Chapter 6 Tertiary lavas

General account

As in Mull, the Tertiary lavas of Skye are divisible into two suites, a lower consisting primarly of olivine-basalts and an upper in which mugearites are at least as abundant as basalt flows and in which subordinate trachytes appear.

The initial explosive phase which produced the basal palagonite tuffs was followed by a vast outpouring of lava from numerous fissures, mostly situated north of the volcanic centre. The composite lava field gradually built up by these extrusions cannot at its maximum have been much less than 4000 ft thick, for some of the downfaulted remnants approach this thickness and much must have been removed by the severe erosion of the late-Tertiary and Pleistocene periods.

It has long been maintained that the lavas of Skye, in common with those of the north-west volcanic province generally, are but remnants of a vast North Atlantic Plateau which embraced also the lavas of Antrim, Iceland and Greenland. Though it is true to say that the lavas of this hypothetical North Atlantic Plateau are in general of similar basaltic type, there are considerable differences in detail. No two areas have exactly the same sequence of lavas and there are petrological differences in the rocks themselves. Their present day distribution also militates against the theory of a common origin since in every case they are grouped about or near an intrusive centre. Moreover, the isolation of the various plateau remnants would require large-scale faulting, whereas so far as is known, the late-Tertiary faults, though very numerous, are nowhere of very great displacement. The distribution of lava types in Skye suggests that they were extruded from several fissures related to a central volcano. Quite apart from the field evidence the postulate of several rather than one fissure is necessary for, if the observed sequence had been built up by the vertical emplacement of flows, the total thickness of the lava-field would have exceeded 7000 ft and faults of this magnitude would be required to bring about the juxtaposition of early and late flows so frequently seen. There is abundant evidence that the Jurassic floor is nowhere very far below sea-level and the introduction of faults with a displacement of much more than 1000 ft is difficult. Moreover, the several groups into which these Skye lavas have been divided all show thinning away from centres which are assumed to be the sites of their feeders. Thus the lava-pile is thought to have been built up by flows from several fissures operating at different times and in different places, meeting and overlapping along their margins and eventually forming an interleaved series which in any one place need not have exceeded 4000 ft in thickness.

A precise age for the period of volcanic activity in Skye and in the Thulean province generally has not yet been satisfactorily determined. Plant remains found in the basal palagonite tuffs of Skye and in the inter-basaltic sediments of Skye, Mull and Antrim have been thought to suggest a period of eruption not earlier than late Oligocene (Simpson 1951, 1952, 1961). A similar dating is said to be given by the remanent magnetism of the Skye basalts and the gabbros of Skye, Ardnamurchan and Rhum (Khan 1960).

On the other hand, Gardner (1887), Manum (1962), Pflug (1956) and Watts (1962) after examining plant material from the Hebrides, Spitzbergen, Iceland and Ireland respectively have generally agreed on a lower Tertiary, probably Eocene, age for the inter-basaltic sediments. Recent potassium-argon age determinations by Brown and Miller (1963) of the Antrim and Mull basalts indicate an age of about 74 million years for these lavas, from which it can only be concluded that they are Eocene or earlier in age.

In 'The Tertiary Igneous Rocks of Skye', Harker (1904, p. 235) described what he called 'The Great Group of Basic Sills'. He first of all referred to the numerous intrusive sheets in the Jurassic strata first recognized as such by Macculloch (1819) and then claimed that this series of sills is continued upwards in the lava-pile. The evidence of the intrusive nature of these sheets was said to be (a) occasional transgression, (b) intersection of the earlier basic dykes, (c) petrological affinities with the lower sills and differences from the lavas, (d) Harker also noted that these supposed sills thin out and disappear in the neighbourhood of the gabbro and granite intrusions, probably, he suggested because of the destruction of the bedding in the lavas of the metamorphosed belt.

It has become abundantly evident during the mapping of northern Skye that Harker was mistaken and that in general the basic sills did not invade the lavas. The supposed sills are nothing more than the hard, compact centres of the lava-flows, emphasized and distinguished from the amygdaloidal tops and bottoms by subsequent erosion. Apparent transgressions when examined in detail turn out to be due to the irregular nature of amygdaloidal zones, on the one hand or to the disturbing effect of the numerous faults and dyke intrusions. No case has been found in which any dyke has been cut across by the basalts of the lava field. Possibly Harker was here referring to sills in the Jurassic basement which are known to be later than the earliest basic dykes. Since Harker did not refer to a specific example it is impossible to check this statement in the field. Moreover, having assumed the identity of the so-called sills in the lava sequence and the sills in the Jurassic sediments, Harker proceeded to deal with them as a group and it is impossible to discover in many instances the origin of the evidence quoted.

Thus it is necessary to contradict the statement that the petrological affinities of the upper 'sills' is with the lower sills and not with the lavas without examining his evidence in detail. The petrological details given in Chapter 7 offer the best evidence in favour of the contradiction.

The apparent thinning and dying out of these 'sills' in the neighbourhood of the major intrusions is simply due to the destruction of bedding and hardening of the lavas by thermal metamorphism.

Since Harker's opinions have great authority and in view of the fact that his conclusions were not only published in Survey memoirs but also incorporated on the published maps of Western Skye (One-inch Minginish (70) Sheet) and Central Skye (One-inch Glenelg (71) Sheet), the lavas of northern Skye were examined with special attention to this question of intrusive sheets being incorporated in them. In every case where a lava succession was examined in detail it was seen to consist of an uninterrupted succession of flows. The massive basalt of the main part of each flow (the 'sill' of Harker) was succeeded by an upper vesicular portion without a plane of division and without any sign of chilling. The tops are almost always reddened and in very many cases had been weathered into a red bole. The bases of the flows are frequently vesicular or brecciated or both. The characteristic step-like features of the lava-field are due to the differential weathering of the softer vesicular portions and the boles and the hard compact centres.

Individual flows are frequently very persistent and can be traced for miles without any appreciable thinning. On the other hand some flows, like that numbered 8 in The Storr Section, are extremely irregular and vary considerably in thickness over a distance of a few yards. The only instances of sheet-like intrusions found in the lavas are (1) an offshoot from the eastern side of a large Allivalite dyke crossing An Cleireach, 3½ miles N.W. of Bracadale, and extending for not more than three-quarters of a mile, (b) three sheets of dolerite cutting across the lavas in Oisgill Bay (Duirinish) at an angle of 30–40°.

In general the highest sill noted was that frequently found in the basal tuff and there is visual evidence in the cliff section some four miles north of Portree that this sill was unable to penetrate the first continuous lava-flow above.

The Skye lavas can be divided into five groups with approximate thickness as follows (Figure 13):

5.	**Osdale Group** Alternating Basalt and Mugearite flows	1600 ft
4.	**Bracadale Group** Alternating Mugearite and Trachyte flows	400 ft
3.	**Beinn Totaig Group** Alternating Basalt and Mugearite flows. A porphyritic basalt at the top of the Group.	2000 ft
2.	**Ramascaig Group** Alternating porphyritic and non-porphyritic Basalts, with a mugearite flow over the top of the Group	2500 ft

1.	**Beinn Edra Group** Non-porphyritic Basalts with a few porphyritic flows and a mugearite at the top of the Group.	1000 ft

Details

Beinn Edra Group

The fissure from which this group of lavas was extruded must have been located in Trotternish and may be that later occupied by the picrite dykes at Beinn Tuath and Glenuachdarach, having the usual N.N.W. trend. All the lavas of the Trotternish peninsula are thought to have emanated from this vent. The flows probably extended westwards as far as the Vaternish peninsula and southwards beyond Drumuie to Portree, Ben Tianavaig and beyond the southern boundary of the one-inch sheet to Ben Lee. The area they covered coincides roughly with that in which the picrite dykes are found.

The lower lavas of the group are to be seen in the neighbourhood of Uig Bay and the Conon Inlier. They appear to consist entirely of undifferentiated basalts. The group as a whole forms the eastern escarpment of Trotternish extending from Portree to Flodigarry, but the lower flows are mostly hidden beneath scree and landslip. The upper part, capped by a conspicuous mugearitic-basalt with columnar jointing, is well seen from The Storr to Beinn Edra. The mugearitic basalt is a striking feature having all the appearance of a columnar sill when seen from a distance.

The following section was measured in the cliff south of Coire Faoin and continued upwards in the southermost gully on the main east face of The Storr.

Section of lavas at The Storr

		feet
	(A, Storr gully; B, Coire Faoin cliff) [1]Numbers refer to rock slices in the Geological Survey Collections.	
A. 24.	Mugearite. grey, platy, forms a small outlier on the summit of the mountian. (S37822) [HU 343 914][1]	10
23.	Mugearitic-basalt, fine-grained, platy, olivine-phyric, feldspars have labradorite cores, but are zoned to oligoclase (S37921) [NG 4952 5400]. Lavas show crude columnar jointing, well-developed red bole at top	25
22.	Basalt, dark, grey, massive, olivine-phyric (S37919) [NG 4952 5399], capped by well-developed bole in which the basaltic texture is still visible (S37920) [NG 4952 5400], but containing abundant stilbite, analcime and chabazite	55
21.	Basalt. Red bole full of amygdales with zeolites	5
	Amygdaloidal basalt	9
	Massive, porphyritic olivine-basalt with olivines up to 3 mm across (S37918) [NG 4952 5399]	10
	Amygdaloidal basalt with chabazite	11

	Massive olivine-basalt	10
20.	Olivine-basalt, grey, porphyritic with corroded olivines up to 3 mm across, labradorites 0.2–0.7 mm long, small granular augites, sparse ores (S37917) [NG 4953 5398]. Red top	12
19.	Olivine-basalt, dark grey, microporphyritic, olivine-phyric with small round amygdales filled with analcite (S37916) [NG 4953 5398]. Red top	10
18.	Basalt, highly amygdaloidal, altered, soft. Perhaps two thin flows; a thin red parting in centre and a thin red bole on top	12
17.	Olivine-basalt, massive, rather coarse, with olivine phenocrysts of 0.41.0 mm diameter, and groundmass labradorite near 0.5 mm long (S37915) [NG 4954 5397]. Shows flow-banding and a well-defined plane at the top	30
16.	Olivine-basalt, dark grey, platy, fine-grained with elongate olivines up to 1.0 x 0.25 mm, in labradorite-granular augite groundmass (S37914) [NG 4954 5397]. Close spaced horizontal joints, some lined with zeolites. Reddened top	20
15.	Olivine-basalt, dark grey, coarse (doleritic), with labradorites up to 3 mm long but averaging 0.5 mm. Small amygdales carrying analcite and chabazite (S37913) [NG 4955 5396]. Six-inch bole on top	30
14.	Olivine-basalt, massive, doleritic, with labradorites averaging about 0.75 mm long; intergranular augite and abundant thomsonite and chabazite (S37912) [NG 4955 5396]. Thin red bole on top. Base not seen but thought to be nearly same horizon as top of Flow 13	50
B. 13.	Olivine-basalt, highly amygdaloidal, grey, microporphyritic olivinephyric, in part chloritized. Amygdales with chlorite, chabazite, analcime (S37911) [NG 4940 5392]. Some thin massive layers. A tongue of dolerite is intruded into this flow from an adjacent dyke at least	60

12.	Olivine-basalt, smooth-weathering, olivine-phyric, coarse, approaching dolerite (S37909) [NG 4944 5388]. Contains sharply defined layers of amygdaloid, and patches of pegmatitoid with coarse labradorite, augite, zeolites (S37910) [NG 4942 5390]. Red bole at top at least	80
11.	Olivine-basalt, massive, coarsely-jointed, microporphyritic olivine-phyric (S37908) [NG 4946 5386]. Pools of zeolites, mostly chabazite. Top fairly well defined but not reddened	20
10..	Porphyritic-basalt, porphyritic feldspar-phyric, with labradorites up to 3 mm long, completely altered olivines and fresh, purplish grey intersertal augites (S37907) [NG 4948 5384]. Amygdaloidal in places. Reddened at top	40
9.	Olivine-basalt, amygdaloidal microporphyritic olivine-phyric, with lenses of compact basalt (S37906) [NG 4950 5382]. Thin red bole at top	45
8.	Olivine-basalt, olivine-phyric, corroded olivines up to 1 mm across. Abundant chabazite in amygdales (S37905) [NG 4952 5380]. Flow impersistent. Reddened at top	0–15
7.	Olivine-basalt, in part highly amygdaloidal but with large irregular lenses of fresh doleritic basalt containing labradorites up to 1.75 mm long, olivines up to P5 mm diameter, tiny granules of augite and abundant analcime (S37904) [NG 4954 5378]. Bole at top	40
6.	Olivine-basalt, microporphyritic, olivine-phyric, lower and upper parts very amygdaloidal, centre massive (S37903) [NG 4956 5376]. Red bole at top	35
5.	Olivine-basalt, grey, microporphyritic labradorite-olivine-phyric (S37902) [NG 4958 5373]. Red bole at top up to 2½ ft thick	12

4.	Olivine-basalt, thick, black-weathering, macroporphyritic olivinephyric (S37900) [NG 4962 5367], in part heavily zeolitic but with rounded patches of fresh, massive basalt containing pegmatitoid regions in which the labradorites average at least 1 mm long (S37901) [NG 4960 5370]. No sign of an inter- mediate parting but a 6-in red bole at top	95
3.	Olivine-basalt, massive, irregularly-jointed, microporphyritic olivinephyric (S37899) [NG 4964 5364]. Red at top	15–20
2.	Olivine-basalt, massive, microporphyritic, ophitic, (S37898) [NG 4966 5362]. A suggestion of columnar jointing. An irregular amygdaloidal basalt occurs in the lower 12 ft, but this is locally cut out by massive basalt. A thin red bole at top	50
1.	Olivine-basalt, grey, microporphyritic labradorite-olivine-phyric (S37896) [NG 4970 5355]. Heavily chloritized in part and zeolitized, chiefly with chabazite (S37897) [NG 4968 5360]. Red bole at top up to 12 in thick. Base concealed by scree	30+

NOTE. It is estimated that a further 400 ft of lava is concealed under scree and landslip.

Further north at the Quirang a section in this same series of lavas was measured from the summit above The Table down the second gully in Maoladh Mor, S.E. of The Table. The sequence here bears direct comparison with that of The Storr approximately ten miles further south.

Section of lavas at the Quirang

		feet
11.	Olivine-basalt, grey, microporphyritic olivine-phyric (S37895) [NG 4498 6915], containing chabazite-filled amygdales (This is the highest lava seen in the Staffin area and probably lies about 150 ft below the mugearite which caps the ridge south from Beinn Edra).	20
10.	Olivine-basalt, grey, chloritized, olivine-phyric, showing wedge-bedding. Amygdales contain chabazite and 'viridite' ; olivine has been replaced by bowlingite (S37893) [NG 4499 6914]-(S37894) [NG 4499 6914]	15–20

9.	Olivine-basalt, grey, fairly massive, microporphyritic olivine-phyric (S37892) [NG 4500 6913]. Capped by a well-defined red bole	35
8.	Olivine-basalt, grey, amygdaloidal, microporphyritic olivine-phyric. Amygdales with chabazite and chlorite (S37891) [NG 4501 6912]. 'Fairly massive as seen in gully	40
7.	Olivine-basalt, dark grey, massive, microporphyritic olivine-phyric, with sub-ophitic augite up to P5 mm across, enclosing labradorite laths of 0.20.25 mm long (S37890) [NG 4502 6911] In the gully no persistent parting could be found in this lava, but in the east face of the cliff, a double parting at about the middle could be seen, so that this may represent at least two flows. A persistent plane marked the top but there was no bole.	120
6.	Porphyritic basalt, dark grey, microporphyritic, with a few labradorites up to 0.7 mm long (S37889) [NG 4503 6909]. The top is slightly reddened	40
5.	Olivine-basalt, grey, massive, olivine-phyric (S37888) [NG 4503 6908]. The top not defined by a bole and not very certain.	
4.	Olivine-basalt.	
	c. Very amygdaloidal olivine-basalt with thin red bole at top.	
	b. Dark grey, massive, almost free from amygdales, striped, microporphyritic olivine-phyric basalt (S37887) [NG 4504 6907] containing 'pegmatitoid' patches with augite, plagioclase, apatite, ilmenite, analcime, chabazite	15
	a. Dark grey, highly amygdaloidal, olivine-phyric basalt with chlorite and chabazite in amygdales (S37886) [NG 4504 6907]	12
	(Probably Flow 7 of The Storr sequence where however, the central portion (b) above is in the form of irregular lenses.)	
3.	Olivine-basalt, dark greenish-grey, chloritized, amygdaloidal in places, containing sub-ophitic augite up to 0.7 mm across (S37885) [NG 4505 6906]. Red layers at top	20

2.	Olivine-basalt, dark grey, altered, highly amygdaloidal especially in a layer 6–10 ft above the base, less amygdaloidal above (S37884) [NG 4506 6905]. Bole at top up to 12 in thick	35
1.	Olivine-basalt, dark grey, microporphyritic olivine-phyric (S37880) [NG 4506 6904]-(S37881) [NG 4506 6904]. Base not seen. Hard ribs up to 2 ft thick, flow-banded, with horizontal ' pegmatitoid ' veins carrying clinopyroxene, ilmenite, thomsonite (S37882) [NG 4506 6904]. Top 6 ft highly amygdaloidal, with chabazite. Patchy bole, apparently formed in situ, which in places preserves the basaltic texture but elswhere obliterates it (S37883) [NG 4506 6905]	50

Comparing this section with that at The Storr it will be seen that in general individual flows are slightly thicker at the latter locality. In total there is apparenty a difference of some 350 ft over the same range of flows. No great significance can be attached to this difference except that it may be an indication that the centre of extrusion was located nearer The Storr than the Quirang. The remanent magnetism of the Trotternish lavas has been investigated by Khan (1960). By comparing the magnetic declination and inclination of individual flows at The Storr and Quirang he has suggested that the lowest exposed flow at the Quirang is the tenth flow up in The Storr sequence. This correlation, however, raises difficulties since the field evidence suggests that the lowest visible flows at the two localities lie at much the same height above the true base of the lava series and Khan's correlation implies what appears to be a rather excessive overlap of more than 700 ft between the two places. The petrology of individual flows is of little help since differences are small but if the secular variation is plotted against true thickness and not as Khan has done (fig. 8, p. 57) simply against a flow number then an alternative correlation is not only possible but is more in accord with the field evidence. In the first place a threefold phase of extrusion is evident, i.e. an early stage during which the individual flows rarely exceed 50 ft in thickness and are usually capped by well developed bole, and which appear to thin northwards, though this is difficult to establish because the lower flows are generally concealed by scree. Probably the lowest 650 ft of The Storr sequence belongs to this stage. The second stage, the climax of the extrusive activity, gave rise to thick flows in quick succession since boles are usually poorly developed or absent. About 200 ft of lava represent this stage—lavas 4 to 9 at The Storr and 4–7 at the Quirang. There is little evidence of any thinning to the north. The final stage consists of flows which at first are of considerable thickness but which later are rarely more than 15 ft in thickness and appear to be dying out rapidly northwards. At The Storr this series of lavas is about 500 ft in thickness apparently reduced to little more than 200 ft at The Quirang.

If Khan's results are re-examined with this argument in mind the correlation would be as follows — first phase, lavas 1–3 in The Storr and Quirang succession; second phase, lavas 4–9 at The Storr and 4–7 at the Quirang; third phase, lavas 10–17 at The Storr and 8–11 at the Quirang. Thus lava-flow 10 at The Storr is equated with flow 8 at the Quirang. The secular variation in these flows is almost identical e.g. declination 177° at The Storr, 173° at the Quirang; inclination 67° in both localities. Declinations also agree well in flows 3–6, i.e. at The Storr 187°, 197°, 204°, 190'; at the Quirang 183°, 198°, 207°, 191°. Inclinations approximate less closely i.e. at The Storr 46°, 67°, 71°, 83°; at the Quirang 47°, 52°, 52°, 57°.

In the lowest flow seen the inclination is the same at both localities but the declination differs considerably (196° at The Storr, 161° at the Quirang) and both declinations and inclinations in Flow 2 differ so considerably that it is probable that Flow 2 at The Storr is not represented in the Quirang sequence at all. Correspondence between the degree of declination could scarcely be closer throughout the sequence and the degree of inclination is the same in lava 10 at The Storr and lava 8 at the Quirang. The lower flows also correspond reasonably well in this respect but flows 4, 5 and 6 show a curious discrepancy in degree of inclination. Flows 7, 8 and 9 at The Storr appear to be the same as Flow 7 of the Quirang sequence for although no bole could be detected in the latter a double parting was seen near the middle.

Southwards from The Storr the mugearite capping the Storr-Beinn Edra escarpment is seen in a downfaulted block at the summit of A'Chorra-bheinn. The mugearite capping the cliff at Sithean Bhealaich Chumhaing is probably the same flow. Here the mugearite cannot be more than 600 ft above the base of the lavas whereas at The Storr this distance must be over 1100 ft.

The mugearite exposed in places south of Tianavaig Bay in the Ollach district may be again the same flow but in this area cannot be more than 100 ft above the base of the lavas.

If these suggested correlations are correct then the Beinn Edra group of lavas shows thinning southwards from The Storr by steady overlap of the higher flows and the southern limit of this group cannot be traced beyond the one-inch sheet boundary.

In the Ollach area a thin porphyritic basalt lies not far above the mugearite. This is regarded as the highest known flow of the Beinn Edra Group. Both these flows should be exposed in Ben Tianavaig but much of the hill is peat-covered and they have not been definitely located. A coarse Hebridean type basalt which forms a more or less continuous feature round the mountain may be that numbered 7 in The Storr sequence. It contains labradorite averaging 0.7 mm long, olivine up to 1.5 mm, ophitic augites up to 3 mm and interstitial analcime and thomsonite. Some distance above it is a microporphyritic labradorite-olivine-phyric basalt which may possibly be Flow 10 of The Storr sequence.

A porphyritic basalt exposed in the stream at Hinnisdal Bridge may be Flow 10 of The Storr sequence and if so is the most westerly recognizable flow at the northern end of this group.

Ramasaig Group

The basalts included in the Ramasaig Group, taking their name from a bay on the west coast of Duirinish, clearly belong to the lower suite of lavas. They differ from those of the Beinn Edra group chiefly in being more frequently porphyritic. They may even have been contemporaneous with that group for though they are described here as if they were later, the two groups have not been seen in contact and there is no field evidence as to their relative ages.

The Ramasaig Group consists of a series of alternating non-porphyritic and porphyritic basalts, the latter distinguishable in the field by their characteristic grey colour. Near the top of the group as seen in Healaval Bheag there is a mugearitic flow. Several basalts of the Hebridean type are found in this group. These lavas

appear to have originated somewhere in the Loch Bracadale area or possibly somewhere offshore N.W. of Idrigil Point. They thin to the north and north-east, to the west are faulted down below sea-level and in the east and south are covered by more recent flows. Thinning is evidenced not only by the dying out of the porphyritic basalts to north and east but also by a general thinning of all flows. In the Ben Connan area individual flows appear to average 80 ft in thickness, at Ben Corkeval they average between 60 and 70 ft, at Dunvegan Head about 60 ft and at Ben Geary in Vaternish they are not more than 45 ft in average thickness. Probably all these estimates are too large since it is impossible to be certain of finding the base of every lava in drift- and peat-covered country. The area covered coincides roughly with that in which the gabbroic dykes are found. The base of this group appears above sea-level at Waterstein Head, on both sides of Moonen Bay, at Oans, and at the west of Dunvegan Head, though everywhere the contact with the underlying rocks is covered by scree or landslip or both.

A typical sequence near the centre of the group is that at Ben Connan.

Sequence of lavas, Ben Connan

10.	Mugearite, forming the cap to the hill; base of Osdale Group (S33801) [NG 1982 4035].

9.	Olivine-basalt, with platy olivines and ophitic augite (S33800) [NG 1982 4029].
8.	Olivine-poor basalt, intergranular augite, brown and green devitrified glass? (S33799) [NG 1986 4019].
7.	Olivine-basalt, ophitic augite, chabazite (S33798) [NG 1991 4013].
6.	Olivine-basalt, olivine-rich, sparse pyroxenes and ores (S33797) [NG 1976 4008].
5.	Olivine-basalt, platy olivine, zoned plagioclase, ophitic augite, analcime and chabazite (S33796) [NG 1988 4004].
4.	Olivine-basalt, fresh olivines, ophitic augite, analcime, thomsonite and chabazite (S33795) [NG 1979 3998]. Items 4–6 are mapped as one flow.
3.	?Porphyritic basalt, large olivines, intergranular augite, with magnetite and haematite (S33794) [NG 1920 3986].
2.	Olivine-basalt, platy olivines, ophitic augite (S33793) [NG 1921 3969].
1.	Olivine-basalt, fresh olivines, intersertal augite, fibrous zeolite (S33792) [NG 1920 3960].

The lavas is ten (or more) flows have a total thickness of about 800 ft. The sequence of continued upwards for a further 600 ft in Healaval Bheag.

Sequence of lavas in Healaval Bheag

8.	Olivine-basalt, ophitic augite (S38094) [NG 2245 4216].
7.	Basalt, Vaternish Hebridean type, ophitic augite, thomsonite, zeolites (S38095) [NG 2241 4212].
6.	Porphyritic-basalts, platy olivines, feldspar-phyric, colourless intergranular augite; two similar flows (S33830) [NG 2239 4203].
5.	Olivine-basalt, medium-sized olivines, zoned feldspars, ophitic augite (S38028) [NG 411 764]
4.	Porphyritic-basalts, feldspar-phyric, olivine-bearing, ophitic augite; two similar flows not separated on six-inch maps (S33826) [NG 2235 4182]-(S33827) [NG 2238 4188].
3.	Basalt, large olivines, intergranular augite (S33825) [NG 2220 4177].
2.	Olivine-basalt, large olivines, intergranular augite (S33821) [NG 2243 4154], (S33822) [NG 2241 4159], (S33823) [NG 2221 4164], (S33824) [NG 2222 4172].
1.	Mugearite. The flow forming the summit rock of Ben Connan (S33819) [NG 2226 4147].

The Ben Connan and Healaval Bheag sections together represent the upper part of the Ramasaig Group. The lower flows are best seen in the Ramasaig-Ben Corkeval area where at least six porphyritic basalt flows are interleaved amongst the olivinebasalts. At least twelve flows are present in a thickness of about 1000 ft. Thus the total thickness of the group cannot have been less than 2500 ft in the centre.

The lower half of this series of lavas includes two flows of Hebridean type basalts. It is estimated to be 1000–1100 ft thick in the Ben Corkeval area but at Dunvegan Head has apparently thinned to about 800 ft; north-east at Beinn Bhreac it is about 500 ft and at Ben Geary in Vaternish about 300 ft. The upper portion, which includes a mugearitic flow, Hebridean type basalts and porphyritic basalts, is probably 1400–1500 ft thick at maximum but thins to 500–600 ft at Beinn Bhreac, and 300–400 ft at Ben Geary. The reduced sequence of flows at Ben Geary is as follows:

Sequence of lavas at Ben Geary

18.	Olivine-basalt, olivine-phyric, micro-porphyritic, intersertal augite, chabazite (S31302) [NG 2531 6147].
17.	Olivine-basalt, as 18, with chabazite, thomsonite and chlorite (S31303) [NG 2515 6139].
16.	Olivine-basalt, microporphyritic, olivine-phyric, ophitic augite, chabazite and analcime (S31304) [NG 2482 6130].
15.	Olivine-basalt, microporphyritic, olivine-phyric, intergranular augite, chabazite, analcime (S31305) [NG 2444 6126].
14.	Olivine-basalt, microporphyritic, olivine-phyric, ophitic augite, zeolites (S31306) [NG 2443 6122].
13.	Olivine-basalt, as 14 (S31307) [NG 2442 6114]. Items 13–16 are mapped as one flow.
12.	Basalt, microporphyritic, olivine-phyric, intersertal augite, analcime (S31308) [NG 2437 6103].
11.	Basalt, microporphyritic, olivine-phyric, ophitic augite, chabazite, thomsonite (S31309) [NG 2433 6097]. Items 11 and 12 as one flow.
10.	Olivine-basalt, as 11 (S31310) [NG 2409 6098].
9.	Olivine-basalt, as 11 (S31311) [NG 2419 6077]. Items 9 and 10 are mapped as one flow with two other similar flows between 8 and 9.
8.	Olivine-basalt, microporphyritic, olivine-phyric, intersertal augite, chabazite, analcime, zeolites (S31312) [NG 2385 6054].
7.	Olivine-basalt, microporphyritic, olivine-phyric, intergranular augite, calcite, zeolites. Shows flow-structure (S31313) [NG 2366 6033].
6.	Olivine-basalt, microporphyritic, olivine-phyric, intergranular augite, chabazite, thomsonite (S31314) [NG 2391 6013]. Items 6 and 7 are mapped as one flow.
5.	Porphyritic-basalt, microporphyritic, olivine-feldspar-phyric, intergranular augite, chabazite (S31315) [NG 2359 6022].
4.	Olivine-basalt, microporphyritic, olivine-phyric, intergranular augite, chabazite (S31316) [NG 2360 6008]. A similar flow is also mapped between 3 and 4.
3.	Porphyritic-basalt, microporphyritic, olivine-feldspar-phyric, intergranular augite (S31317) [NG 2357 5974].
2.	Olivine-basalt, microporphyritic, olivine-phyric, ophitic augite (S31318) [NG 2358 5969].
1.	Olivine-basalt, microporphyritic, olivine-phyric, ophitic augite (S31319) [NG 2357 5969]. Items 1–3 are mapped as one flow.

Beinn Totaig Group

The Beinn Totaig Group of lava flows, named from the hill N.E. of Loch Harport, corresponds with the lower third of the Upper Series of Mull. They are basalts, with several thick mugearitic flows and a porphyritic basalt at the top of the group, which appear to have been extruded from a fissure in the Mugeary area, 4 miles S.W. of Portree. The mugearites and basalts occupy a wide arcuate belt from Roineval (just over the southern boundary of one-inch Portree (80) Sheet) to Loch Greshornish including Druim na Criche, Creag a'Chait, Skriaig, Beinn na Greine, Beinn Totaig, Ben Duagrich, Ben Grasco and Ben Uigshader.

A typical section in this group is that measured in the eastern slopes of Beinn na Greine, two miles south-west of Portree:

Section of lavas at Beinn na Greine

12.	Olivine-basalt, coarse, with analcime (S38011) [NG 4609 4175], (S38012) [NG 4596 4163]. The summit cairn at 1367 ft contains large blocks of mugearite but no exposure of this rock could be found at this level.	
11.	Olivine-basalt, micro-porphyritic, labradorite-olivine-phyric (S38010) [NG 4616 4172]. Forms a feature above the head of a stream at about 1150 ft above sea-level. Items 11 and 12 are mapped as one flow.	
10.	Mugearite (S38009) [NG 4636 4171]. A columnar flow with slender columns which forms a feature at about 1100 ft.	40
9.	Mugearite (S38008) [NG 4644 4170]. Columnar.	12+
8.	Mugearite (S38007) [NG 4660 4166]. Platy with a few labradorite phenocrysts. Items 8–10 are mapped as one flow.	30+
7.	Olivine-basalt (S38006) [NG 4680 4165]. Platy weathering. Exposed at about 1000 ft O.D.	25
6.	Olivine-basalt (S38004) [NG 4698 4146]. Massive olivine-phyric, subophitic, cut by a mugearite-basalt dyke (S38005) [NG 4690 4155].	30+
5.	Olivine-basalt (S38003) [NG 4701 4141]. Dark grey, fine-grained. Olivine much altered to bowlingite. Bole at top.	20
4.	Basalt. An alkaline olivine-basalt forming a strong feature. Layers of pegmatitoid with labradorite, clinopyroxene, ores, thomsonite and analcime near top (S38002) [NG 4704 4139]. Bole at top. Items 4 to 7 are mapped as one flow. Gap of approximately 150 ft probably covering basalt and mugearite flows.	40+
3.	Mugearite (S38000) [NG 4719 4135]. Black. Apparently with bole above.	12+
2.	Olivine-basalt (S37999) [NG 4728 4132]. Olivine-phyric, amygdaloidal in upper part.	20+

1.	Olivine-basalt (S37998) [NG 4740 4132]. Coarse, olivine-phyric. A small sill is injected into this lava. Items 1 and 2 are mapped as one flow.	50+

This flow is about 600–700 ft above the base of the lavas but the rock is scree-covered. It is probable, however, that another mugearite flow is present in the flows below.

The most interesting feature of this group is the development of composite mugearite lava-flows. These were first described by Harker from Druim na Criche (one-inch Portree (80) Sheet), Roineval (one-inch Glenelg (71) Sheet) and Talisker (one-inch Minginish (70) Sheet) as composite double sills or laccolites. Kennedy (1931) has shown however, that the examples quoted by Harker are composite lava-flows. The survey of one-inch Sheet 80 has amply confirmed Kennedy's view and has shown that such flows are common in the central area extending from Roineval in the south to Beinn na Boineide, 13 miles to the north-west. These flows consist of a non-porphyritic portion, usually the lower, and a porphyritic portion. The non-porphyritic rock is a normal platy mugearite carrying plagioclase (labradorite) phenocrysts. At Roineval this kind of relationship is well seen—here over a distance of a few inches the non-porphyritic phase passes into the porphyritic by rapid increase in size and number of phenocrysts. At Druim na Criche, 1½ miles N.E. of Roineval, on the other hand, the two rocks are separated by a sharp boundary. At Talisker there is a gradual transition between the types as at Roineval. Though the field relationships elsewhere are not so clearly seen as at the three localities mentioned it would appear that the porphyritic mugearite an occur as a separate flow and in those cases in which it lies below a non-porphyritic mugearite the two are probably quite distinct flows. In the Dunvegan area the porphyritic-mugearites are extremely well developed with very large labradorite phenocrysts.

These porphyritic mugearites, except in the extreme south of the sheet, only occur in the upper part of the Beinn Totaig Group as at Druim na Criche. It is thought that this group fills the space between the Ramasaig lavas to the west and the Beinn Edra lavas to the east. The top of the group is taken to be the porphyritic basalt flow which forms the cap of Braon a'Mheallain and of Beinn Bhreac, and is exposed in Glen Osdale. At about this horizon there was a pause in the volcanic activity and ashy and shaly sediments with plants were laid down. These plants beds in Glen Osdale have yielded the best preserved Tertiary plant remains known from Skye. A small expanse of sediment one-third of a mile north of Loch Dearg, south-east of Druim na Criche may be of the same age, as also may the tuffs just west of Gesto House on the north-east side of Loch Harport. The distribution of this group of lavas coincides roughly with the area in which the mugearite dykes and sills are found.

Bracadale Group

After the extrusion of the mugearites and basalts of the Beinn Totaig Group the centre of extrusion appears to have shifted westwards to a fissure lying along the line Ben Scudaig-Ben Aketil. The magma had become more acid by this time and the products of the eruption were primarily mugearite lavas, porphyritic and non-porphyritic with subordinate trachyte and trachytic tuffs. As might be expected the trachytes have a more limited distribution and it is only in the Ben Scudaig area where all four flows are seen. In all directions from this centre the lavas thin and the trachyte flows disappear one by one.

This group is best seen at Ros a'Mheallain north of the large fault which traverses Loch Beag and Allt Mor. The summit of the hill is a big-feldspar mugearite similar to those at Roineval. The base of this flow is scree covered and the next rock exposed below is a slaggy trachyte seen in the slope above the feature made by a mugearite, below which again, at road level is another trachyte with abundant stilbite.

A more extended, but not so clearly exposed sequence is to be found on the south-western slope of Ben Scudaig. Here is the most complete succession of the group, consisting of porphyritic and non-porphyritic mugearites with four trachyte horizons, of which one at least is a double flow with a bole between. The group here is about 400 ft thick.

The most southerly trachytes in one-inch Portree (80) Sheet are those exposed in the Sumardale River and its tributaries south of Beinn nan Lochan. The Druim na Criche ridge is formed by the attenuated eastern extension of the group. To the north the trachytes are seen in Glen Colbost and in the valleys of Abhainn Bhaile Mheadonaich and Allt Ruairidh. The area two to three miles south of Edinbain contains many small exposures of the trachyte flows and some of the finest examples of the big-feldspar mugearites. A small outcrop of trachyte just north-east of Strone Geers and the mugearites of Beinn na Boineide, Upperglen and Beinn Eirisalain comprise the most northerly examples of the group now remaining. The Bracadale Group is the most restricted both in extent and thickness of all the lava groups. On the general principle that the basic lavas are more fluid than the acid this is only to be expected. Nor is it surprising to find that the acid dykes and sills have a distribution similar to that of the more acid lavas.

Osdale Group

The mugearites and trachytes of the Bracadale Group are succeeded by a sequence of basalts and mugearites similar to that of the Beinn Totaig group. Only remnants of this, the latest series of lavas, have survived, but their distribution suggests that they were derived from a fissure still further to the west. The islands of Wiay, Harlosh, and Oronsay, the northern end of the Minginish promontory, the area round Struan and Struanmore, Boust Hill, Colbost and Osdale in the south and in the north Cruachan Beinn a'Chearcaill and Ben Aketil are composed of lavas of this group. Porphyritic mugearites are present but their relationship to the non-porphyritic mugearite is nowhere very clear.

This area of distribution is, coincidently, or not, that in which the tholeiite dykes found.

Magmatic sources for the lava suite

The sequence and distribution of lavas in North Skye suggests that though closely linked to the site of the Central Volcano in the Cuillin area, the lavas were actually extruded from local reservoirs developed as shallow offshoots from the main magma mass and subsequently becoming independent of it. During the period in which the lavas were being extruded the main magma was becoming more acid and the local reservoirs represented samples taken from the magma at successive stages in this process, probably because of their geographical relationships to the main magma reservoir. The first stage was the formation of a tuff vent somewhere in the Portree area. Palagonite tuffs are found wherever the base of the lavas is exposed but in the Portree area they are much thicker than elsewhere. At this stage the Cuillin Volcano may have become established as a tuff cone with only subordinate lavas of limited extent. Later a vent opened in a fissure further north and basalt lavas were extruded, slowly at first since the thick boles of the lowest lavas indicate long pauses between flows. Eventually a lava plateau of 1000 ft was built up extending over half the island. Meanwhile a second vent had opened in the west. Again the initial stages were slow and sediments were able to accumulate in places between flows. Lavas, porphyritic and non-porphyritic basalts (of the Hebridean type) eventually built up until the western half of the island was covered to a depth of 2000 ft. In both the early vents the magma pressure must have dropped towards the end of the phase and mugearites were drawn off.

A third stage was the opening of a vent west of the first towards the centre of the northern part of the island from which were extruded mugearites and basalts. In this case the main magma reservoir must have been tapped near the basalt-mugearite junction so that repeated pulses in magma pressure produced first basalt flows then mugearite flows. The next eruption took place from a vent still further westwards and one which tapped the main reservoir at a higher level, i.e. at about the trachytemugearite junction so that in this case the alteration of lavas was trachyte-mugearite. A further westward migration tapped the reservoir at much the same level as at the fourth stage and again the flows were alternating basalts and mugearites. The final phase in the expanding magma period was the intrusion of a large dolerite sill in the underlying Jurassic sediments. The sill underlies the whole area and in bulk of magma must have represented little less than one quarter of that extruded as lava. It maintained a close approximation to a single isobaric level which is much the same as that occupied by the main gabbro laccolite of the Cuillins.

The final stage in the volcanic history of North Skye was the collapse of the area overlying the main magma reservoir, pari passu with the intrusion of a great swarm of dykes. That the two phenomena were penecontemporaneous is shown by the fact that many dykes occupy fault planes whilst many others cut across them.

From the nature and direction of the fractures it is inferred that the main magma reservoir had the form of an inverted V-shaped cleft trending N.N.W. more or less along the line marked by the eastern coast of Vaternish.

Though the majority of the dykes are dolerites and definitely associated with the Cuillin centre, and the increase in density and size of the dolerite dykes as the gabbro mass is approached is very striking, there are others which are geographically related to the lavas. The area within which the picrite dykes are found is that covered by the lavas of the Beinn Edra Group. The gabbroic dykes are found in the Ramascaig Group area, the mugearite dykes in the Beinn Totaig Group area, the trachyte dykes in the Bracadale Group area and the tholeiite dykes, which are as usual late, are found in the Osdale Group area. Thus there appears to be an association of dykes and lavas which can hardly be coincidental :

Beinn Edra Group Lavas—Olivine-basalts—picrite dykes

Ramascaig Group Lavas—Porphyritic and non-porphyritic basalts—gabbroic dykes

Beinn Totaig Group Lavas—Mugearites and basalts—mugearite dykes

Bracadale Group Lavas—Trachytes and mugearites—trachyte dykes

Osdale Group Lavas—Mugearites and basalts—tholeiite dykes

The only possible explanation of this association is that beneath each lava field was established an intermediate reservoir fed from the main magma and of the same composition as the lavas above. In fact the lavas were extruded through fissures from the intermediate reservoir and not directly from the main magma. It is probable that crystallization began in these intermediate reservoirs rather than in the main magma, in which case the extrusion of coarsely porphyritic lavas of remarkably uniform composition and of composite flows is readily understood, for these intermediate reservoirs were probably sill-like bodies in which layering could easily take place. The collapse of the roof of the main magma which eventually took place must have squeezed out the magma remaining in the intermediate reservoirs, through innumerable fissures, in the form of dykes. It is not possible to substantiate Harker's postulate that the dykes were feeders either for the lavas or for the sills. No case of such a relationship has been established and all the dykes appear to be later than all the lavas. It is more likely that the feeders were few and large like those now operating in the lava-field of Hekla in Iceland.

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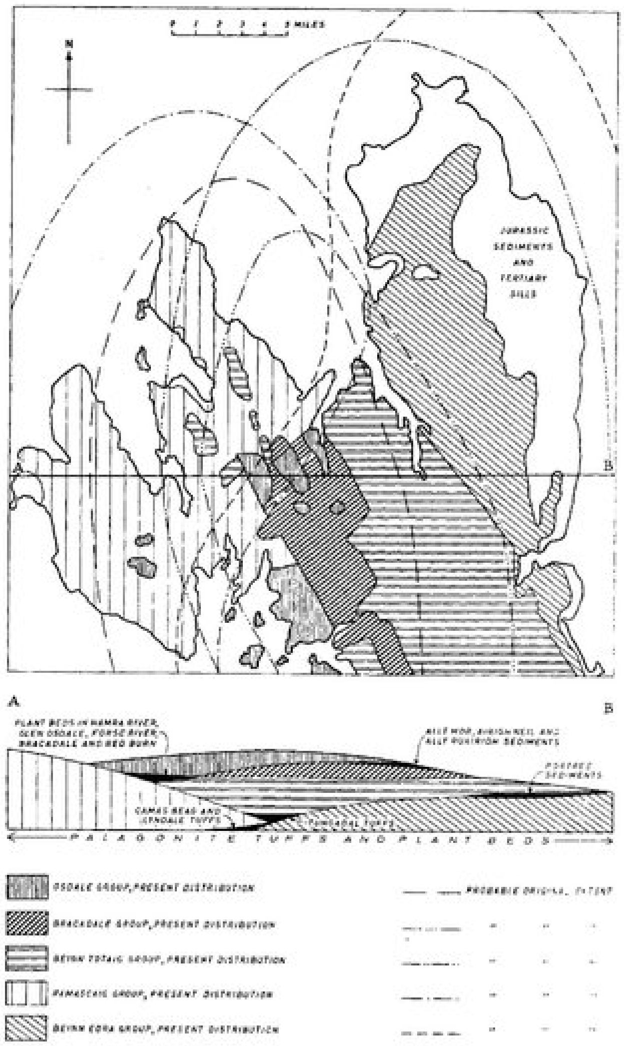

FIG. 13. *Sketch-map showing the outcrops of the main lava-groups and section showing their mutual relationships. The suggested former limits of the groups are projected from the known thickness of the present day remnants. Intervals, between extrusive episodes are represented in many places by plant-bearing sediments and tuffs.*

(Figure 13) Sketch-map showing the outcrops of the main lava-groups and section showing their mutual relationships. The suggested former limits of the groups are projected from the known thickness of the present day remnants. Intervals, between extrusive episodes are represented in many places by plant-bearing sediments and tuffs.