, except that its felspar-phenocrysts are sometimes fresh labradorite, and sometimes replaced by calcite. In the cores of this sill, rhyolite (acid pitchstone) of analogous type is also found, and is extremely beautiful under the microscope on account of its skeletal growths and local devitrification, combined with perfect freshness (S18486) [NM 5237 2031]. The phenocrysts of the felsites, allied to the inninmorites, seem distinctly less prominent than in the true inninmorites. Where porphyritic structure fails altogether, felsitic equivalents of the leidleites are found (S14604) [NM 5254 2581], (S14618) [NM 5378 2213], (S14631) [NM 5324 2302], (S14658) [NM 5243 2816]. Their main distinguishing mark, as compared with many other felsites, is a tendency to carry fairly numerous pseudomorphs after acicular, or skeletal, augite.

Composite sills

The close genetic relationship between the tholeiite-andesite-felsite assemblage of the Loch Scridain district is emphasized by a proneness of these rocks to occur in composite sills in which the rule is that the marginal portions are more basic than the interiors. The field-occurrence of the Rudha' a' Chromain sill has already been described in detail as a striking and easily located example (p. 266). In this case, Talaidh Type of tholeiite (S17170) [NM 5238 2024], Anal. IX., (Table 2), p.17) has a felsitic and rhyolitic interior of inninmorite affinity (S14894) [NM 5237 2027], (S14895) [NM 5237 2027], (S18486) [NM 5237 2031], agreeing closely in composition with an analysed specimen from south of Coire Buidhe (S18464) [NM 5361 2259], Anal. I., (Table 4),.p 20).

Another good example is exposed at the bend of the Carsaig road, east-north-east of Cnoc a' Bhràghad. Here, Brunton Type of tholeiite (S14633) [NM 5324 2302] borders felsite of leidleite affinity (S14832) [NM 5701 3651], (S14631) [NM 5324 2302].

An 8-ft. sill on the same road, 50 yds. north-west of the wood-above Feorlin Cottage, has variolitic margins allied to Talaidh Type of tholeiite (S14581) [NM 5347 2227], (S14584) [NM 5347 2227], and a glassy or stony interior of leidleitie and felsitic affinities (S14582) [NM 5347 2227]–(S14583) [NM 5347 2227].

Coire Buidhe, in this same neighbourhood, at the 900 ft. contour, affords another good case, though somewhat less marked. Talaidh Type of tholeiite (S14663) [NM 5365 2283], (S15993) [NM 5371 2277] here borders glassy inninmorite (S14664) [NM 5365 2283], (S15992) [NM 5371 2277]. The latter has a few phenocrysts of hypersthene.

Similarly, towards the northern limit of the area, 1000 yds. north-north-west of the cairn on Coirc Bheinn, tholeiite allied to the Salen Type (S17119) [NM 4804 3334] occurs above and below a glassy andesite in which hypersthene again figures (S17120) [NM 4798 3334]. An extremely good example of hypersthene-bytownite cognate xenoliths comes from this sill (S17121) [NM 4798 3330].

The Scobull Point sheet, already described (p. 265) on account of its local lack of marginal chilling, shows basic tholeiite (S20798a), (S20801b) with tholeiitic leidleite (S20799) [NM 4683 2700] between.

In the three pairs of leidleites quoted, (Table 11), p. 263 (S15996) [NM 5021 2337], (S15997) [NM 5021 2337], (S17243) [NM 5018 2359], (S17244) [NM 5018 2359], (S17245) [NM 5057 2261], (S17246) [NM 5057 2261], it seems to us that in each case the stony outer members of the sills are more basic than the glassy interiors. The microscopic contrast is least in regard to the first of these three pairs, and it is for this pair that full analyses are available. In the other two cases, the stony marginal part of the sills closely approaches Talaidh Type of tholeiite (Figure 47)B. It will be understood that comparison without analyses leaves room for uncertainty, especially in the case of rocks which are partially glassy, and Mr. Anderson is doubtful whether (1) we are correct in believing that most of the sheets with stony margins and glassy interiors are more basic in their marginal portions, and (2) even, if this be the case, whether the difference of composition may not be a segregation-phenomenon. He is therefore inclined to question the grouping of the generality of such sheets along with such admittedly composite sheets as, those of Rudh' a' Chromain, etc. H.H.T., E.B.B.

TABLE II.—NON-PORPHYRITIC CENTRAL MAGMA-TYPE OF FIG. 2.

	Tholeiite Salen Type	Basalt Staffa Type			Basalt Compact Central Type		Tholeiite Brunton Type		Quartz-Dolerite and Tholeiite Talaidh Type		
	I.	II.	III.	A	IV.	V.	VI.	VII.	VIII.	IX.	
SiO_2	47·35	47·80	49·76	52·13	50·54	53·78	51·53	51·63	52·16	53·97	SiO_2
TiO_2	1·75	....	0·94	....	2·80	2·28	1·57	2·00	3·25	1·24	TiO_2
Al_2O_3	13·90	14·80	14·42	14·87	12·86	12·69	11·05	11·77	11·95	14·65	Al_2O_3
Fe_2O_3	5·87	....	3·95	....	4·13	3·44	2·73	3·23	4·86	3·62	Fe_2O_3
FeO	8·96	13·08	7·77	11·40	8·75	8·94	10·98	10·47	9·92	6·32	FeO
MnO	0·23	0·09	0·20	0·32	0·32	0·53	0·45	0·35	0·18	0·30	MnO
(Co, Ni)O	nt. fd.	....	nt. fd.	....	0·06	nt. fd.	nt. fd.	0·04	....	nt. fd.	(Co, Ni)O
MgO	5·97	6·84	5·30	6·46	4·63	2·58	5·21	5·02	3·77	4·49	MgO
CaO	10·65	12·89	10·22	10·56	8·71	6·36	9·68	9·34	7·14	7·98	CaO
BaO	....	....	0·04	....	nt. fd.	0·09	nt. fd.	0·03	....	0·04	BaO
Na_2O	2·73	2·48	2·49	2·60	2·89	2·74	3·48	2·90	2·36	2·54	Na_2O
K_2O	0·54	0·86	1·83	0·69	1·43	2·27	0·86	0·91	1·74	1·52	K_2O
Li_2O	....	....	tr.	....	nt. fd.	nt. fd.	tr.	nt. fd.	....	tr.	Li_2O
$H_2O-105°$	1·16	1·41	1·03	1·19	2·25	2·19	1·26	1·40	1·95	0·94	$H_2O+105°$
H_2O at 105°	1·04		2·04		0·17	1·19	0·71	0·68	0·56	1·92	H_2O at 105°
P_2O_5	0·24	....	0·21	....	0·34	0·55	0·22	0·29	0·24	0·27	P_2O_5
CO_2	0·32	....	0·06	....	0·33	0·08	0·08	0·11	0·18	0·51	CO_2
FeS_2	....	....	0·04	....	nt. fd.	0·42	0·26	0·08	....	0·09	FeS_2
S	0·23	....	....	....	....	....	....	....	0·18	....	S
	100·91	100·25	100·30	100,22	100·24	100·13	100·07	100·27	100·44	100·40	
Spec. grav.	2·96	....	2·72	....	2·90	2·68	2·93	2·95	2·91	2·83	

(Table 2) Non-Porphyritic Central Magma-Type of Figure 2

TABLE III.—INTERMEDIATE TO SUBACID MAGMA-TYPE OF FIG. 2.

	Craignurite (basic)	Leidleite		Inninmorite		Craignurite (acid)	
	I.	II.	III.	IV.	V.	VI.	
SiO_2	55·82	59·21	61·69	62·37	64·13	66·27	SiO_2
TiO_2	1·62	1·06	1·00	1·06	1·19	0·87	TiO_2
Al_2O_3	11·47	14·06	14·43	12·04	13·15	11·92	Al_2O_3
Fe_2O_3	3·68	2·66	1·23	1·87	1·08	3·09	Fe_2O_3
FeO	7·66	4·87	5·86	5·81	6·31	3·18	FeO
MnO	0·40	0·24	0·30	0·24	0·27	0·31	MnO
(Co,Ni)O	0·04	nt. fd.	nt. fd.	nt. fd.	nt. fd.	nt. fd.	(Co,Ni)O
MgO	4·08	3·71	2·81	0·97	1·08	1·44	MgO
CaO	7·88	5·95	4·97	3·51	3·62	3·30	CaO
BaO	0·03	0·03	0·04	0·07	0·09	nt. fd.	BaO
Na_2O	2·58	2·06	3·20	3·47	3·64	2·89	Na_2O
K_2O	2·00	2·83	1·72	2·34	2·32	4·03	K_2O
Li_2O	tr.	nt. fd.	nt. fd.	nt fd.	nt. fd.	tr.	Li_2O
$H_2O+105°$.	1·88	1·49	2·32	5·54	2·71	1·51	$H_2O+105°$
H_2O at 105°	0·66	2·06	0·25	0·44	0·36	0·78	H_2O at 105°
P_2O_5	0·23	0·20	0·24	0·30	0·31	0·17	P_2O_5
Co_2	0·08	...	...	...	...	0·53	Co_2
FeS_2	0·09	nt. fd.	nt. fd.	nt fd.	nt. fd.	nt. fd.	FeS_2
Cl	...	nt. fd.	0·02	...	...	...	Cl
	100·18	100·43	100·08	100·03	100·26	100·29	
Spec. grav.	2·88	2·61	2·64	2·50	2·57	2·65	

(Table 3) Intermediate to Subacid Magma-Type of Figure 2

TABLE XI.—Water of Augite-Andesites.

	Ia	Ib	IIa	IIb	IIIa	IIIb	IV.	V.	
SiO_2 . .	61·69	59·21					62·37	64·13	SiO_2
$H_2O+105°$.	2·36	1·54	2·38	1·56	2·44	0·93	5·54	2·71	$H_2O+105°$
H_2O at 105°	0·25	2·05	0·45	1·34	0·38	1·64	0·44	0·36	H_2O at 105°
Cl . . .	0·02	nt. fd.							Cl
Spec. grav. .	2·64	2·61	2·82	2·77	2·89	2·71	2·50	2·57	

(Table 11) Water of augite-andesites

TABLE IX.

	Phenocrysts		Amygdale—Minerals: Outside Pneumatolysis Limit								Amygdale—Minerals: Inside Pneumatolysis Limit			Amygdale—Minerals: Inside Contact-Zone		Mud-Stone	Xenoliths and enclosed Spinel			
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIIa.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	
SiO_2 . .	49·72	50·80	53·74	53·41	52·35	53·29	48·91	46·51	46·62	46·78	46·21	46·10	45·5	38·60	37·66	30·26	40·74	38·67	0·77	SiO_2
TiO_2 . .	0·85	—	—	—	—	—	—	—	—	—	—	nt. fd.	—	0·12	0·32	1·32	1·19	0·90	0·50	TiO_2
Al_2O_3 . .	0·90	31·64	0·82	1·76	1·71	—	0·11	2·40	3·90	24·82	27·09	25·65	26·0	23·51	21·21	27·34	31·90	37·27	63·81	Al_2O_3
Fe_2O_3 . .	1·72	—	—	—	—	—	—	1·14	0·61	—	—	—	—	0·97	1·67	1·57	1·53	2·78	4·20	Fe_2O_3
FeO . .	27·77	—	—	—	—	—	2·07	1·65	1·08	—	—	0·35	—	0·22	0·34	17·18	4·34	5·07	24·09	FeO
MnO . .	0·98	—	—	—	—	—	2·27	—	—	—	—	nt. fd.	—	0·29	0·53	0·13	0·13	0·17	0·15	MnO
(Co, Ni)O .	nt. fd.	—	—	—	—	—	—	—	—	—	—	nt. fd.	—	nt. fd.	nt. fd.	0·04	nt. fd.	nt. fd.	nt. fd.	(Co, Ni)O
MgO . .	12·09	—	—	—	—	—	0·56	0·47	—	—	—	0·32	—	0·40	0·45	0·34	0·66	2·35	6·37	MgO
CaO . .	3·89	12·83	31·19	31·69	31·48	33·41	40·39	33·40	33·08	13·90	12·45	14·17	14·8	22·79	33·36	0·74	0·88	4·85	0·36	CaO
BaO . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	nt. fd.	nt. fd.	—	—	BaO
Na_2O . .	0·23	3·56	9·94	8·11	8·04	8·80	0·22	0·36	0·80	0·89	—	tr.	—	tr.	1·17	1·08	2·76	3·63	—	Na_2O
K_2O . .	0·12	tr.	nt. fd.	2·43	2·47	—	1·16	1·15	0·57	—	—	0·03	—	0·03	0·73	2·05	7·72	3·01	—	K_2O
Li_2O . .	tr.	—	—	—	—	—	—	—	—	—	—	nt. fd.	—	tr.	nt. fd.	nt. fd.	tr.	nt. fd.	—	Li_2O
$H_2O+105°$	1·37	0·38	2·38	2·66	4·07	4·56	4·17	12·91	12·11	13·64	13·78	13·78	13·8	0·89	0·20	7·20	3·44	1·03	0·14	$H_2O+105°$
H_2O at 105°	0·08	—	0·6	—	—	—	—	—	—	—	—	0·13	—	0·09	nt. fd.	1·44	0·61	0·22	nt. fd.	H_2O at 105°
P_2O_5 . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·24	0·86	—	—	P_2O_5
CO_2 . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·04	—	—	CO_2
FeS_2 . .	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	nt. fd.	nt. fd.	—	—	FeS_2
	100·13	99·05	99·67	101·05	100·67	100·06	100·76	100·10	99·81	99·80	100·44	100·13	100·0	100·21	100·19	100·04	100·21	100·35	100·39	
Spec. grav.	3·44	2·78	...	...	...	...	2·605	...	2·423	...		2·285		3·498	3·61		2·65	2·91	3·887	

I. Uniaxial Augite. II. Labradorite. III.–VI. Pectolite. VII. Xonotlite. VIII. IX. Tobermorite.[1] X.–XII. Scolecite. XIII. Pink Epidote. XIV. Garnet. XV. Basal Mudstone (altered). XVI. Uncontaminated argillaceous xenolith. XVII. Contaminated argillaceous xenolith. XVIII. Dark-green Spinel.

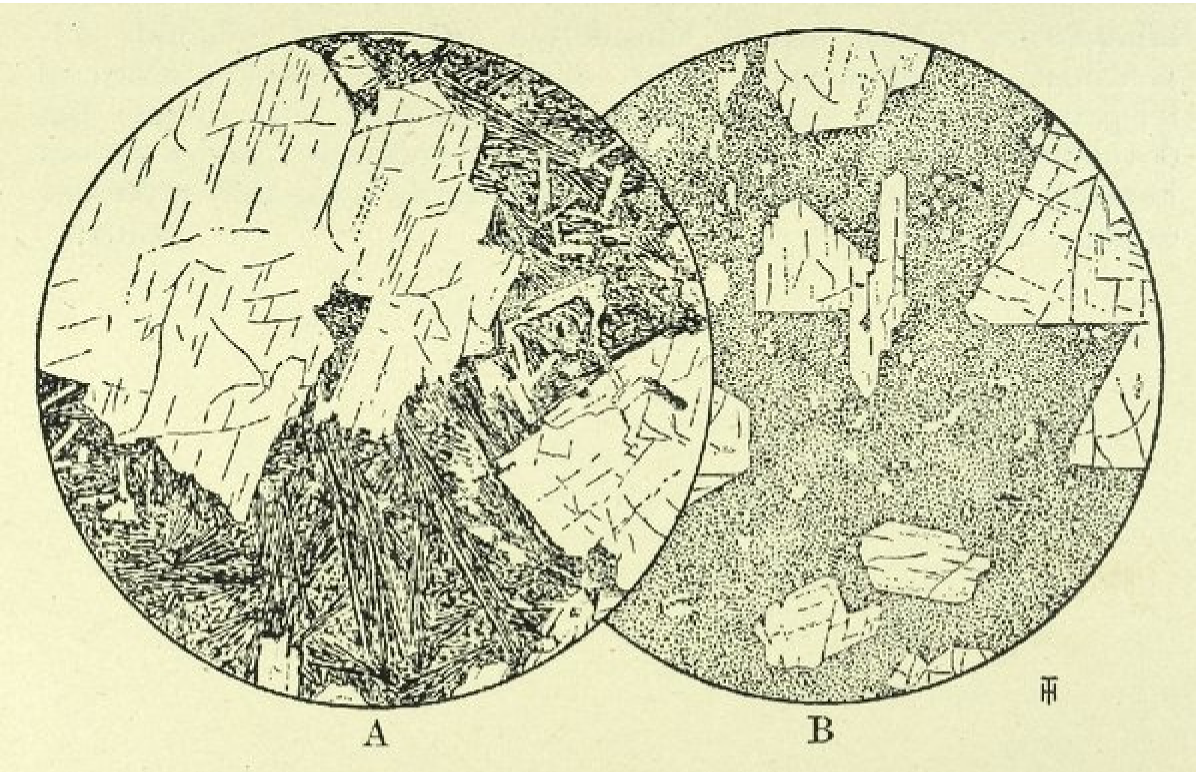
[1] In British Museum Students' Index Tobermorite is listed as a synonym of Cyrolite.

(Table 9) Analyses other than bulk anayses of igneous rocks, made from material collected collected in the Mull District.

TABLE VI.—PORPHYRITIC CENTRAL MAGMA-TYPE OF FIG. 3.

	Dolerite	Gabbro			Basalt			
	I.	A	B	II.	III.	IV.	V.	
SiO_2 .	45·54	46·39	47·28	48·34	47·24	47·49	48·51	SiO_2
TiO_2 .	1·06	0·26	0·28	0·95	1·46	0·93	1·46	TiO_2
Al_2O_3 .	23·39	26·34	21·11	20·10	18·55	21·46	19·44	Al_2O_3
Cr_2O_3 .	...	tr.	...	...	...	...	...	Cr_2O_3
Fe_2O_3 .	1·98	2·02	3·52	1·97	6·02	1·72	5·66	Fe_2O_3
FeO .	6·98	3·15	3·91	6·62	4·06	4·80	4·00	FeO
MnO .	0·27	0·14	0·15	0·32	0·31	0·15	0·23	MnO
(Co,Ni)O	...	...	...	nt. fd.	0·05	0·04	0·04	(Co,Ni)O
MgO .	4·60	4·82	8·06	5·49	5·24	4·59	5·12	MgO
CaO .	11·82	15·29	13·42	13·16	11·72	13·24	12·03	CaO
BaO .	...	...	...	0·10	nt. fd	nt. fd.	nt. fd.	BaO
Na_2O .	2·50	1·63	1·52	1·66	2·42	2·17	2·53	Na_2O
K_2O .	0·44	0·20	0·29	0·98	0·15	0·42	0·25	K_2O
Li_2O .	...	...	...	nt. fd.	nt. fd.	nt. fd.	nt. fd.	Li_2O
$H_2O+105°$	0·72	0·48	0·53	0·44	2·24	2·54	0·48	$H_2O+105°$
H_2O at 105°	0·62	0·10	0·13	0·02	0·21	0·17	0·04	H_2O at 105°
P_2O_5 .	0·13	tr.	tr.	0·04	0·26	0·43	0·16	P_2O_5
CO_2 .	...	...	...	0·11	0·19	0·08	0·09	CO_2
FeS_2 .	...	...	...	nt. fd.	nt. fd.	nt. fd.	nt. fd.	FeS_2
	100·05	100·82	100·20	100·30	100·12	100·23	100·04	
Spec. grav.	2·85	2·85	2·90	2·93	2·85	2·82	2·93	

(Table 6) Porphyritic Central Magma-Type of Figure 3



(Figure 23) Basaltic facies of Small Felspar Dolerite intrusions, N.W. of Sgùrr Dearg. A. [(S16472) [NM 6557 3545]] x 17. Interior of an intrusion, showing porphyritic crystals of albitized labradorite bytownite in a variolitic matrix composed of narrow crystals of titaniferous augite, finely-divided iron-ore, a little plagioclase, and a chloritized residuum. (Compare

with Figure 21B, p. 151) B [[(S18652)](NM 6340 3561)] x 17. Chilled edge of a sheet, showing porphyritic felspars of identical character but having an aphanitic matrix in which all structure is suppressed and which presumably consolidated as glass. (Compare with Figure 21 C, p. 151)

TABLE IV.—ACID MAGMA-TYPE OF FIG. 2.

	I.	II.	III.	IV.	V.	
SiO_2	70·70	71·30	72·66	73·12	73·32	SiO_2
TiO_2	1·27	0·58	0·34	0·39	0·51	TiO_2
Al_2O_3	11·78	11·24	12·00	12·44	12·25	Al_2O_3
Fe_2O_3	1·32	1·80	2·03	2·09	2·77	Fe_2O_3
FeO	3·45	2·84	2·04	1·65	2·20	FeO
MnO	0·07	0·31	0·18	0·17	0·12	MnO
(Co,Ni)O	...	nt. fd.	nt. fd.	nt. fd.	nt. fd.	(Co,Ni)O
MgO	0·53	0·61	0·07	0·14	0·11	MgO
CaO	1·30	1·56	1·25	0·88	1·65	CaO
BaO	...	0·07	0·12	nt. fd.	0·09	BaO
Na_2O	2·48	3·44	3·26	3·90	3·92	Na_2O
K_2O	4·71	4·66	5·26	4·67	2·34	K_2O
Li_2O	...	? tr.	nt. fd.	nt. fd.	nt. fd.	Li_2O
$H_2O + 105°$	1·14	1·04	0·47	0·24	0·35	$H_2O + 105°$
H_2O at 105°	0·50	0·39	0·22	0·25	0·35	H_2O at 105°
P_2O_5	0·26	0·22	0·04	0·09	0·10	P_2O_5
CO_2	0·51	...	0·24	0·05	0·06	CO_2
FeS_2	...	nt. fd.	nt. fd.	nt. fd.	nt. fd.	FeS_2
S	0·08	...	...	...	...	S
	100·10	100·06	100·18	100·08	100·14	
Spec. grav.	2·58	2·53	2·61	2·57	2·66	

(Table 4) Acid Magma-type of Figure 2

A B

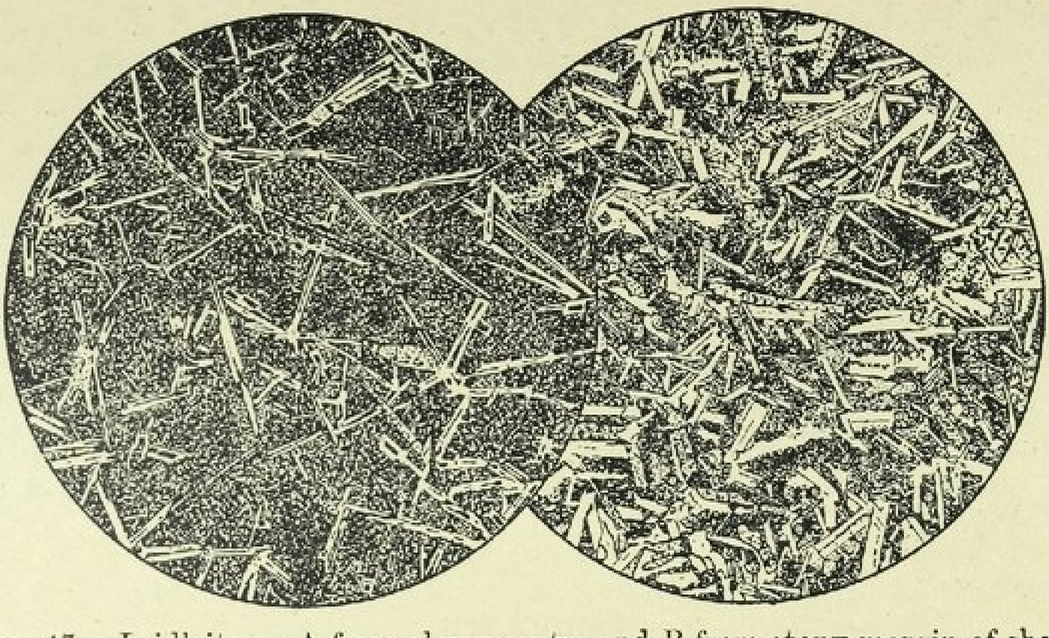


FIG. 47.—Leidleites. A from glassy centre and B from stony margin of sheet numbered 2 in Fig. 43, p. 261.

(Figure 47) Leidleites. A from glassy centre and B from stony margin of sheet numbered 2 in Figure 43, p. 261. A. [(S17243) [NM 5018 2359]1×20. Narrow laths and skeletal growths of plagioclase, and blades of augite (and some hypersthene) in a matrix of brown glass. B. [(S17244) [NM 5018 2359]] ×20. Laths of plagioclase, and elongated crystals of augite (and some hypersthene), in a matrix of felspar-microliths, augite-granules, and interstitial glass. There is an approach to the intersertal structure of the tholeiites. Quoted from Quart, Journ. Geol. Soc., vol. lxxi., 1916, p. 208.