Chapter 23 Sheets exclusive of cone-sheets: South-West Mull. Introduction and Loch Scridain

Introduction

There is in south-western Mull (Figure 42) a great field of sheet-intrusion, where individual sheets show no marked tendency to dip inwards towards the plutonic centre of the island, but often rather the reverse. The inclination of many of the sheets is markedly capricious, but in the majority of cases it is at quite moderate angles; and, since the lavas of the district are also gently inclined, it is natural to class the sheets as sills. It should be realized, however, that frankly transgressive relationships are everywhere the rule, and that several of the steeper sheets are only arbitrarily distinguished from dykes. Under these circumstances, the lowly-inclined habit, commonly adopted by the sheets, does not have any very close connexion with the bedding of the Tertiary lavas or Mesozoic sediments; and indeed, several lowly inclined sheets are met with traversing highly inclined gneiss in the Gribun and Ross of Mull peninsulas. E.M.A., J.E R., (B.L).

On the one-inch Map, the sills considered in this chapter are lettered D, where basic or intermediate, and F where acid. There are certain early sill-like masses of olivine-dolerite, on Ben More, characterized by an irregular laccolithic tendency, which, combined with their relatively early date, separates them conveniently from the normal sheets of their immediate neighbourhood. They have been lettered eD on the one-inch Map, and are treated in Chapter 11. A few bostonite-sills (lettered bO) also occur in south-western Mull, but they are considered along with allied alkali-types in Chapter 14.

In (Figure 42), it has been found possible to show many sill-occurrences which are omitted from the one-inch Map. It will be understood, however, that, except along streams and the sea-shore, no attempt has been made to record the evidence completely, even on the six-inch field-maps. The boundaries of the south-western field of intrusion are best characterized on the north across Loch na Keal, and on the west in the Ross of Mull. Eastwards, the failing of the sheets is somewhat blurred by an abundance of other intrusions; and, southwards, the sea intervenes.

The petrology and field-relations of the sheets of the whole field are sufficiently harmonious to support the view that, with subordinate exceptions, the intrusions belong to a single complex—if this expression be employed in the same broad sense as when we speak of the Central Lavas, or the Late Basic Cone-Sheets of Mull. There are sufficient local differences, however, to render a subdivision of the field desirable. In (Figure 42), a line is drawn marking the northern border of the Loch Scridain district characterized by an abundant development of pitchstone, and also by an unusual profusion of accidental xenoliths. Probably, within this line, a bulk-analysis of the sills would show an andesitic composition, with rather more than 55% silica. Outside this line, there are two districts, the one named after Gribun, the other after Ben More. The dividing-line between these two coincides roughly with the junction of Sheet 43 and 44 of the one-inch Map, except that the Gribun district extends east into Sheet 44 to include Brimishgan. A bulk-analysis in both the northern districts would probably show a tholeiitic composition, with less than 55% silica. At the same time, the Gribun district is much more obviously connected with the Loch Scridain district than either of them is with Ben More.

Such little evidence as is available suggests that the sills of south-western Mull fall within the long period of activity characterized by the intermittent injection of cone-sheets. It is argued later (pp. 279, 290) that perhaps the most probable date is in the latter part of the cone-sheet cycle, when tholeiitic magma was more particularly available and was very prone to yield acid differentiates.

The remainder of the present chapter will be devoted to the field-relations of the sills of the Loch Scridain district, with particular attention paid to the prevalence of pitchstone. In Chapter 24, the highly characteristic xenolith-assemblage of the Loch Scridain sills is considered in some detail. In Chapter 25, a full account of the igneous petrology of the sills is given. Chapter 26 passes on to the remainder of the southwestern field included in the districts of Gribun and Ben More. E.B.B.

Sills and sheets of Loch Scridain district (sheets 35, 43, 44); field-relations

The sheets of the Loch Scridain district south of the broken line (Figure 42) are most of them gently inclined, with a tendency to dip southward or south-eastward. This dip, however, is far from constant in direction; and many of the sheets are steep.

As will be explained in Chapter 25, there is a wide petrological range among the sheets of the district; they include olivine-basalts and dolerites of various types, and also a suite of tholeiites, andesites (leidleite and inninmorite), and felsites. Most of the sheets are either tholeiite or andesite. The two can frequently be distinguished from one another in the field by a tendency of the tholeiites to be of greater thickness and coarser crystallization: they are often from 15 to 30 ft. thick; whereas the andesites are mostly thinner than 15 ft. Among the andesite-sheets between 5 and 6 ft. thick, many have glassy centres (pitchstone).<ref>For Mr Bailey's view that, in a large number of cases, tholeiite and andesite are combined in composite-sheets, *see* pp. 264, 286.</ref>

No wholly tholeiitic sheet is known to have a glassy centre. On the other hand it is possible, though it is not quite demonstrated, that such exceptional sheets of the district as have glassy margins may be tholeiite throughout. So far as observation goes, glassy centres and margins appear to be mutually exclusive phenomena; and they will be considered separately in the sequel under the: two headings Pitchstone and Tachylyte Margins. E.M.A.

On very rare occasions, some of the sheets fail to chill at their margins; and, in one case, conspicuous melting of marginal country-rock has been recorded. Both these phenomena are dealt with, presently, under the heading Chilled Margins—Sometimes Absent. E.B.B.

A very general feature of the tholeiite-andesite assemblage of Loch Scridain is a tendency to carry 'cognate' and 'accidental' xenoliths (Chapter 24). A few of the assemblage are obviously composite, with markedly acid interiors. A good example of a sheet which is both xenolithic and composite is described at the close of the present chapter under the title of the Rudh' a' Chromain Sill.

Pitchstone

An account has been given in Chapter 2 of the development of our knowledge regarding the occurrence of pitchstone among the Loch Scridain sheets. (Figure 43) and (Figure 44) have been borrowed from the Quarterly Journal of the Geological Society of London, Vol. LXXI., to illustrate the account given below. Since (Figure 43) was drawn, several additional occurrences of pitchstone have been mapped, including convenient exposures along Loch Scridain west of Glen Seilisdeir; but these additions and sufficiently indicated by the letters pD on the one-inch Map, Sheets 43 and 44, while the numbers on (Figure 43) serve as a useful basis for the notes which follow and cover all analysed material.

Most of the pitchstones are non-porphyritic andesites of the type defined as glassy leidleite (p. 281); a few are porphyritic andesites distinguished in the field by small phenocrysts of felspar and augite, and are called glassy inninmorites (p. 282); a few, again, are of rhyolitic composition.

In any particular sill, pitchstone is generally associated with more crystalline rocks, to which the descriptive term stony is applicable. The two types are often interbanded in layers parallel to the margins of the intrusion; and, within individual layers, there is frequently an intermingling according to the sheath-and-core arrangement described by Sir Archibald Geikie and others from occurrences elsewhere in Scotland. Of these two relationships, the interbanding will be considered first.

Although the transition from a glassy to a stony band in these Loch Scridain sills is, characteristically, abrupt, there is never any resemblance to a chilled contact. A typical non-porphyritic sill may contain a central 5 ft. of pitchstone, with 3 ft. above, and an equal thickness below, of finely crystallized rock, in some cases andesite, in others tholeiite. The stony margins may be thinner in proportion, and in one instance were observed to fail. In most cases, the pitchstone forms a single fairly regular layer in the centre of the sheet, but sometimes it is split by stony partings. Thus, in an exposure slightly north of east of Tiroran (Sheet 44), there are at least two bands of pitchstone, and farther west, on the east promontory of Slochd Bay (Sheet 43), parallel interbanding of glassy and stony layers is again well seen.

Among the inninmorite-pitchstones, stony partings seem to be more common than is the case with their non-porphyritic fellows, and Nos. 5 and 6 (Figure 43) show rapid alternations of glass and stone. No. 4, on the other hand, is iiminmorite-pitchstone throughout.

Sheath-and-core structure is very frequently met with among the pitchstone-sills of Loch Scridain, whether leidleite or inninmorite. (Figure 44) illustrates a typical example, and may be briefly described as follows: The stony base and top of the intrusion appear to throw off arms, or, more accurately, narrow sheets of a similar material, which traverse the glassy portion in a branching and sinuous manner, completely dividing it into irregular rounded cores, which are not in visible connexion. In many cases the sheaths of crystalline matter, varying from a quarter of an inch to 3 inches in thickness, show a median joint or suture-line, along which terminate numerous minute transverse joints.

A point of particular interest was noted in the sill partly shown in (Figure 44). Here the median sutures can, in some cases, be traced downwards, and form a continuation of main joint-planes, which cut at right angles across the stony base of the sheet. The impression produced on an observer is that the transition from glassy to stony material has been brought about by the escape by some volatile material—in the first place from the stony margins, and, secondarily, along joint-planes developed in an already consolidated, though still in large measure glassy, magma. There is general agreement that this first impression is entirely correct in regard to the stony crystallization of the sheaths. Accordingly, we shall consider this side of the subject first.

There are probably only two alternative interpretations of sheath-and-core structure available: (1) the sheaths might be regarded as later intrusions, or segregations, surrounding and separating earlier-formed glass, or (2) the sheaths are derived from the glass by modification in *situ.* We think that the field-appearance decides definitely in favour of modification in *situ;*<ref>The same conclusion is expressed by Sir Archibald Geikie in regard to the Eskdale Dyke of Southern Scotland; Ancient Volcanoes of Great Britain, 1897, Vol. II., p. 134.</ref> not infrequently, indeed, one can detect a ghostly reminder of sheath-and-core structure in a sill that has become wholly stony. Moreover, where the sheath is narrow, it is possible to slice across it (S15998) [NM 5021 2337] and *see* with a pocket lens or a microscope that the limits of devitrification are not rock-boundaries, but are traversed in every direction by individual crystals.

The next point of importance, to which attention may be directed, is that the analyses of pitchstones by Mr. Radley, quoted in (Table 11), show a notable content of water retained by the rock when heated up to 105°C. Probably this water is in a condition of molecular diffusion, or solution, in the glass. Its amount is particularly striking in IV. (S15989) [NM 5077 2552], an inninmorite-pitchstone in which crystallization has proceeded to a much smaller extent than in the case of any of the other rocks analysed.

During crystallization of the magma, this dissolved water must of necessity be set at liberty. It may, in part, be expelled bodily from the rock, or it may be segregated into cavities or cracks. In either case, it is easy to see that jointing of a hot, though solid, glass might facilitate the removal of dissolved water, and thus open up the way to devitrification. One is, of course, faced with the difficulty of deciding whether, or no, the devitrification of the sheaths actually occurred while the glass was cooling (primary devitrification), or whether it took place long afterwards (secondary devitrification).<ref>Cf. T. G. Bonney, Presidential Address, Quart. Journ. Geol. Soc., vol. xli., 1885, p. 37.</ref> No quite positive answer can be given, but it is very doubtful whether any one familiar with sheath-and-core structure in the Loch Scridain field-exposures would hesitate in regarding it as primary; moreover, the microscopic appearances of the devitrified base of stony leidleites seems to indicate a natural step towards the indisputably igneous crystallization of the craignurites (described in Chapter 19).

If now we accept the hypothesis, that sheath-and-core structure is determined by devitrification of a hot glass sufficiently solid to admit of the formation of joints, the question naturally arises whether the stony marginal layers of so many of the sills of the district are not, in a sense, sheaths which have succeeded in ridding themselves of water owing to their external position. It is probable that this has been an important factor in many cases; and, in the opinion of the present writer, the facts, in so far as they have been investigated, do not warrant any further deduction. Mr. Bailey, however, believes that another factor can be recognized, and his argument is as follows. E.M.A.

It is common experience that andesite and rhyolitic magmas, under superficial, or comparable, conditions of cooling, are much more prone, than basalt, to glassy consolidation. In the petrological sequel, it is pointed out that, in several cases, the marginal portions of the Loch Scridain sills are more basic than their interiors, and this in itself would favour the occurrence of a central glassy layer flanked by stone.<ref>See footnote, p. 268.</ref>Mr. Anderson does not regard the composite character of the generality of the sills with stony margins and glassy interiors as established (p. 287).</ref>

It would, however, be easy to exaggerate the importance of the basicity-factor. Not only does sheath-and-core structure demonstrate the possibility of one and the same magma presenting two different consolidation-facies side by side, but also it is established that some of the thoroughly glassy sills are andesite, while others that are stony are felsite. The analysed inninmorite from Tòm a' Choilich (S15989) [NM 5077 2552], with its 62 per cent. SiO_2 (Anal. IV., (Table 11)), is almost a pure glass with a very small proportion of crystals, mostly phenocrysts; whereas, the felsite (S18464) [NM 5361 2259] has almost 71 per cent. SiO_2 (Anal. I., (Table 4),p. 20), and yet is denitrified to stone. The difference would be less, it is true, if the two rocks were compared after dehydration, but it would still remain worthy of attention—at any rate, it would remain greater than the difference between the stony marginal and glassy central portions of the sill, Loc. 1 (Anals. Ia. and Ib., (Table 11)). E.B.B.

Tachylyte-margins

Glass-selvages in Mull have been, in the main, recorded from the North-West basaltic dykes, and will be further referred to in Chapter 34 dealing with these. Of cases which fall under the present heading, the best known is perhaps that, recorded by the late Duke of Argyll, and fully described by Professor Cole (p. 47), bordering a roughly horizontal sill intruded into the assemblage which contains the leaf-beds at Ardtun. The tachylyte here forms an upper and a lower border seldom exceeding an inch in thickness, and, as in the other two cases to be recorded, is markedly sperulitic. From Professor Cole's analysis of the tachylyte, which contains 53 per cent. of silica, and the microscopic description of the remainder of the rock, there can be no doubt that the sill is tholeiitic. E.M.A.

A very interesting case has been described by Professor Heddle (p. 49) from the margins of an inclined sheet, which reaches the coast of the Gribun peninsula near Dearg Sgeir, as indicated by a note on the one-inch Map (Sheet 43). Inland, this sheet generally dips south at from 45° to 60°, but on the coast, where Professor Heddle examined it, it assumes an irregular habit; and figures as a little complex of connected sheets and dykes. At several points in the somewhat extensive coastal exposure, there is a conspicuous selvage of glass, which varies somewhat rapidly and capriciously in thickness. The maximum seen is about 2 ft., where glass constitutes the whole of a vein. Professor Heddle, in his text and illustration, shows that locally "the tachylyte has manifestly been dragged forward, in a *condition of plasticity, if not of fluidity,* while the flow of the more central portions was still continuing." E.B.B.

A hitherto unrecorded example occurs about 500 yds. to the west of Tiroran, where the lower border of a sill, dipping gently to the north, can be seen to be formed by about an inch of tachylyte, (S18527) [NM 4759 2805]. E.M.A.

Chilled margins-sometimes absent

When it is stated that the great majority of the sills of the Loch Scridain district have stony marginal portions, even where their interiors, as often happens, are glassy, it must not be thought that their actual margins are unchilled. The almost invariable rule is that, towards the contact with country-rock, the grain of crystallization of the sill is very markedly reduced. The result is an extremely compact layer, though seldom with any appreciable vitreous lustre (*see* previous section).

While conspicuous marginal chilling is almost invariably shown by the Loch Scridain sills, there are a few noteworthy exceptions. An easily located sill reaches westwards from Scobull Point on the north shore of Loch Scridain to the 104 ft. cairn at Slochd (Sheet 43). It is a composite sill, with tholeiite-margins and a leidleite-interior (S20799) [NM 4683 2700], which latter often retains glassy cores. Like so many of the sills of the district it is highly xenolithic (S20800) [NM 4683 2700], with ' accidental ' xenoliths ranging up to 6 ft. in diameter. It is intruded into vesicular basalts of Plateau Type. Both the top and the bottom of the sill show variable relations to the adjacent lava, sometimes chilling, and sometimes continuing their normal grade of crystallization (finely-doleritic) without modification right up to the point of contact. A series of micro-slides were taken to investigate the matter: (S20798) [NM 4596 2687] [NM 4596 2687] [NM 4596 2687] shows the Plateau Basalt lava above the sill; (S20798a) and (S20798b) show unchilled tholeiite in contact with Plateau Basalt, and invading and apparently carrrying off metamorphosed amygdales, so that there can be little doubt that an appreciable solution of the lava has occurred; (S20801) [NM 4679 2697] [NM 4679 2697] shows Plateau Basalt lava below the sill; and (S20801b) shows merging of this lava into unchilled tholeiite of the sill.

What is probably another example of the same kind is exhibited farther west along the north shore of Loch Scridain at Port na Croise. In this case, the unchilled upper surface of an inninmorite-porphyrite (S20796) [NM 4266 2640] is overlain by a rock which is almost certainly referable to the Staffa Type of columnar basalt-lavas (S20797) [NM 4267 2641].

Dr. Clough seems to have found the same occasional failure to chill in examples examined by him on the south side of Loch Scridain (Sheet 43). He has noted on his field-map that a xenolithic sill with sheath-and-core structure, exposed along the shore of Port Mòr, is "sometimes distinctly chilled at the base, but apparently not always."Again he remarks, in regard to the base of a xenolithic sill north-east of Eilean Bàn, at the mouth of Loch na Làthaich, that the "junction is sharp but chilling doubtful."

The local absence of marginal chilling may be connected with high temperature of intrusion, or with some compositional peculiarity which tended to delay consolidation. It is worthy of note that a sill belonging to the Loch Scridain assemblage, and exposed at Tràigh Bhàn na Sgurra (spelt Tràigh Bhan Sgoir in the Memoir on Sheet 35), has melted the pelitic gneiss, into which it has been intruded. A careful description has already been published by Messrs. Clough and Cunningham Craig in the Geological Survey Memoir on Sheet 35, and their account is completed by petrological notes by Dr. Flett. It is only necessary to state that the melting of the pelitic gneiss has proceeded in one extreme case to a thickness of 4 or 5 ft.; and that the banding of the softened pelitic gneiss, in another instance, has been sharply deflected in sympathy with the flow-movement of the sill. Intrusion of melted gneiss (buchite) is also recorded as a minor phenomenon. The molten gneiss, Dr. Flett has shown, is cordierite-sillimanite-buchite<ref>*See* footnote, p. 268.</ref> with green spinel. The sill is one of the common tholeiitic assemblage, and is characterized by many xenoliths both 'cognate' and 'accidental.' E.B.B.

Rudh' A' Chromain Sill

Reference has been made, on more than one occasion, to the possibly frequent, though generally inconspicuous, composite character of the sheets of the Loch Scridain district. Very often, these sheets are also xenolithic. A list of composite sheets represented in the Survey collection is given, p. 286, and of xenolithic sheets, p. 272. The Rudh' a' Chromain Sill is taken at this juncture as a very well-defined, clearly exposed, and easily located composite sill with strongly developed xenolithic character. It must be understood that, while the composite character of this selected example is easily recognizable in the field, this is not true of the majority of the sheets of the district.

Rudh' Chromain is situated on the south coast of Mull (Sheet 44) just below the Nuns' Pass, west of Carsaig Bay, (Figure 42). (Figure 45) illustrates the shore-section as drawn by Mr. D. Tait. From above downwards, the section is roughly as follows:

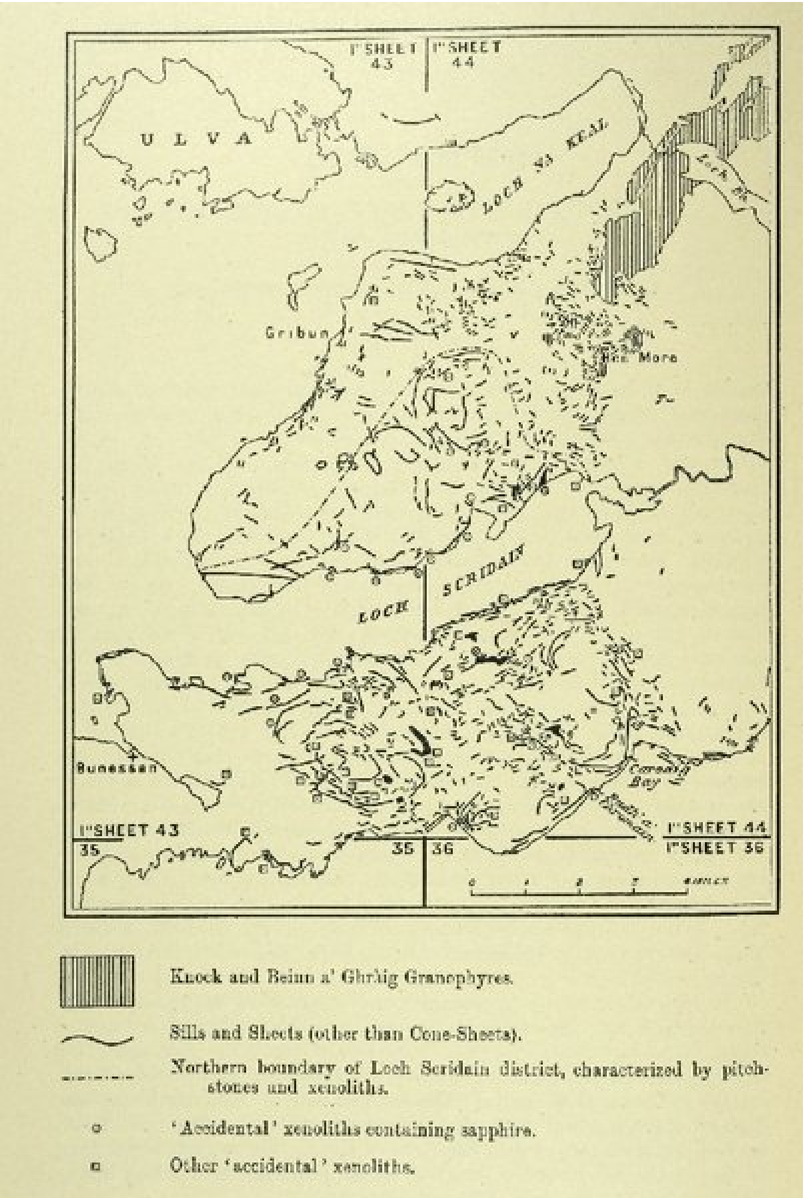
Upper tholeiite-band with chilled top. Below the compact surface-layer, come 4–6 ft. with abundant cognate' gabroid xenoliths; and, below this again, 2½-5 ft. densely crowded with aluminous xenoliths of all shapes, ranging from an an inch to 4 ft in length.

Central felsite 20–30 ft., pale grey, slightly porphyritic, and locally glassy, with sheath-and-core structure. There is no sign of chilling on approach to the tholeiite-bands above and below; but, though there is a slight increase of basicity for a foot or two, shown by a darkening of colour, the contacts are well-defined. A few xenoliths occur, mainly, perhaps, in the less acid layers where they consist of sandstone, and range up to 6 inches in length. The more central xenoliths include shale as well as sandstone, and are larger, sometimes attaining several feet in diameter and averaging 2 ft.

Lower tholeiite-band 2–5 ft., characterized particularly by the size and abundance of its 'cognate' xenoliths and the relative rarity of 'accidental' xenoliths. It shows a well marked chilled base.

The petrology of these layers is referred to later (p. 286). Here it may be pointed out that the marginal tholeiite is represented by Analysis IX., (Table 2), p. 17, while the acid interior is identical in type with the analysed specimen (I, (Table 4), p. 20) from another sill of the district.

Although the Rudh' a' Chromain sill shows compact chilled margins, it has thermally altered the Carsaig Sandstone for a few millimetres from the contact. A melt has been developed between the sand-grains, and, on subsequent cooling, tridymite has deposited as fringes about the undissolved quartz-remnants. The tridymite has now reverted to quartz in optical continuity with the quartz of the original grains, but it still retains its characteristic crystal-form. H.H.T.



(Figure 42) Map of South-West Mull, showing distribution of Sills and Sheets other than Cone-Sheets.

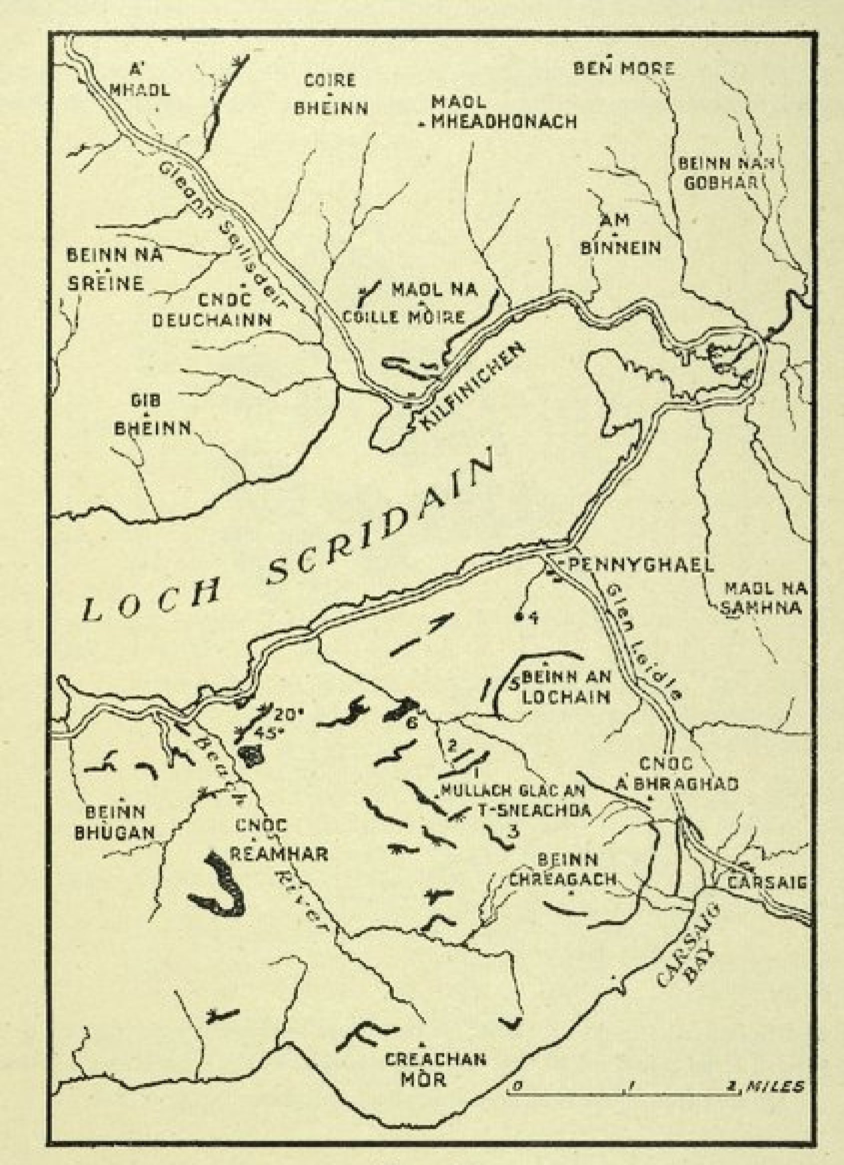


Fig. 43.

(Figure 43) Map of some of the occurrences of Pitchstone in Loch Scridain district. Quoted from Quart. Journ. Geol. Soc., vol. lxai., 1916, p. 206.

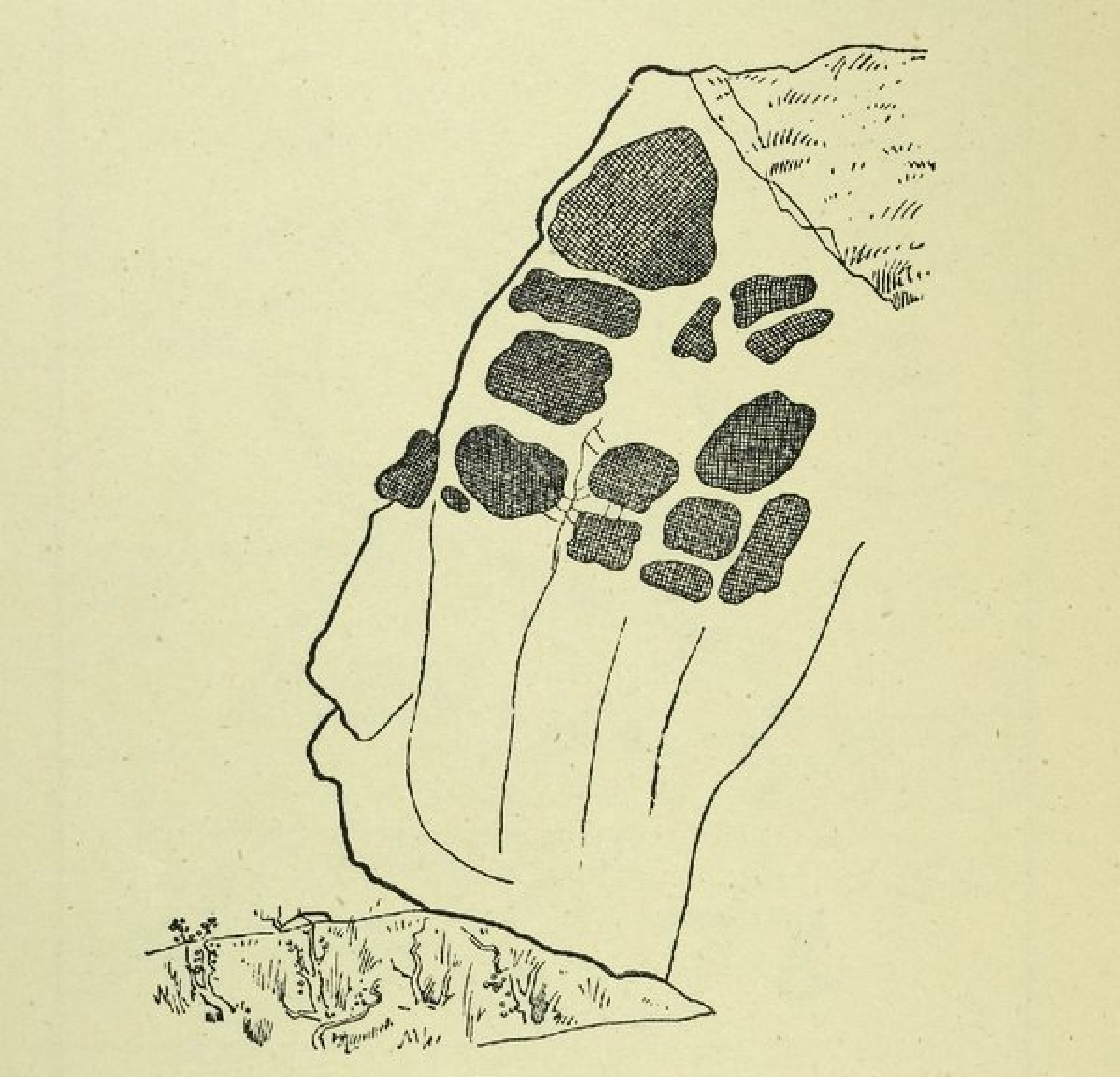


FIG. 44.

(Figure 44) Sheath and-Core Structure as exhibited in the Sheet numbered 1 in Figure 43, p. 261. The shaded areas represent pitchstone. The height of the crag is about 5 feet. Quoted from Quart. Journ. Geol. Soc., vol. lxxi, 1916, p. 211.

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_2Oat 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 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

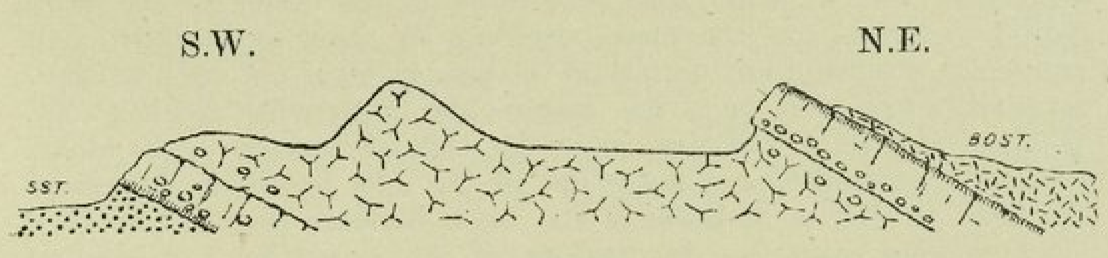


FIG. 45.

(Figure 45) Section at Rudh' a' Chromain across xenolithic composite sheet, showing external chilled margins against sandstone (SST) and bostonite (BOST). Quoted with minor alterations from Quart. Journ. Geol. Soc., vol. lxxviii, 1922, p. 234.

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
	100·94	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