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OF SCIENCE & TECHNOLOGY

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THE EXPLORATION BOARD

ICELAND EXPEDITION 1959

(Final Report)

by

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Note:

The geological section in this report has been prepared by Dr.G.F.L.Walker from detailed field reports produced by the two student members of the expedition, who are also jointly responsible for the remainder of the report.

The actual production was completed by the last named author in the Autumn of 1960.

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INTRODUCTION

In November 1958 it was suggested to the then 2nd Year Geology department that it would be of value to follow up the work of three earlier Imperial College expeditions (1955, 1957 and 1958) to Iceland with a small geological expedition in the summer of 1959. These three expeditions had all been at least partly concerned with a study of the stratigraphy and petrology of the Tertiary lavas of Eastern Iceland, and it should be stressed from the outset that the study is largely a regional one and that an extension of the area previously surveyed would be of considerable interest.

With this aim in view an area of about 36 square miles between Berufjarda and Surdurdalor was chosen. This would also facilitate a visit to Thrandarjokull, a small ice cap to the South. It was hoped to visit this and consolidate the work carried out by the 1958 Imperial College Expedition which visited the ice cap, made glaciological observations and carried out a primary survey.

Dr.G.P.L. walker kindly agreed to supervise the work in Iceland and also offered considerable assistance with other matters, in particular with regard to transport in Iceland.

EXPEDITION TIMETABLE

July 2nd	a.m.	Arrived Reykjavik on M.S.Gullfoss. Customs and freight formalities.
	p.m.	Van, belonging to Dr.G.P.L.Walker packed and journey to Eastern Iceland commenced.
July 7th		Arrived Surdurdalur.
July 8th		Started two-day preliminary geological survey in Surdurdalur
July 10th		Moved camp to base camp site in Berufjarda.
July 11th		Collected food from Djupivogur, the crated food having been sent round from Reykjavik by sea. Purchased miscellaneous stores.
July 12th		Commenced Geological work.
August 22nd		Walked to Djupivogur with remaining stores, camping equipment and rock specimens.
August 23rd		Sailed from Djupivogur on M.S.Esja for Reykjavik
August 24th		Arrived Reykjavik and moved to Youth Hostel for three nights rest.
August 27th		Sailed from Reykjavik for Leith on M.S.Gullfoss.

Travel arrangements

(a) Personnel - At first passages were sought through the shipping agents at Leith (R.Cairns & Co., 8 Commercial Street, Leith) but as this proved unsuccessful the assistance was obtained of Sewell and Crowther Ltd. of South Kensington, who later supplied passages. This firm also went to considerable trouble to facilitate changes in plan made during the latter part of the summer term. (Due to unforseen circumstances the membership of the expedition was changed and a passage had to be rebooked) It is recommended that travel arrangements for any future expedition to Iceland should be made through this agency and that bo kings should be made as early as possible, since some difficulty may be encountered in obtaining third class accommodation.

The student members of the expedition travelled independently to and from Leith by rail, Dr.Walker travelling in his van.

In Iceland the party travelled together between Reykjavik and Berufjarda, Dr.Walter transporting them in his own Austin A.40. van. It should, however, be pointed out that there is a regular bus service between Reykjavik and Egilstadir.

Edwards and Gibson returned to Reykjavik by boat from Djupivogur; this service operates every ten days approximately throughout the summer with less frequent sailings in the winter months. Dr. Walker returned to Reykjavik by road.

(b) Freight. The freight, in excess of personal baggage, consisted of two large tea chests and one smaller one. The latter contained the food for the first ten days out of Reykjavik and was carried all the way from London in the back of Dr. Walker's van.

The two larger cases, containing the rest of the food and a few small items of equipment, were taken to Leith by rail as excess baggage by one of the party and shipped to Reykjavik with the members of the expedition. After the necessary customes formalities on arrival these two cases were despatched by sea to Djupivogur and collected from there on their arrival on the coastal steamer, eight days later.

All equipment and specimens on the return journey were carried as personal baggage.

N.B. It is suggested that future expeditions should use small tea chests, not exceeding 1 cwt. laden weight, to which carrying handles have been attached.

Finance

As the expedition was financed by the members themselves, no detailed information as to the cost of the expedition was kept. However, the total cost to the Student members (both of whom obtained vacation grants from their respective Local Education Authorities) was approximately £60, although this included the purchase of a considerable amount of camping and field equipment. Food costs worked out at about £10 per man.

Insurance

The cost of insurance for the members of the expedition and for the stores and equipment was undertaken by The Imperial College Exploration Board. This was arranged through Mr. Anas of the College Finance Dept. (Tel.222 Int.)

(Mr. Anas required the name, date of birth and home address of each member of the expedition)

Equipment and stores were insured as follows:-

Climbing rope.	£6. 0. 0.
2 Sleeping bags.	12. 0. 0.
Pressure cooker	3. 0. 0.
2 Air beds.	6. 0. 0.
1 C-Mode Tent	14. 0. 0.
1 Arctic Guinea Tent (with fly sheet)	26. 0. 0.
1 2-pint Primus stove	2.10. 0.
2 Altimeters	50. 0. 0.
1 Pr. Binoculars	10. 0. 0.
Food	45. 0. 0.

EQUIPMENT

(1) Camping Equipment

3 Tents (Black's Arctic Guinea with fly sheet.
(
(Black's New Guinea with fly sheet.
(
(Edgingtons "C" Mead.

2 Air mattresses.

2 Sleeping bags.

Billies.

1 ½pt. primus and prickers.

1 2pt. primus and prickers.

2 enamel plates.

2 mugs.

1 tinopener

2 K.F.S. sets.

spare cutlery.

1 first aid box.

1 bottle methylated spirits.

Oil cans for paraffin.

matches.

spare tent pegs and nylon cord for guys.

<u>Fig.1.</u> Photograph showing one of the party checking stores on arrival at the main camp site in Berufjarda.

Notes on the Camping equipment.

The two tents with fly sheets were used for sleeping in and the third tent as a food and equipment store and cook tent. This arrangement proved most satisfactory and may be regarded as almost ideal.

The New Guinea (which was almost new) was fitted with one centre pole at the back and an "A" frame at the front. If one is to be fairly static with only a few camp sites an "A" frame is a great help; it increases the room in the tent and facilitates entry. However, it makes the tent less rigid and if moving camp each night it is not worth the extra trouble of pitching with "A" frames. This tent was also fitted with a separate ground sheet which led to draughts getting in between the walls of the tent and the floor. A sewn in ground sheet is preferred; this also makes pitching the tent easier.

The Arctic Guinea, which was kindly lent by the Imperial College Exploration Board, had already seen several seasons' useful work and had been extensively repaired prior to the Expedition's departure. It was fitted with a sewn in ground sheet and "A" poles. Considerable trouble was experienced due to the failure of the canvas in the fly sheet. This can be partly attributed to the severe weather conditions experienced by the partly and partly to the age of the tent and the consequent state of the canvas.

The arrangement shown in the figure overleaf proved most satisfactory for cooking in the wet and stormy conditions encountered.

Spares for the Primus can be obtained at most of the local stores in Eastern Iceland, but methylated spirits could only be purchased in Reykjavik.

The pressure cooker was not pressure tight and so could not be used, as was hoped, to reduce the time spent in preparing meals. It is suggested that future expedition members check this item of equipment especially carefully and acquaint themselves with its many uses. Theoretically it should save a great deal of time and fuel.

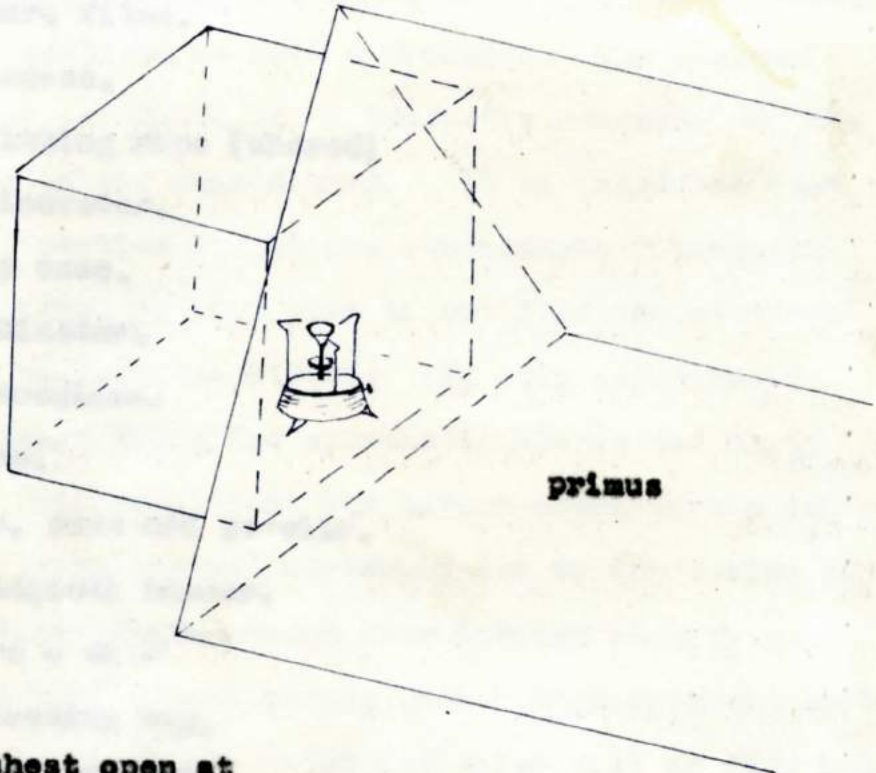

Fig. 2. Diagram showing the arrangement of the store tent, tea chest and primus used for cooking under bad weather conditions

(2) **Field and Scientific Equipment**

(per person unless otherwise stated)

Camera and accessories.

Spare films.

Compass.

Climbing rope (shared)

Clinometer.

Map case.

Altimeter.

Binoculars.

Maps.

Inks, pens and pencils.

Geological hammer.

Spare - do -

Collecting bag.

Field notebooks.

Rulers.

Rubber bands and paper clips.

drawing pins.

180° Protractor.

Eraser.

Small set square.

Tracing and graph paper.

Sketch pad.

Writing paper and envelopes.

Notes on field and scientific equipment.

The Altimeters used by the expedition were kindly loaned by the Royal Geographical Society and proved indispensible. They were graduated to 20 ft. it being possible to estimate to half a division. The maximum scale reading was 5,000 ft. - perfectly adequate for the variation in relief encountered. It is suggested that, if possible, parties should use instruments fittedwith adjustable scales so that when in the fild the readings are as near as possible direct; the only adjustments to be made being those for systematic errors and daily variation. In actual fact the latter often turned out to be quite large, almost certainly due to the series of deep depressions which passed over Iceland in July and August. In more normal years, when a high pressure system is centred over Iceland, daily variation will be very small. It is suggested that the altimeters are checked for systematic errors before leaving London.

The party carried two 35 mm. cameras, one for black and white and one for colour. The results were rather disappointing, probably due to inexperience and very poor weather. Photography was impossible for long periods. A short focal length, wide angle lens would have been a great help for cliff sections.

Oil filled prismatic compasses were used; these were of the standard Ex W.D. pattern and proved perfectly serviceable. The magnetic variation at Berujardar in August 1959 was 21° E.

Two pairs of 6 x 30 binoculars were taken which proved useful for studying the cliff sections as well as for some rather amateur ornithology. However, they are rather heavy and must be listed among the unessential items.

A 100 ft. nylon rope, also loaned by the Royal Geographical Society, was taken as a safety precaution in case of difficulties on the mountain cliffs. However, it was not used.

The bulk of the rest of the field equipment belonged to the members personally and had been collected for previous field excursions in the British Isles.

List of food

50 packets Soup.
14 tins Glaxo dried milk.
7 lbs. sweets.
25 pks. porridge oats.
2 lbs Ovaltine.
3 lbs Ovaltine biscuits.
6 lbs Honey
24 x ½ lb. potato powder.
6 lbs cooking fat.
48 x 1 lb. lifeboat biscuits
3 lbs dried egg.
50 lbs chocolate (2 oz. bars)
5 lbs drinking chocolate.
1 gross oxo cubes.
6 x 8 oz. tins pineapples.
12 x 4 oz. Dried cabbage.
10 x 12 oz. dried peas.
1 x 5 lbs bilberry
2 lbs tea.

2 x 1½ lbs tins salt
4 lbs Horlicks.
2 x 6 doz Horlicks tablets
34 lbs sugar
3 tubes sauce
3 tins Marmite
3 lbs Jam
14 lbs Margarine
36 small bars Romney mint cake.
1 x 5 lbs sweet biscuits
1 x 4½ lbs - do -
3 lbs Nescafe.
24 x 12 oz tinned meat
6 x 8 oz. pears
3 lbs dried apricots
6 x 12 oz.dried potatoes
8 x 12 oz.dried onions.
2 x 2lbs apple slices

N.B. One third of the above stores was used by Dr.Walker.
Deficiences in the above were normally made up by purchases in Iceland (see under each item in following notes)
The above list includes all stores ordered through the Exploration Board and certain additional items purchased before the Expedition's departure.
The above, when packed in three packing cases, two large and one small, weighed approximately 5 cwt.

Notes on individual food items

Food consumed per man per week:-

1¾ lbs.	lifeboat biscuits (12 biscuits a day - usually eaten with margarine on account of diet, in our opinion, being deficient in fat)
2⅝ lbs.	porridge (6 oz. a day divided approximately 4½ oz. for breakfast and 1½ oz. to thicken stew in evenings) Deficiency made up by supplies from Dr.Walker.
2 lbs.	sugar (Used on drinks, porridge and dried fruit to taste) One can do with less but in view of high calorific value we would not advise it. Amount taken deficient by 20 lbs. Cheap in Iceland. Doubtful economics to take it at all. Amount made up by purchases in Iceland.
1¾ lbs.	chocolate. (2 x 2 oz.bars a day) Considered of extreme importance due to high calorific value. Milk chocolate is preferable to plain. Variety to cater for personal tastes. Amount considered sufficient. Expensive in Iceland - well worth taking.
7	oxo cubes. 1 per man added to the nightly stew. 2 would have been preferable and some for drinks appreciated. Advise allow 21/week/man. Stores deficient by approx 3 gross.
1/9 lb.	dried egg (total of 1lb. per person during stay in Iceland) Luxury item scrambled for breakfast, makes welcome change as fresh eggs may not be available.
5/9 lb.	jam, honey, marmalade - luxury items eaten on biscuits at breakfast or supper or both. Makes lifeboat biscuits very tasty. Allow ½ lb/man/week (i.e. 1 lb. jar per person per fortnight) Stores in excess by 1½ lbs.
7 pkts.	Horlicks tablets (1/man/day) Stores deficient by 3 doz. pkts. Theoretical deficiency as one of the party did not like them.
7/27lb.	barley sugars. 1 x 7 lb. tin shared among the party. Very welcome.

1/9 tin Marmite. 1 x 4 oz. per man for whole stay. Very inadequate as this can be used for stews, drinks, and on biscuits. This and Bovril would also add Vitamin B and Protein respectively.

7¼ oz. Sweet and Ovaltine biscuits - both very much appreciated as regular after supper extra - about 3 or 4 biscuits a night.

4/27 lb. Horlicks powder - not used due to (a) lack of fresh milk and (b) nobody liked it with powdered milk. Some used in stews to add protein and calories. largely a matter of personal choice.

1⅜ pkts. Soup. Used every other night with stew or by itself. The amount suggested as being adequate depends on size of rest of evening meal. Maximum amount - ½ pkt/day/person. Avoid varieties which take a long time to cook. In party of 3 one pkt per night might do. Not all varieties make the same volume. Advise experimenting before final choice is made.

2/9 lb. Cooking fat (one 2 lb. drum for whole stay) No really needed as little fried food was eaten. Used to make stew more fatty. If much frying is contemplated, an obvious necessity.

14/27 lb. Margarine. Used on biscuits, in stew, in dried potato, dried egg. Amount deficient but we managed. Allow 1 lb. per week per man.

4 x 8 oz. tins of fruit for whole stay - welcome luxury item.

1 tube sauce for whole stay - used for flavouring stews. Suggest 3 tubes per man for whole stay.

1 lb. salt adequate for 9 weeks.

7 oz. dried potato powder. Used as thickener for stew or made up according to instructions. Allow 1 x ½ lb./week/man.

9½ oz. tinned meat. Added to stew on alternate nights. Due to lack of protein this amount was considered insufficient. Allow at least 1 x 12 oz. tin/man/week.

1/31b Dried fruit. Very welcome. Bilberries preferred to apples due to (a) higher weight : bulk ratio (b) better quality fruit. NO fresh fruit or vegetables available.

½ can	Dried vegetables/day/man; measured this way for convenience - although 1 portion = 1 oz. cabbage as against 3 oz. peas, onions or potatoes. The quality of the vegetables was not too good except in the case of the onions, the cabbage especially being very stalky. However we never had either the patience or time to cook them long enough so perhaps we didn't give them a fair trial.
9 oz.	Dried milk. Quality very unsatisfactory as one could never get it to mix. Thus it could only be used in dishes where one couldn't taste it, i.e. porridge and stews. One member of the party could drink it in milk drinks but it was not satisfactory. Useless in tea. Suggest experimentation with other brands.
2 oz.	Tea. Not used - see above.
6 oz.	Drinking chocolate, coffee, Ovaltine - amount required varies very much according to individual taste. We found ourselves short of Ovaltine but with excess coffee, but these amounts would have been considerably altered with fresh milk available.

General Notes on Diet

Although it would appear from the above that we were lacking in many items, the deficiencies were not large and got round by careful rationing and the purchase of some items locally.

The most important think lacking in the diet was bulk. There was nothing that one could eat "ad-lib" until one felt satisfied, and several times we finished the evening meal feeling hungry. Also breakfast consisted of only a hot drink and about 4½ oz. of porridge - not a very substantial meal to begin a hard and often strenuous day's work in the field. Later we added some ships biscuits purchased in Djupivogur and we calculate that this deficiency was about 9 lifeboat biscuits a day (48 biscuits - 1 lb) These biscuits were of excellent quality and edible with jam, etc.

The other major deficiency was protein. We feel that although a protein deficiency for about six weeks is not harmful in the normal course of events, it is advisable to maintain the protein level. We suggest that future expeditions should investigate the possibility of taking cheese in bulk and dehydrated meat, even if these items are somewhat expensive.

Geological Report

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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, whichrange 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-in 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 also 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.4)

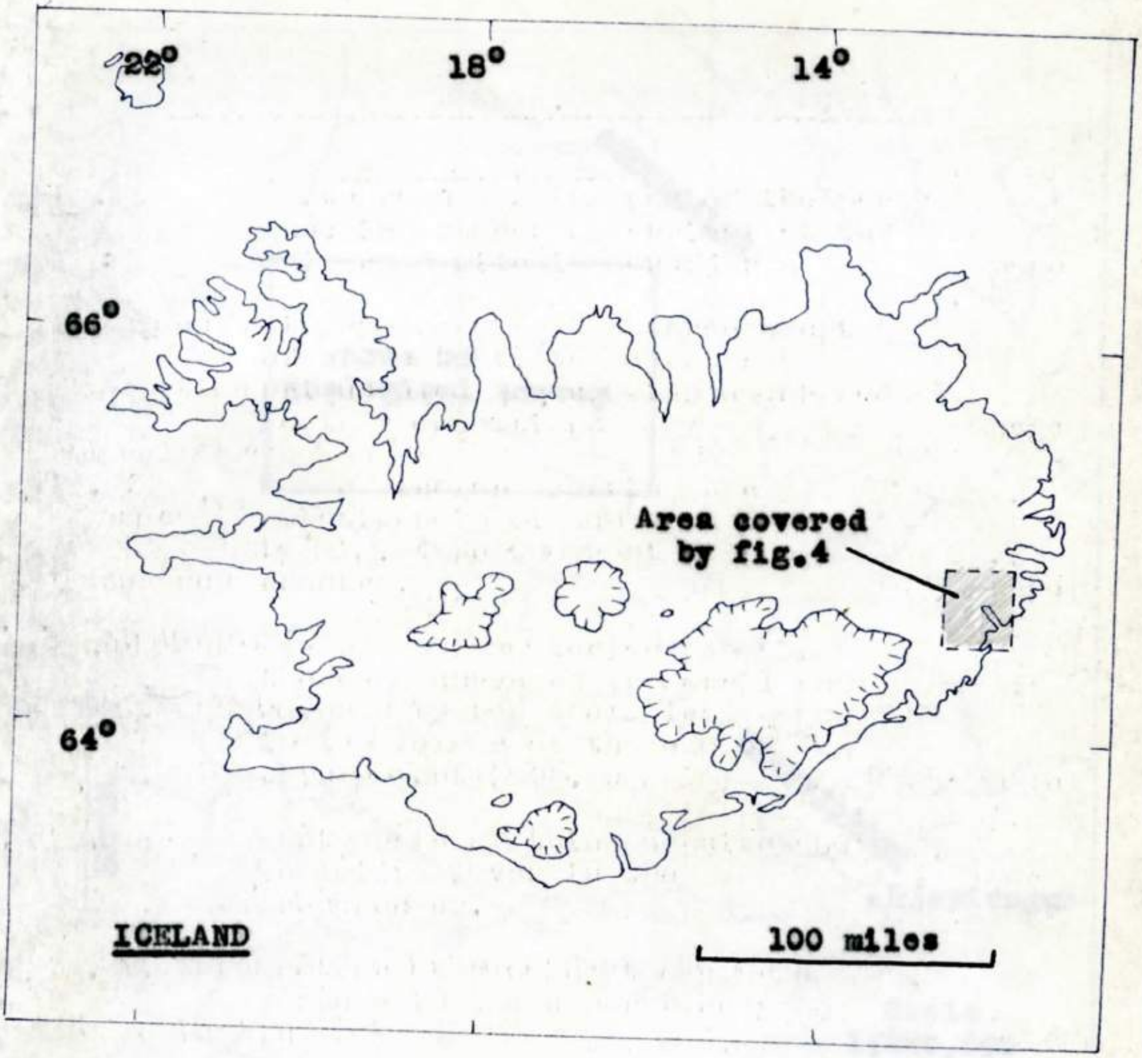

Fig. 3 Map of Iceland showing the relationship of the area covered by fig 4 to the rest of the country.

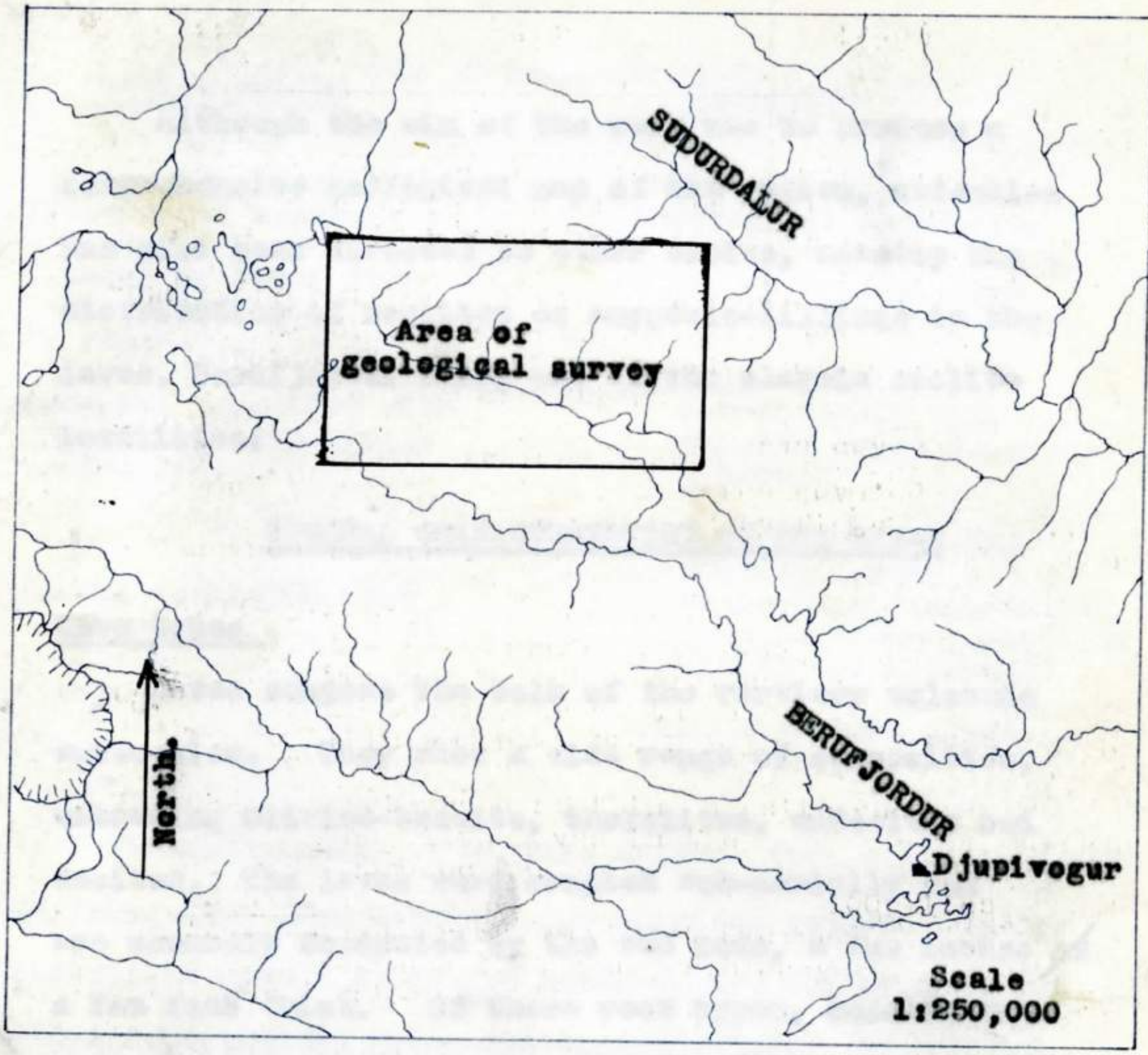

Fig. 4 Map of Eastern Iceland showing the area surveyed in detail and covered by the geological maps in the folder at the end of this report.

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 spheroidal 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 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 of Svartagil, are often crowded with lithophysae, are roughly banded 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 3 mm. long of composition approximately An35.

<u>Thickness of flows</u>

Of the basalt lavas, the few flows of porphyritic basalt, averaging 60 to 70 ft. are the thickest. Next come the tholeiites, 44 flows of which average 42 ft. in thickness, although individual flows of 100 ft. are common. By comparison 63 measured flows of olivine-basalt average only 16 ft. in thickness. The andesite flows tend to be between 40 and 70 ft. 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 270 ft. for the flow on Fossarfell and to well over 500 ft. 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 30 ft. 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 over-folding 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, ofter 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 andesite lavas, especially when one flow has over-ridden the termination of the previous one. Amygdales in the rock are often elongated and flattened, andpipe amygdales may be curved over in the direction of movement. Flow-banding is less conspicuous in tholeiites, andunlike 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 close 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-banded pink-red rhyolite exhibits vertical columns 10 to 15 ft. 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 2 ins. in diameter and associated with them are vesicles up to 18 ins. long lined with auhedral 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 18 ins. in diameter. One example was noted in Arnahusgil of such a tunnel about 5 ft. 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 4 ins. thick cutting the lavas of the porphyritic basalt lavas (an olivine-basalt with felspar phenocrysts) on the lower slopes of Fossarfell just to the east of the 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 where the gully debouches on to 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 3,500 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 50 ft. in thickness of green tuffs is seen, bearing fragments up to ½ in. 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 1 ft. 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 700 ft. of andesites and tholeiites are exposed, the individual flows tending to decrease in thickness upwards from about 25 ft. to about 10 ft. The flow-banding in these rocks is often highly irregular. There are occasional interbedded tuffs up to 2 ft. 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 are seen, both pale in colour, the upper being yellow.

Fig.5. Photograph of thin Andesite and Tholeiite lavas in the Krossloekur.

They are separated by 4 ft. of steeply-dipping sperulitic 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 west of the Trollaskrida may be the stratigraphic equivalent of these dacites.

Above the yellow dacite in the Selgil comes 20 ft. 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 West bank of the lower Trollaskrida; and (30 ft. thick, with andesite blocks up to 2 ft.) on andesite just west of the intrusion of Smatindur.

These andesite and tholeiite flows constitute a conformable succession inclined at about 25° towards the S.W. The flows are considered to have been the flanks of 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 slope of the present valley being 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, 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 600 ft. 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 feldpar phenocrysts is a useful field criterion. Relations on the outlier are rather complicated on H audafell, andit seems likely that the lower parts of 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 eastern 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 palagonitetuff beds wedge out westwards.

The uppermost dacite lavas on Berufjardartindur has strongly-developed flow-banding, the orientation of which presents features of considerable interest; the dip of the flow-banding is seen to increase up-dip, as shown on the accompanying diagram, until it is practically vertical. At the eastern end of the mountain. There are two ways in which this may be explained. 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

Fig.6. Photograph showing the coarse texture in the upper blocky tuff.

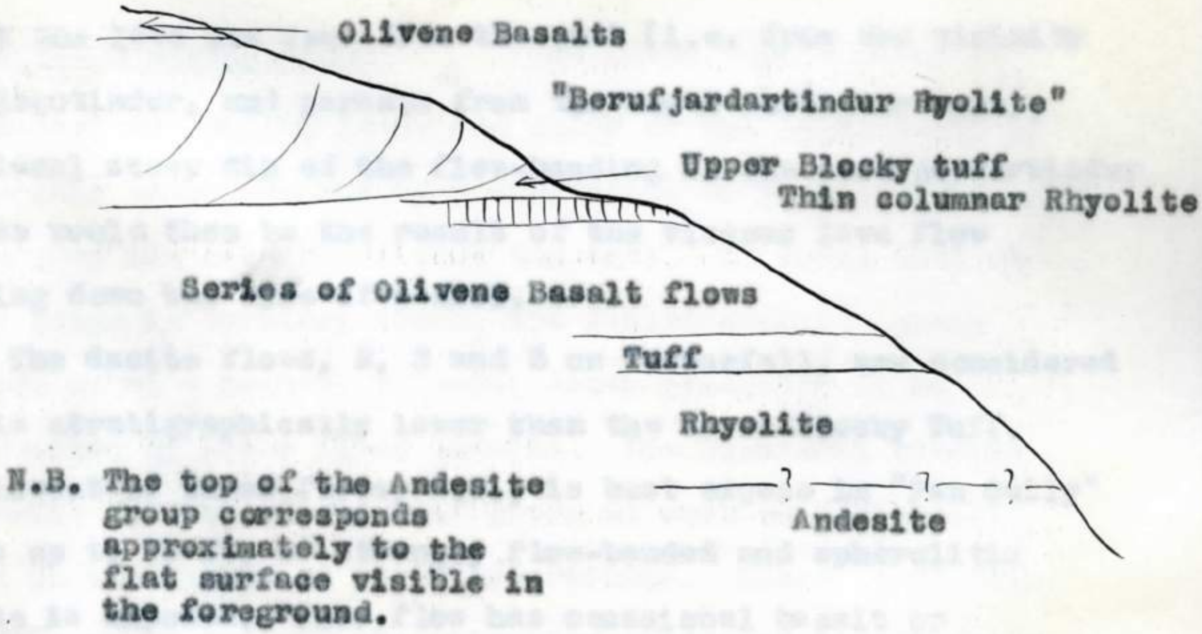

Fig.7. Explanatory diagram and photograph of the uppermost lava on Berufjardartindur.

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 a hill.

The dacite flows, 2, 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 expose in "Fan Gully" where up to 70 ft. of strongly flow-banded and spherulitic dacite is exposed. This flow has occasional basalt or andesite xenoliths up to 3 ft. across and the flow has a brecciated top with small lithophysae, capped by 6 ft. 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 350 ft. 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 290 ft. 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.

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 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 1030 ft. 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.

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 AND 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 10 ft. in thickness and include both basic and intermediate members. Some acid and composite dykes also occur. A considerable number of

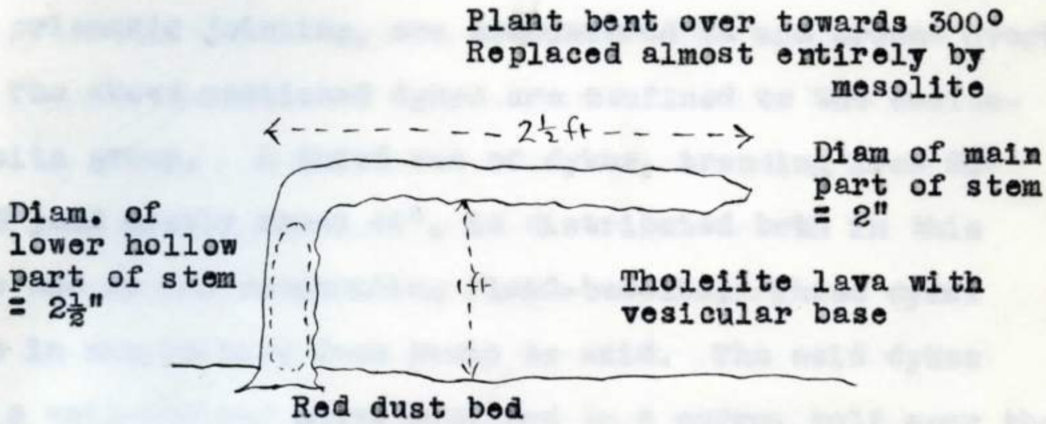

Fig.8. Diagram and photograph of part of a sapling embedded in tholeiite lava at 1,030 ft. in the Nongil.

irregular, fine-grained basalt sheets, many of them with good prismatic jointing, are encountered in and around Svartagil.

The above mentioned dykes are confined to the dacite-andesite group. A third set of dykes, trending from 20° to 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 10-20 ft. in thickness although thicker members also occur; one at the head of Trollaskrida is made up of 100 ft. 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 ½ inch diameter. Flow-banding is not common, but bands of vesicles were observed in a 3 ft. 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 1 ft. of pitchstone. One of these plug-like vents, exposed in the Selgil at 850 ft. altitude, is seen feeding a dacite lava flow. Two vent-like intrusions of andesite are seen in the Krosslockur, 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 1,500 ft. 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 & 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
	1 ft.apart		
15.	Basalt	1	Z.39
16.	Basalt	6	Z.40
17.	Basalt	6	Z.41
18.	Basalt	13	Z.42 (s)
19.	Basalt	4	Z.43

20.	Dolerite with sparse phenocrysts	20	Z.44 (s)	
21.	Dolerite	4	Z.45 (s)	r.74
22.	Porphyritic dolerite	12	Z.46	
23.	Dolerite	10	Z.47	

Average thickness - 7.7 ft.

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

Physical Geology

The area covered by the detailed geological survey is situated at the head of Berufjordur, one of the long fjords, so typical of the eastern coast of Iceland. These fjords represent the drowned lower portions of large East-West glacial valleys, and everywhere in the area mapped evidence of this former glaciation is apparent.

Glacial striae are particularly well preserved on the valley floor and some very fine roches moutonnes can also be seen. Striae were also found on the top of Fossarfell - two crossing sets being recorded. On the valley sides, especially the southern side, rapid post glacial erosion has removed some of the more obvious evidence of glaciation, but the general "U" shape of the main valley clearly indicates that the present day land form is almost entirely due to glaciation during the pleistocene and early Holocene

It seems likely that at its maximum extent only the higher peaks round Kistufell poked through the ice cover as nunataks.

Two further points are worthy of note:-

(a) Drift in the upper portion of the valley is not extensive and one must assume that it was mostly swept into the fjord or further out into the sea.

(b) There is considerable evidence for a late glacial phase with the development of corrie glaciers on the sides of the main East-West valleys. Svartagil must have housed one such glacier, while a small corrie glacier still exists on Kistufell.

The raised beaches - studied further to the north by an Imperial College Expedition in 1958 - are also very well developed in Berufjordur, and their varying heights and degree of perfection point to a complicated post glacial history, with several major variations in sea level.

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