INTRODUCTION.

The Brito-Icelandic or Thulean basaltic province embraces N.W.Britain, Iceland, the Faroes, Jan Mayen and large parts of Greenland. Of the regions Iceland forms the largest surviving remnant, and is made up almost entirely of volcanic rocks, which range in age from lower-most Tertiary to the present day.

Iceland is structurally a broad syncline with the older Tertiary volcanic rocks in the east and north-west dipping at a small angle towards and below the broad Quaternary volcanic belt running across the centre of the island.

The first geological map of the whole of Iceland was published by Thoroddsson at the close of the last century. Since then, isolated areas have been mapped in greater detail. In the Tertiary outcrop of eastern Iceland, in particular, various areas have been mapped by Hawkes and his co-workers, and by Walker. No detailed work has, however, been undertaken in the area with which this report is concerned. This area comprises the valley at the head of Berufjordur, and the mountain ridges to the north and south of it. About eighteen square miles of this ground has now been geologically mapped, extending from Fossarfell, on the south, to Ofaeruddsnafir on the north (fig.1.).

Although the aim of the work was to produce a comprehensive geological map of the region, attention has also been directed to other topics, notably the distribution of zeolites as amygdale-fillings in the lavas, Berufjordur being one of the classic zeolite localities.

GENERAL CHARACTERISTICS OF THE LAVAS.

Lava types.- Lavas compose the bulk of the Tertiary volcanic succession. They show a wide range of composition, embracing olivine-basalts, tholeiites, andesites and dacites. The lavas were erupted sub-aerially and are commonly separated by the red beds, a few inches or a few feet thick. Of these rock-types, basalts are predominant, the two types (olivine-basalts and tholeiites) occur in approximately equal amounts. These two types are distinguished in the field by a number of characteristics, as follows:

Olivine-basalt	Tholeiite
Relatively coarse-grained	Very fine-grained
Often shows speroidal weathering, with a dark brown or black soft weathered crust	Spheroidal weathering uncommon, with a grey or pale brown hard outer weathered crust
No regular jointing.	Angular jointing, occasionally with a massive crude columnar jointing
Numerous amygdales with zeolites, especially analcite	Amygdales frequently bearing quartz, chalcedony, celadonite, with or without zeolites Analcite not recorded.
Poorly developed flow structure.	Flow-structure often prominent.

Mineralogically, tholeiite differs from olivine-basalt in being free from olivine. In chemical composition the tholeiites have a lower MgO content, and differ from the olivine-basalts in being silica-saturated.

In addition to these two types of basalt, three flows have been seen bearing up to 10% of large feldspar phenocrysts.

The andesites, transitional in composition between the tholeiites and the dacites, are characterised by a reddish ~~appear~~ appearance, a hard and flinty nature, a very fine grain, and an angular jointing. Amygdales are common and are characteristically filled with quartz and chalcedony although zeolites (especially heulandite, stilbite and mordenite) do occur.

The dacite lavas are either red-pink or pale grey in colour. The red and pink dacites tend to have strong flow-banding along which they split into thin sheets. The paler rocks, particularly those seen north ofSvartagil, are often crowded with lithophysae, are roughly bended, and give rise to screes of large rectangular slabs. Pitchstones, green or black in colour and often spherulitic, are usually found at the top and sometimes at the base of the flows. The dacites occasionally contain feldspar phenocrysts up to 3mm. long of composition approximately An35.

Thickness of flows.- Of the basalt lavas, the few flows of

porphyritic basalt, averaging 50 to 70ft. are the thickest. Next come the tholeiites, 44 flows of which average 42ft. in thickness, although individual flows of 100ft. are common. By comparison 63 measured flows of olivine-basalt average only 16ft. in thickness. The andesite flows tend to be between 40 and 70ft. thick. The acid lavas, which must have been extremely viscous when erupted have a thickness which varies from 20 to 30 ft. for some flows to 270ft. for the flow on Fossarfell to well over 500ft. for the upper dacite flow on Berufjardartindur. The thickness must depend on the amount of material available at the time of extrusion, and also on the gradient of the surface down which the lava flows.

Lateral extent of flows.- It is difficult to trace individual lava flows for appreciable distances. Flows seen on the steep northern face of Fossarfell tend to wedge out after a mile or so; others are more persistent, and a porphyritic basalt and the underlying 30ft. tholeiite can be traced for four miles. Thin groups of lavas are more persistent than single flows, although even they vary in thickness.

The flows of andesite characteristically thicken, thin and die out abruptly; and the dacites, owing to the great viscosity of the magma, are restricted in lateral extent. It is probable that many basalt flows would be more extensive were they not terminated in many instances where they are banked up against 'hills' of dacite or andesite.

Flow structures.- Flow-banding in the dacites is particularly well developed and the rocks are in consequence fissile and split readily into sheets about half an inch thick. Sometimes the flow bands are highly contorted, with overfolding and local thrusting, and occasionally patches of pitchstone are dragged in from above. Such folding is best developed in the uppermost parts of flows (e.g. in the Selgil flow). The pitchstone, often spherulitic, at the top of a flow is usually banded, and green pitchstone usually underlies black. Of particular interest are the ridges of green spherulitic pitchstone at the head of Illagil, which may be due to lateral pressure at the surface of a still-viscous flow. At other times the dacite lavas have a black upper surface.

The intrusive dacites resemble the extrusive flows in having good flow banding that is now vertical or steeply inclined.

A less strong flow-banding is seen in the andesites

lavas, especially when one flow has over-ridden the termination of the previous one. Amygdales in the rock are often elongated and flattened, and pipe amygdales may be curved over in the direction of movement. Flow-banding is less conspicuous in tholeiites, and unlike the dacites and andesites, the rock has little tendency to split into flakes. The flow structure is due to a parallelism of the tiny feldspar crystals in the rock. In the olivine-basalts, flow results in the development of layers of small vesicles.

Jointing.- A crude, massive prismatic jointing is seen in some of the tholeiite and andesite lavas but is more noticeable viewed from a distance than seen cl se up. No good example of columnar jointing has, however, been observed in any of the basic or intermediate lavas. An excellent example of columnar dacite can be seen on the north-east flank of Raudafell in Breiddalur, where horizontally flow-~~bended~~ banded pink-red rhyolite exhibits vertical columns 10 to 15ft. high.

Vesicles, amygdales and lava tunnels.- The olivine-basalts are highly amygdaloidal, amygdales being distributed throughout the flow although somewhat concentrated towards the top. Small pipe-amygdales are sometimes found. Amygdales are much less abundant in the tholeiites and, if present, tend to occur near the top of the flow, which may be scoriaceous. Amygdales are often flattened by flow, and quartz, chalcedony and celadonite are the most common infillings. Large pipe-amygdales are sometimes seen, up to 2ins. in diameter and associated with them are vesicles up to 18ins. long lined with euhedral quartz crystals, as in the Selgil.

Open lava tunnels with concentric flow-banding around them are commonly encountered at the base of tholeiite lavas. The tunnels are usually empty, and 12 to 18ins. in diameter. One example was noted in Arnahusgil of such a tunnel about 5ft. across and infilled with agglomerate. Two of the lava tunnels which are also common in andesite lavas were found to be lined with well-formed wheat-sheaf stilbite crystals and aggregates.

Basalt pegmatite.- One good example was found, with a number of veins up to 4ins. thick cutting the lavas of the porphyritic basalt lavas (an olivine-basalt with feldspar phenocrysts) on the lower slopes of Fossarfell just to the east of the ~~Arn~~ Arnahusgil. These pegmatites are coarser in grain than the basalt in which they occur.

Weathering of the rocks.- The weathering and method of break-down of the rocks is useful in distinguishing between the

rock-types from a distance or on aerial photographs. The dacite lavas form pale-coloured and scree-covered rounded hills, such as Raudafell, in contrast to the dacite intrusions which stand up as jagged peaks. Acid dykes are readily visible from a distance, showing up as white stripes across the ground. The existence of acid rocks in a gully can usually be detected on aerial photographs by the pale colour of the outwash ~~fanm~~ where the gully debouches onto the valley floor.

STRATIGRAPHY.

Geologically the area is divisible into two distinct units:

1. A dacite-andesite complex consisting of a great thickness of dacite, andesite and tholeiite lavas, often with rather steep dip, associated with thick acid tuffs. This complex forms the north-western half of the mapped ground

2. Abutting against and overlying (1): a considerable thickness (over 3500 ft.) of flood basalts, comprising mostly tholeiite and olivine-basalt lavas. These lavas are a generally conformable sequence gently dipping towards the south-west.

The dacite-andesite group.- The lowest rocks exposed in the area mapped, The Lower Green Tuffs are seen in several small inliers, of which the largest is in the Illagil. Here about 50ft. of in thickness of green tuffs is seen, bearing fragments up to ½in. of green dacite and, in the lower part, occasional blocks of andesite. The tuff is inclined S.W. at 30° and forms a mound against which the overlying andesites are banked up. The tuff is reddish-brown in colour just below these andesites. Numerous irregular andesite stringers up to 1ft. cut the tuff. Small inliers of a similar tuff are seen 1600 yds. up the Selgil; in the stream S.E. of Raudafell; and to the north of Svartagil. A great thickness of similar tuff is seen in Breiddalur, particularly well exposed in the Innri-Ljosa, with overlying andesite banked up against it. It is probable that this thick tuff is to be correlated with that in the Illagil, the two being continuous below Ofaerudalsnefir.

The andesite and tholeiite lavas succeeding the Lower Green Tuffs are well exposed in Svartagil and in all the streams to the west as far as, and including, Selgil. In Svartagil some 700ft. of andesites and tholeiites are exposed, the individual flows tending to decrease in thickness upwards from about 25 ft. to about 10ftThe flow-banding in these rocks is often highly irregular. There are

occasional interbedded and tuffs up to 2ft. thick.

A number of dacite flows are interbedded with the andesites. The pale, speckled, flow-banded dacite exposed at the camp appears to be continuous with the lowest dacite flow on Fossarfell, where it has a pitchstone top dipping south at 20°. This dacite outcrop continues northwards from the camp into the Selgil, where two flows ~~continues northwards~~ are seen, both pale in colour, the upper being yellow. They are separated by 4ft. of steeply-dipping spherulitic pitchstone. Overturned folds in the flow-banding indicate a movement from the N.E. The lowest dacite on Raudafell, and part of the dacite outlier W. of the Trollaskrida may be the stratigraphic equivalent of these dacites.

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Above the yellow dacite in the Selgil comes 20ft. of blue-green tuff (red at the top), overlain by andesite. Other exposures of what are considered to be the same tuff are seen near the confluence of Selgil and the Berufjardara; just north of the camp: beneath the agglomerate of the vent dacite higher up Selgil; on dacite above the W. bank of the lower Trollaskrida; and (30ft. thick, with andesite blocks up to 2ft.) on andesite just west of the intrusion of Smatindur.

~~On Fossarfell, a flow 100ft. thick of porphyritic basalt rests on the lowest dacite west of the camp, the dacite are overlain by andesites.~~

These andesite and tholeiite flows constitute a conformable succession inclined at about 25° towards the S.W. The flows are considered to have the flanks of ~~an~~ a volcano, the acid complex forming the core of which is exposed to the north or north-east. The northern slopes of the valley at the head of Berufjordur represent approximately the exhumed surface of this volcano, the lavas and the slopes of the ~~surface of~~ of the present valley being ~~parallel~~ parallel.

The andesites are overlain by several dacite lavas. The col. Berufjardaskard has dacites on either side. A strongly flow-banded flow of bluish-red dacite is seen on the east, and it is probably related to the dacite plug which forms striking pinnacles (due to the near-vertical flow-banding) on the S.W. ridge of Flogutindur. Flogutindur itself is capped by a second dacite flow, the two flows being separated by a thin acid tuff bed. On the west side of the col. a lower dacite flow is overlain, on the N.E "nose" of Berufjardartindur, by a succession consisting of acid tuff

~~acid tuff~~, palagonite tuff bearing blocks of acid rock, and palagonite tuff alternating with basalt and succeeded by several basalt flows. This group of rocks is overlain by acid tuff, and the succession wedges out westwards along the south face of Berufjardartindur. The uppermost dacite flow on this mountain attains a thickness of 600ft. and forms impressive precipices.

Traced towards the south-west, several separate dacite lavas are seen on the dip slopes south of Ofaerudalsnafir. Correlation of the outcrops of dacite is often very difficult on account of the usual lack of distinctive characters and the concealment of the contacts and occasionally of the whole outcrop by scree produced by the ready frost-splitting of dacite along the flow-banding. Petrological studies might help, and the presence or absence of feldspar phenocrysts is a useful field criterion.. Relations on the outlier are rather complicated on Raudafell, and it seems likely that the lower parts of the the dacite on the hill are intrusive, with steeply-dipping flow-banding. One of the dacite flows is seen, in the upper Selgil, joined to the vent-feeder.

The only persistent horizon in this succession of acid rocks is a tuff, referred to as the Upper Blocky Tuff, it can be traced from the E. end of Berufjardartindur (where it underlies topmost rhyolite) to the head of Trollaskrida. The manner in which this acid tuff cuts across so many different underlying flows suggests that it marks the opening of a new phase of acid volcanicity after a period of quiescence and erosion. This is particularly marked at the eastern end of Berufjardartindur, where a number of flows and palagonite tuff beds wedge out westwards.

The uppermost dacite avas on Berufjardartindur has strongly-developed flow-banding, the orientation of which presents features of considerable interest; the dip of the flowebanding is seen to increase up-dip, as shown on the accompanying diagram, until it is practically vertical. At the E. end of the mountain. There are two ways in which t this may be e xplained. The observed distribution could have been produced by movement of the lava in an easterly direction. However, this would involve movement of the lava flow uphill, rising in the process through a vertical height of some 300 ft. (after making due allowance for the later regional tilting). The alternative explanation is that the lava has come from the east (i.e., from the vicinity of Flogutindur, and perhaps from the known

Smatindur vent); the local steep dip of the flow-banding in the Berufjardartindur dacite would then be the result of the viscous lava flow running down the side of ahill.

The dacite flows, 2 and 3 and 5 on Fossarfell are considered to lie stratigraphically lower than the Upper Blocky Tuff. The lowest of these flows, A.2, is best exposed in "Fan Gully", where up to 70ft. of strongly flow-banded and spherulitic dacite is exposed. This flow has occasional basalt or andesite xenoliths up to 3ft. across, and the flow has a brecciated top with small lithophysae, capped by 6ft. of green pitchstone and a thin acid tuff. Traced westwards, this lava flow terminates abruptly east of "Deep Gully".

The second dacite flow on Fossarfell, A.3, is seen 350ft. up "Deep Gully", where it is banked up against tholeiite, blocks of which are enclosed in the dacite. The dacite is white or pink, free from phenocrysts, and strongly flow-banded. The third dacite, R.5, is seen in "Fan Gully". The topmost dacite is 290ft, thick in "Fan Gully". The rock is pale in colour, contains feldspar phenocrysts, and is coarsely flow-banded. The upper part of the flow is blocky, and it is capped by green pitchstone followed by red tuff.

The flood-basalt group.- The great accumulation of andesite and dacite lavas and tuffs of the lower group is overlain unconformably by a succession of basalt lavas which overstep the acid rocks from the west. It seems that at one stage in Tertiary times, the dacite-andesite group stood up as a central volacano, later gradually to be submerged by later flood basalts. The uppermost basalts overlie the top of the acid group as seen on Fossarfell and on the summit of Berufjardartindur. These flows form only a small part of the extensive system of basalt flows which cover a large part of the coastal area of eastern Iceland. The accompanying stratigraphic column and geological map and sections illustrate the nature of the basalt succession, and although only a limited thickness of rocks was studied, it can be seen that there is no sign of rhythm in the lavas erupted.

The individual lava flows are commonly separated by red beds, which exceptionally attain a thickness of 20 -30ft. They must represent a considerable time interval(cf. Hawkes, Geol. Mag. 1916, 385-95). In thin section the material composing the red beds is seen to be composed of lava fragments averaging 1mm. in diameter, and the beds are proabably tuffaceous or wind-borne deposits. A bed of somewhat different type is seen at the entrance to a small gorge in the Grjota. A brown bed containing angular basalt fragments up to one inch is overlain by a mudstone or fine-grained brown tuff overlain by green tuff. The beds appear to be lacustrine

overlain by green tuff. The beds appear to be local, and are probably fluviatile and deposited in a rock-basin.

Plant remains are often encountered in the red beds between flows. Especially noteworthy was a sapling embedded in tholeiite lava at 1030ft. in the Nongil. The stem, although largely replaced by quartz, chalcedony, heulandite and calcite, still retains some of the woody structure. The root has been replaced by fibrous mesolite. As shown on the accompanying sketch, the sapling has been bent over by the enclosing lava.

~~DYKES & OTHER INTRUSIONS.~~

~~The tertiary dyke swarm in the Berufjordur area is locally very intense. The dykes cutting the dacite-andesite group tend to trend in two general directions, namely 115° and 165°. These dykes average 10ft. in thickness and include both basic and intermediate~~

The flood basalts dip towards the W.S.W. or S.W. at an angle varying from 3° to 7° It seems reasonably certain that they were originally near-horizontal, and have subsequently been tilted.

DYKES & OTHER INTRUSIONS.

The tertiary dyke swarm in the Berufjordur area is locally very intense. The dykes cutting the dacite-andesite group tent to trend in two general directions, namely 115° and 165°. These dykes average 10ft. in thickness and include both basic and intermediate members. Some acid and composite dykes also occur. A considerable number of irregular, fine-grained basalt sheets, many of them with good prismatic jointing, are encountered in and around Svartagil.

The above-mentioned ~~are~~ dykes are confined to the dacite-andesite group. A third set of dykes, trending from 20°-85°, and mostly about 40° is distributed both in this group and in the surrounding flood-basalts. These dykes range in composition from basic to acid. The acid dykes form a well-defined group confined to a narrow belt near the head of Berufjordur and are probably of relatively age. They average 10-20ft. in thickness although thicker members also occur; one at the head of Tullaskrida is made up of 100ft. of white dacite, the two rock-types perhaps representing successive intrusions.

Most of this set of dykes are basic. Most conspicuous are the dykes of porphyritic basalt, in which the plagioclase phenocrysts (e.g. in a dyke near the head of Trollaskrida) may reach ½inch diameter. Flow-banding is not common, but bands of vesicles were observed in a 5ft. basalt

vesicles were observed in a 3ft. basalt dyke west of the Arnahusgil.

Other intrusions include the acid vents in the Selgil. In these, the dacite composing the intrusion is margined by about 1ft. of pitchstone. One of these plug-like vents, exposed in the Selgil at 850ft. altitude, is seen feeding a dacite lava flow. Two vent-like intrusions of andesite are seen in the Krossloekur, and the more southerly of the two is seen to feed an andesite flow.

The flood basalt lavas are believed to have been produced by fissure eruptions and the dykes represent the channels for these eruptions. This is supported by the observations that the dykes and lavas are petrographically similar and that the intensity of the dyke swarm diminishes upwards; also by the lack of alternative channels such as plug-like conduits to allow the passage of magma to the surface.

The significance of the acid dykes is not clear although they are often composite, with basic margins. They appear to be earlier than the bulk of the basic dykes in the area, and are frequently cut by them. None of them passes upwards from the dacite-andesite group into the flood basalts. They may be the feeders for dacite lava flows, although this seems unlikely in view of the fact that the observed feeders are vents, nearly circular in cross-section. It is perhaps more likely that they are surface manifestation of some large acid intrusion which is nowhere exposed at the surface.

The following study was made of the dykes in a well-exposed strip of ground, commencing at the base of a prominent flow at 1,500ft. in the Nongil and extending at the base of this flow for a distance of one mile to the west.

Rock-type	width, ft.	Spec.No
1. Vesicular basalt	3	-
2. Olivine-basalt	24	Z.26 (s)
3. Porphyritic basalt	6½	Z.27 (s)
4. Porphyritic basalt	3½	Z.28
5. Porphyritic basalt	10	Z.29 and r.73
6. Fine-grained basalt	7	Z.30
7. Fine-grained basalt	9	Z.31
8. Olivine-basalt	2	Z.32
9. Fine-grained basalt	4½	Z.33 (s)
10. Porphyritic basalt	7	Z.34 (s)
11. Basalt	1	Z.35
12. Dolerite	7	Z.36 (s)
13. Basalt	10	Z.37
14. Dolerite	7	Z.38

(and mostly dark 40°)

The above-mentioned dykes are confined to the dacite-andesite group. A third set of dykes, trending from 20° to 85°, is distributed both in this group and in the surrounding flood basalts. These range in composition from basic to acid. The acid dykes form a well-defined group confined to the (dykes) belt near the head of Berufjardar (narrow) and are probably relatively age. They average 10-20 fr. in thickness although thicker members also occur; one (of) at the head of Tvillaskrida is made up of 100 fr of white dacite ~~margined by~~ with 6 fr. margins of red dacite, the two rock-types perhaps representing successive intrusions.

Most of this set of dykes are basic. Most conspicuous are the dykes of porphyritic basalt, in which the plagioclase phenocrysts (e.g. in a dyke near the head of Tvillaskrida) may reach 1/2 inch diameter. Flow-banding is not common, but bands of vesicles were observed in a 3 fr basalt dyke west of the Arnahusgil.

Other intrusions include the acid vents in the Selgil. In these, the dacite composing the intrusion is margined by ~~but~~ 1 fr. of pitchstone. Two vent-like intrusions of andesite are seen in the Krossloekur, ~~of Arack~~ and the ~~last~~ (more) southerly of the two is seen to feed an andesite flow.

One of these ~~vents~~ plug-like vents, exposed in the Selgil at 850 fr altitude, is seen feeding a dacite lava flow

~~It is very likely that the basic dykes represent~~

The ~~flood~~ basalt lavas are believed to have been produced by fissure eruptions and the dykes represent the channels for these eruptions. This is supported by the observation that the dykes and lavas are petrographically similar, and that the intensity of the dyke swarm diminishes upwards; also by the lack of ~~other possible~~ alternative channels, (such as plug-like conduits) to allow the passage of magma to the surface

The significance of the acid dykes is not clear, they appear to be earlier than the bulk of the basic dykes in the area, and are frequently cut by them. (although they are often composite, with basic margins) None of them passes upwards from the dacite-andesite group into the flood basalts. They may be the feeders for dacite lava flows, although this seems unlikely in view of the fact that the observed feeders are vents, nearly circular in cross-section. It is perhaps more likely that they are ~~surface high-~~ ~~test~~ the surface manifestation of some large acid intrusion which is nowhere exposed at the surface.

The following study was made of ~~one~~ the dykes in a well-exposed strip of ground, commencing at the base of a prominent flow at 1500 fr. in the Nongil and extending up the base of this flow for a distance of one mile to the west.

Rock-type	width, fr.	Spec. No.
1. Vesicular basalt	3	—
2. Olivine-basalt	24	Z.26 (s)
3. Porphyritic basalt	6½	Z.27 (s)
	2½	Z.28

5. Porphyritic basalt	10	2.29, r.73
6. Fine-grained basalt	7	2.30
7. " "	9	2.31
8. Olivine-basalt	2	2.32
9. Fine-grained basalt	4½	2.33 (s)
10. Porphyritic basalt	7	2.34 (s)
11. Basalt	1	2.35
12. Dolerite	7	2.36 (s)
13. Basalt	10	2.37
14. Dolerite — 1 ft apart	7	2.38
15. Basalt	1	2.39
16. "	6	2.40
17. "	6	2.41
18. "	13	2.42 (s)
19. "	4	2.43
20. Dolerite with sparse phenocrysts	20	2.44 (s)
21. Dolerite	4	2.45 (s), r.74
22. Porphyritic dolerite	12	2.46
23. Dolerite	10	2.47
average thickness	7.7 ft.	

The aggregate thickness of these 23 dykes is 167½ ft, representing a crustal ~~stretch of~~ extension of 3 %.

PHYSICAL GEOLOGY

Abundant evidence of glaciation is found, and a small ~~corrie~~ glacier still occupies a corrie on the northern face of Kistufell. Fossardfell was completely over-ridden by the ice, but some of the higher peaks, eg. the rather jagged summits N. of Berufjordur, appear to have escaped glaciation and must have stood above the ice ~~as~~ surface as nunataks. Striae