Joint Universities Expedition

South-East Iceland 1974

Final Report

School of Environmental Sciences, University of East Anglia
Department of Civil Engineering, University College of Swansea
Science Institute, University of Iceland, Reykjavik.

JOINT UNIVERSITIES EXPEDITION TO SOUTH EAST ICELAND

1974

FINAL REPORT

WITH THE APPROVAL OF THE ROYAL GEOGRAPHICAL SOCIETY

the

ursandur.

JOINT UNIVERSITIES ICELAND EXPEDITION

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Norwich NOR 88C
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November 1974.

Dear Sir,

JOINT UNIVERSITIES EXPEDITION TO S.E. ICELAND, 1974.

Please find enclosed a copy of the final report of the Joint Universities Iceland Expedition, 1974. All the members felt that the expedition was successful in carrying out its programme.

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DIAGRAMS.

PHOTOGRAPHS.

INTRODUCTION

The Joint Universities Iceland Expedition (1974) visited the Breidamerkursandur area of Austur - Skaftafellssysla in south-east Iceland. The purpose of the expedition was to carry out research in glacial geology and geomorphology close to the margin of Breidamerkurjökull, an outlet glacier of the Vatnajökull ice-cap - the largest ice-cap in Europe. In addition to several specific research projects, the expedition made some observations on the flora and fauna of the area, kept a continuous meteorological record over the period of seven weeks spent in the field, and carried out a programme of mountaineering activities.

The expedition party was drawn from several institutions, and had a diversity of interests and backgrounds. Members of the expedition were:

PHILIP HARRIS, 23, a graduate of University College, Swansea, Department of Geography. A post-graduate research student at the School of Environmental Sciences, University of East Anglia, studying glaci-lacustrine sedimentation, hydrologic and chemical budgets of glacial lakes. A member of the University College of Swansea Geography Department expedition to Midt-Jotunheimen (Norway, 1972) and a member of the Joint Universities Spitsbergen Expedition (1973).

ELIZABETH MORRIS, 28, Senior Research Associate in the School of Environmental Sciences, University of East Anglia. Work on basal sliding of glaciers led to a Bristol University Ph.D. in Physics. This was followed by X-ray topographic work on ice at the Carnegie Laboratory of Physics, University of Dundee. Glaciological fieldwork experience in the French Alps, 1973.

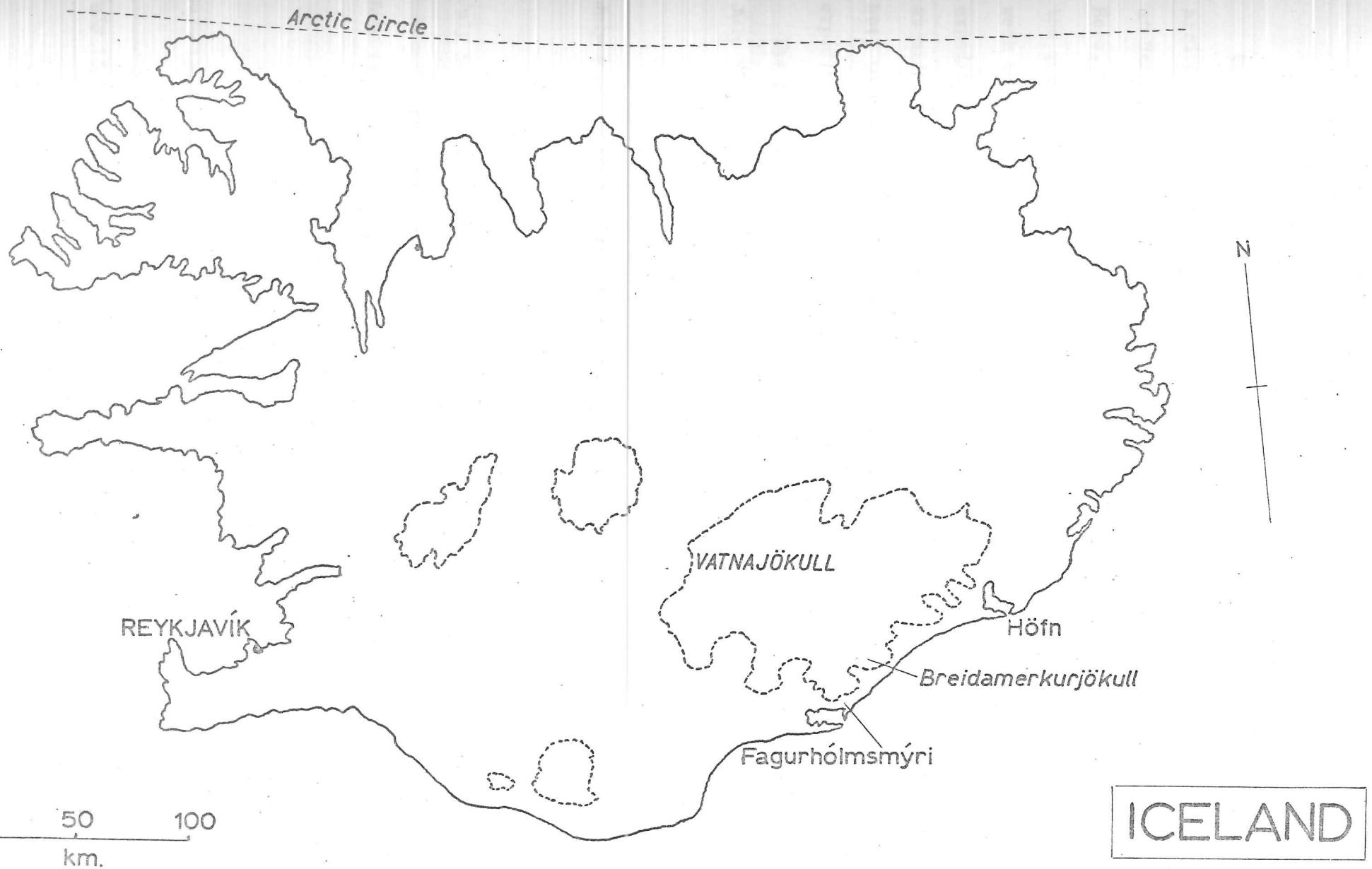
ANN GREENHOUGH, 21, a graduate of University College, Swansea. A member of Swansea Northern Scandinavian Expedition (1972) and an assistant member of the Geography Department Midt-Jotunheimen (Norway) Expedition.

JOHN SLOCOMBE, 21, at present an undergraduate of University College of Swansea, Department of Civil Engineering, with a main interest in engineering geology. Extensive mountaineering experience in all parts of Britain; experience in rock-climbing instruction on the sea-cliffs of South Wales.

JON EIRIKSSON, 29, a graduate student of the Geological Institute of the University of Iceland, Reykjavik. Geological experience in south-west Iceland (field mapping techniques) and central-northern Iceland (Quaternary sedimentary sequences).

GUY POULIQUEN, 26, joined the expedition for four weeks as a field assistant.

Initial planning of the expedition started in November 1973; equipment and food was dispatched in mid-May 1974 and the expedition flew to Iceland on June 29th, 1974. Members were in the field area for a total of seven weeks, returning to England on August 25th.


Arctic Circle
N
VATNAJÖKULL
REYKJAVÍK
Höfn
Breidamerkurjökull
Fagurhólmsmýri
0
50
100
km.
ICELAND

EXPEDITION PROGRAMME.

The expedition left for Iceland on Saturday June 29th. 1974, and arrived in Reykjavík that evening. A further flight landed the party at Höfn, in south-east Iceland, on the morning of Monday July 1st. Here, the previously dispatched food and equipment was collected from the quayside; it had arrived by sea from Felixstowe in England just a week before. Hiring a lorry from a local worker, the members of the expedition completed the final 100 km. to the field base, overland. At midnight on Tuesday July 2nd. the expedition arrived at the Breidá hut, on the Breidamerkursandur. This was to be the base for the expedition for about the next two months.

The programme of work, whilst in the field, was as follows:

July 3 --- Settled in at the hut; erected meteorological instruments; checked and changed instruments (installed by a previous expedition) on the S. shore of the lake Breidárlón.

July 4 --- Walked eastwards to the lake Jökulsárlón; inflated rubber boat; set up boat and equipment on N.W. shore of the lake, about ¾hr. walk from the hut.

July 5-10-John and Phil work off rubber boat on Jökulsárlón; Liz and Ann examine fluted ground moraine near E. shore of Jökulsárlón.

July 11--- All four members make excursion onto the snout of the glacier Breidamerkurjökull and walk westwards towards the N.W. shore of Breidárlón. Instruments (installed by a previous expedition) checked and measurements of retreat of snout of glacier made.

July 12 --John, Ann and Phil work on the lake Jökulsárlón; Jón Eiríksson arrives from Reykjavík, to stay with the expedition for a week.

July 13-18-Liz works on fluted ground moraine 3 km. N. of the Breidá hut, Phil works on Jökulsárlón lake; John, Jón and Ann rotate assisting

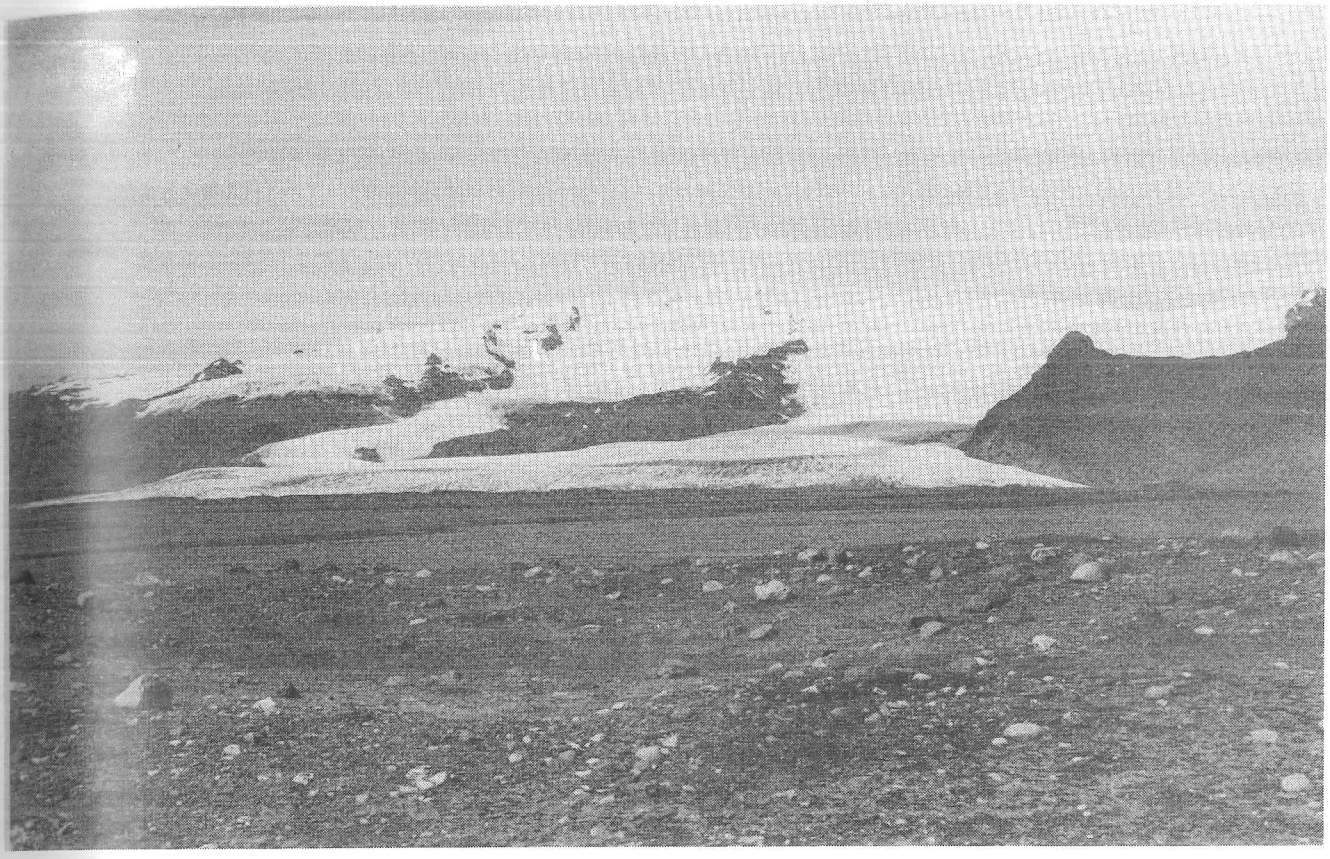


Fig 1 Öraefajökull, from the Breidarmerkursandur

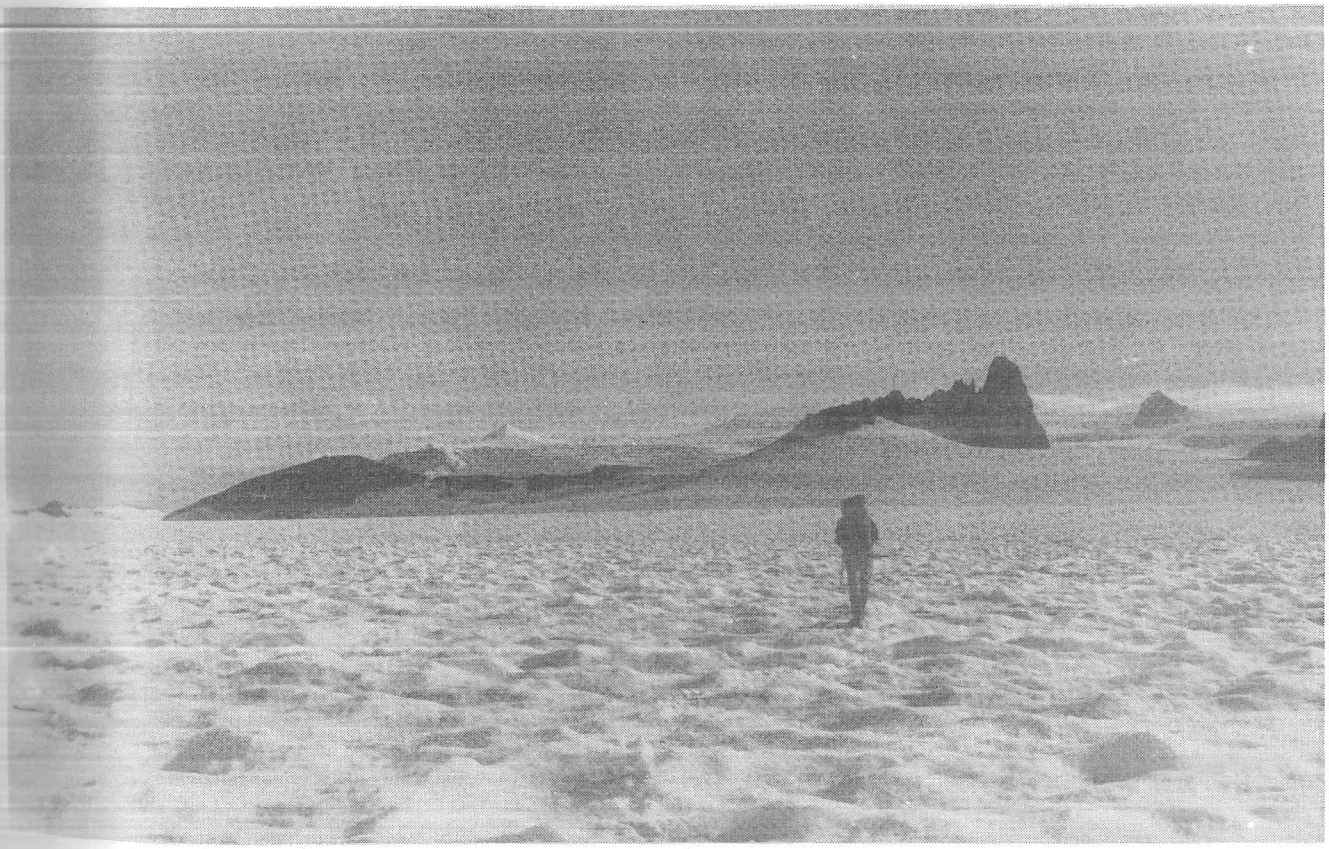


Fig 2 Approaching Fingurbjörg on the Vatnajökull ice-cap

each project in turn.

July 19--All five members make a successful mountaineering excursion to climb Fáskatindur (795m.) about 6km. distant from the hut.

July 20-21- Work continues both on the lake and on the fluted ground moraine surfaces.

July 22-- Jón Eiríksson departs;Guy Pouliquen arrives to help as a field assistant. Ann departs to Fagurhólsmyrí to collect more fuel for the outboard motor and for the cooking stoves. John and Phil carry out repairs on the rubber boat.

July 23-24- All members spend two days mountaineering on the S.E. flank of Öraefajökull, the highest mountain in Iceland (approx. 2000m.)

July 25-29- John, Phil and Ann camp on the E. shore of Jökulsárlón, in order to complete the work necessary on this lake. Liz and Guy continue with fluted moraine studies.

July 30-- Local farmer helps in moving expedition boat and equipment from Jökulsárlón to Breidárlón.

July 31-August 5-- John and Phil work on the lake Breidárlón, Liz on some fluted moraine close to the snout of Breidamerkurjökull.

August 6-9-- Ann and Phil visit the Skaftafell area of Iceland, about 30km. from the hut. Over four days proglacial areas of five outlet glaciers issuing from the western flanks of Öraefajökull are examined. During this period the three other members are stormbound at the hut, during the worst period of weather experienced by the expedition.

August 10-- Work finished on Breidárlón; John and Phil take boat downstream out of Breidárlón and into another connecting lake- Fjallsárlón- a proglacial lake of the glacier Fjallsjökull.

August 11-13- Lake studies on Fjallsárlón; extensive photographic work. Work continues on areas of fluted ground moraine in the proglacial zone of W. Breidamerkurjökull.

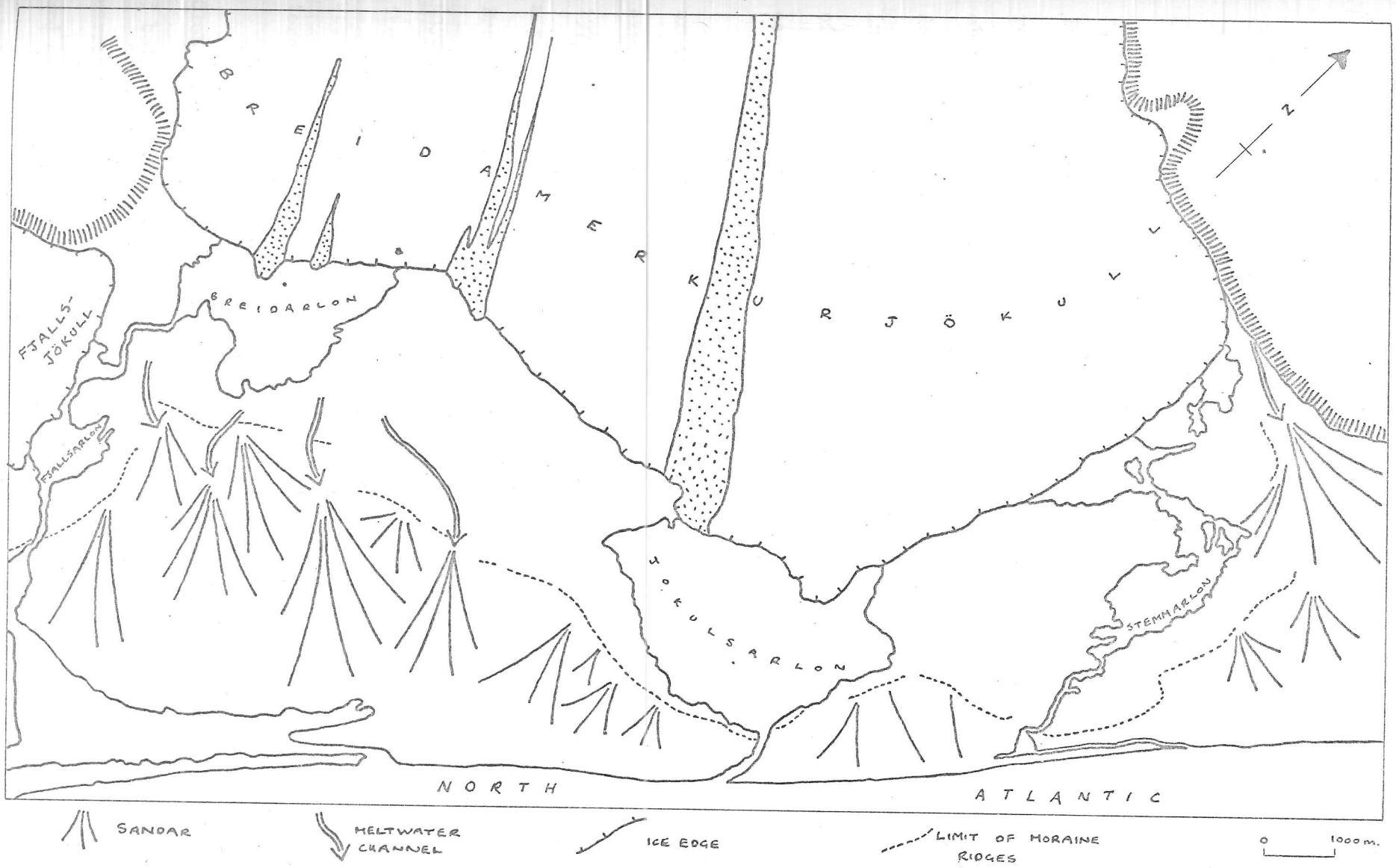
August 14-16- John and Phil make a 3-day mountaineering/glaciological excursion to several nunataks on the Breida glacier. A total of nearly 40 miles is walked on the glacier, attaining a height of over 4000 ft.

August 17-18- Work on fluted moraine completed; equipment and stores are packed ready for return journey.

August 19- Instruments at W.Breida collected; glacier retreat measurements are made.

August 20--Expedition leaves field area, in hired lorry, and arrives in Hofn in the evening.

The expedition returned to Reykjavík on Thursday August 22nd. and arrived back in Britain on Sunday, the 25th. A total of seven weeks was spent in the field, and eight days spent travelling.



Breidamerkurjökull and its proglacial area.

SOME PREVIOUS EXPEDITIONS TO THE BREIDAMERKURSANDUR

Of the many expeditions which have visited the Breidamerkursandur, one of the first was an expedition from Durham University in 1952. The programme of work included glaciology, survey, ornithology and botany. The terminal moraines of Fossadalur were examined and a study was made of two ice-bound lakes in Esjufjöll - a nunatak on the Breidamerkur glacier. Ablation and ice movement measurements in this region were also taken, together with a programme of meteorological observations. The surveying included running a chain of heights down the main moraine of Breidamerkurjökull, ornithological work included a general survey of all birds, and an estimation of the number of breeding pairs and a programme of ringing of the Great Skua. An ecological study of the Steinthors nunatak was also undertaken.

In 1959 the Brathay Exploration Group made the first of many ornithological expeditions to the Breidamerkursandur. A similar expedition took place two years later in 1961 and the years 1963 to 1973 have seen an expedition nearly every year. In 1970, for example, a period of seven days at the end of July was spent on the Breidamerkursandur by one such ornithological party. In five of these days 300 different birds were ringed, of which 100 were weighed and their wing lengths measured. In total, fourteen different bird species were identified on the Breidamerkursandur, including skuas, gulls, terns, wheatears, eider ducks and grey-lag geese.

In 1967 a four-man expedition from Oxford University Exploration Club spent seven and a half weeks at Breidamerkursandur. Consisting of 3 botanists and one agriculturalist a general botanical investigation was carried out, together with some photography of the retreating ice margin and certain recessional features.

During the period 1964-68 members of the Geography Department of the University of Glasgow led by Dr. R.J. Price mounted several expeditions to Breidamerkursandur and completed a valuable programme of work. A large and comprehensive field research project studying glaciological and glacial geomorphological problems of the area has resulted, inter alia, in the production of 1 : 15,000 photogrammetric maps of the snout of Breidamerkurjökull and its glacial area. The 1966 Glasgow expedition, for instance, spent a period of ten weeks in the area, chiefly studying geomorphological problems. Morphological and stratigraphical mapping of the proglacial area was undertaken, as well as the construction of large scale maps (1 : 4,000) of eskers emerging at the ice front. In 2 localities near the ice margin rates of movement of the ice and ablation were measured over a period of eight weeks. The photogrammetric maps based on aerial photography taken in 1945 and 1965 has enabled the amount of ice wastage to be calculated and the changes in the proglacial drainage and land forms to be studied over the 20-year period.

In order to demonstrate the work which Dr. Price and others of Glasgow University had done at Breidamerkurjökull, a field expedition for members of the Quaternary Field Study Group was organised in July 1968. The purpose of the excursion was to demonstrate landforms, deposits and drainage systems in an area of very rapid deglacierization. Sixteen members of the Study Group representing a wide range of interests (university lecturers in geology and geography, members of the Institute of Geological Sciences and of the Soil Survey) took part in six field excursions in the Breidamerkurjökull area.

A similar venture was mounted for the International Glaciological Society over an eight-day period in June and July 1970. Moraines, eskers, abandoned channels and sandurs were examined over a large part

of the proglacial area; medial moraines, supraglacial streams, dirt cones and ice structures were examined on the glacier surface itself.

A party from the School of Environmental Sciences at the University of East Anglia visited the Breidamerkursandur in 1971. Dr. J.P. Barkham studied ecological aspects of the sandur, including work on the vegetational colonisation of moraines of different ages. Dr. G.S. Boulton and Mr. D. Dent, with the help of undergraduates, carried out a programme of observations in natural and artificial tunnels beneath the frontal and lateral margins of Breidamerkurjökull - observations which were initiated in 1970. Studies were made of the nature and rate of abrasional processes, the incorporation of debris by the ice, its lodgement against the bed, and the properties of newly formed till. Subglacial water pressures and the stress imposed by the moving glacier against obstructions in its path were measured.

This work was continued by a smaller expedition in the Spring of 1972 when an abrasion rate of 1 - 3 mm/yr. was determined for a marble slab fixed to bedrock.

A brief visit to the Breidamerkursandur was made during the period March 27th to April 6th 1974 by two members of the School of Environmental Sciences, accompanied by Professor J.H. Hartshorn of the University of Massachusetts, U.S.A. Samples of till of different ages were collected for magnetic investigations and the characteristics of two large proglacial lakes were examined using temperature-salinity measuring apparatus and a free-fall sediment corer.

P.W.V.H.

SCIENTIFIC REPORTS.

GLACI-LACUSTRINE SEDIMENTATION INVESTIGATIONS ON THE PROGLACIAL LAKES OF BREIDAMERKURJOKULL AND FJALLSJOKULL

Introduction. The retreat of the ice margins of the glaciers Breidamerkurjökull and Fjallsjökull in S.E. Iceland has exposed a number of deep depressions which are at present filled with meltwaters from these glaciers. Most of the depressions are bounded by ice on their northern or western sides, forming the proglacial lakes Stemmárlón, Jökulsárlón, Breidárlón and Fjallsárlón. One of the main projects of the expedition was to obtain information on the nature of sedimentation in these lakes. Three of the lakes were investigated; it was not possible, for several reasons, to work on Stemmárlón, the easternmost of the lakes.

Working from a large, motor-driven inflatable boat an extensive programme of sediment sampling was undertaken; in addition considerable work was carried out on the total environment of each lake, in order to throw light on the processes of sedimentation in them. Very broadly, similar investigations were effected on all three lakes, for comparison purposes.

Jökulsárlón. Jökulsárlón is the largest of the proglacial lakes, being about 6 sq. km. in area, and reaching depths of over 100 m. in places. The lake increases in depth with proximity to the ice-front, and over 80% of the area of the lake basin lies below sea-level. The ice-front forming the northern boundary of the lake seems in part to be floating and in part grounded. This may explain the locally variable advance and retreat of this margin. The position of the ice front in the summer of 1974 was surveyed and is shown on the accompanying maps.

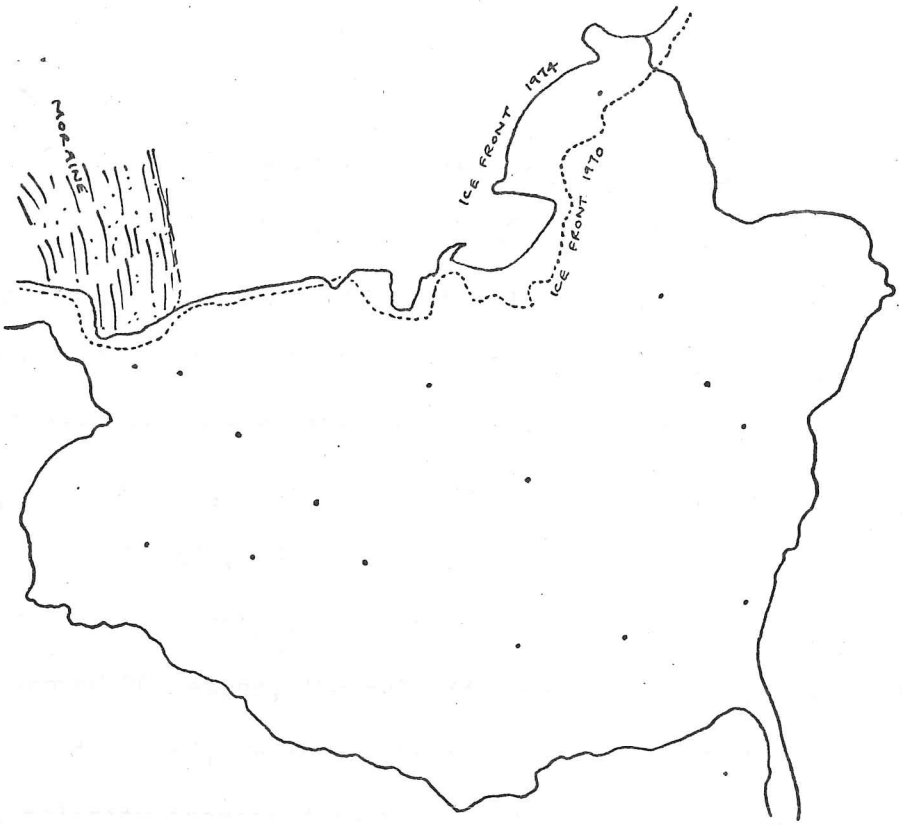
The sediment sampling programme on Jökulsárlón consisted of collecting both core and bulk grab samples. About fifteen grab samples were taken from a variety of areas in thelake, and these samples are at present being analysed in the laboratory. Mechanical analyses of

several samples already completed, have revealed high proportions of silt and clay and large amounts of pebbles and granules, with a noticeable absence of sand and sand-sized material. The silt and clay particles have settled out through the body of the lake water, or may have been deposited from turbid underflows, in the bottom parts of the lake. The occurrence of granules and pebbles, and in some instances, of larger stones, is interpreted as the product of iceberg droppings. These "dropstones" are a fairly common feature of many glacial lake sediments. In addition to these mechanical analyses, the moisture contents of the collected sediments are being calculated, in order to discern any differences in rates of consolidation of the accumulated sediment, both within and between various lakes. For five samples taken from Jökulsárlón and already investigated, moisture contents range from about 50% to 90%.

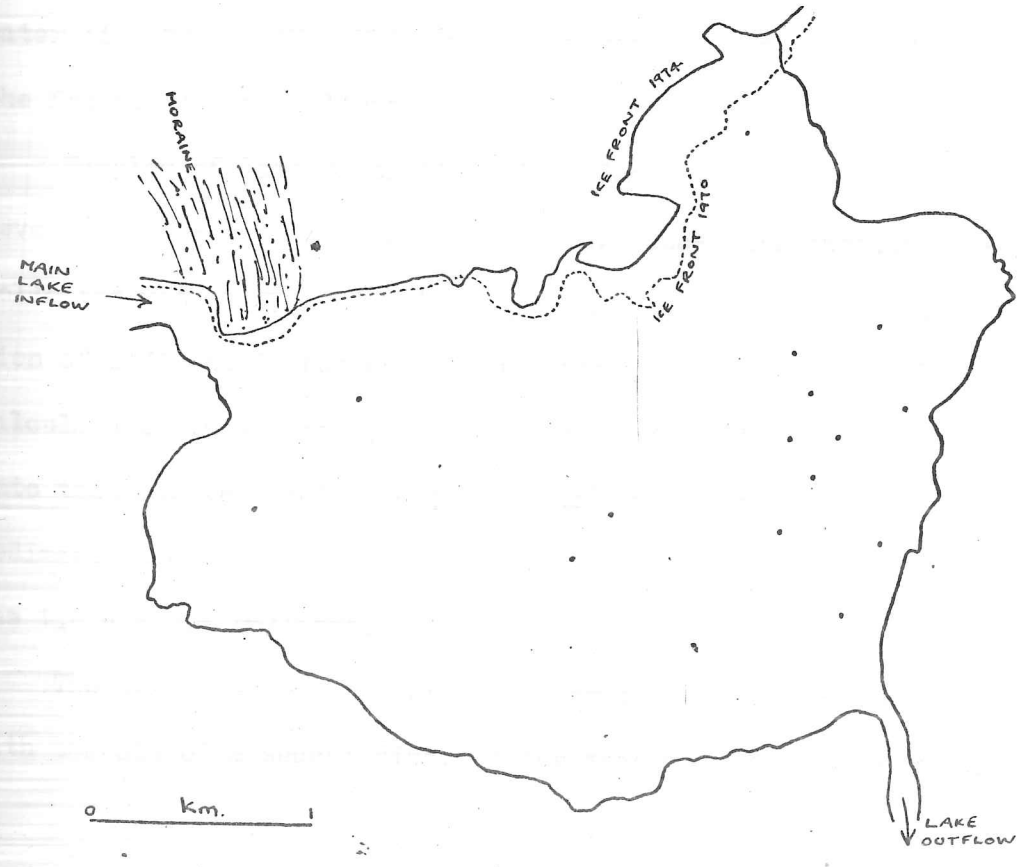
About fifteen half-metre cores of the uppermost portion of sediment were collected from the eastern, central and north-western areas of Jökulsárlón. A free-fall coring device was used. These cores will be sectioned and the sectioned faces cleaned, hopefully to reveal the nature of the layering of the sediment. A varved or rhythmically-controlled sediment pattern is suspected, from observations during the collection of the samples.

The temperature of the lake water of Jökulsárlón was investigated on a fairly extensive basis. A temperature-salinity bridge was used to obtain temperatures at depths from 0 to 100 metres, in over twenty different locations in the lake. Surface water temperatures in the main body of the lake were generally found to be around 1.5°C, with little variation between locations. Nearer the ice-front surface temperatures dropped to around 1°C, or less. With increasing depth, the general pattern was a swift decrease in temperature in the upper 5 - 10 m. of

Jökulsárlón: sites of grab sediment samples.



Jökulsárlón: sites of core sediment samples.



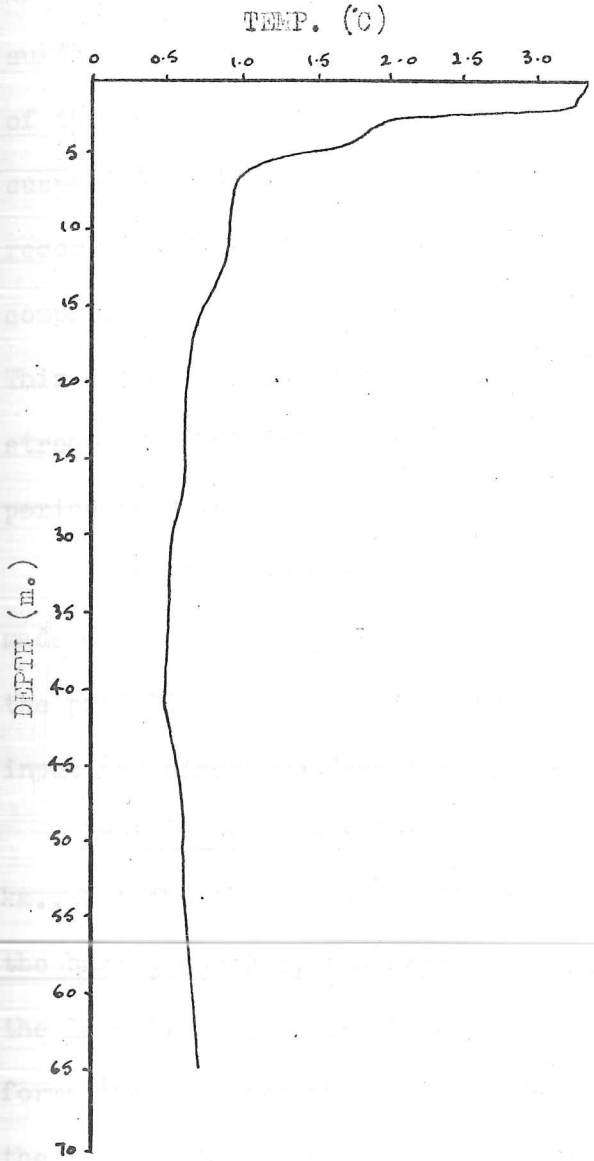
water, constant or even increasing temperature in the middle layers, and a further decrease to 0.1°C or zero in the bottom layers. Much variation occurred in the middle layers of water in different parts of the lake, however.

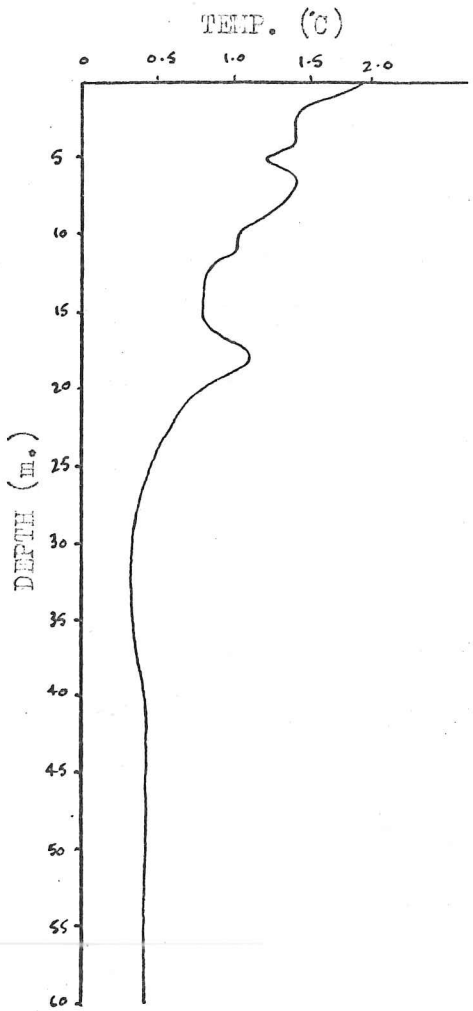
Jökulsárlón lies very close to the North Atlantic Ocean, and is connected to the sea by the river Jökulsá, about 1000 m. in length. This river has cut its bed sufficiently deep to allow the inflow of sea water into the lake at high tide. In summer, however, the water in the lake becomes practically fresh, during the two or three months of intense ice melting, as the meltwater manages to prevent the inflow of the sea at high tide. The salinity of the lake water of Jökulsárlón was therefore another subject of investigation. At surface, and down to depths of around 70 metres, the salinity was almost negligible, about 0.5 parts per thousand, or less. In the deep areas of the lake, below 70 metres, salinity increased to between 4 and 6 parts per thousand and generally remained at this down to the bottom of the lake. It appears that in the deepest parts of the lake, a body of slightly saline water lies "dormant". This water may represent a residual mass, which the fresh, glacial meltwater has not yet flushed out of the lake.

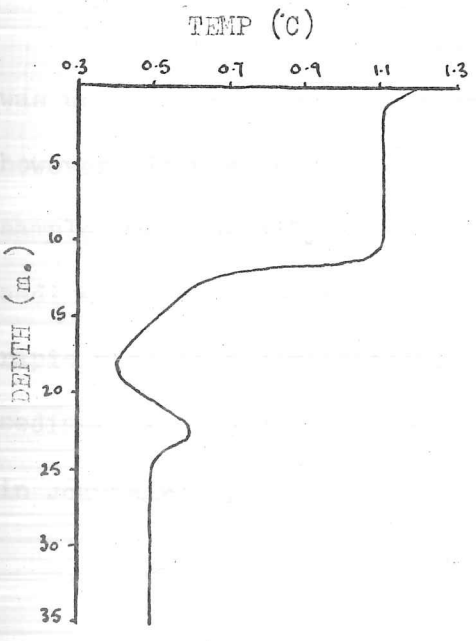
Samples of lake water at various depths were collected from several different areas of Jökulsárlón. One-litre samples were collected with a special water-sampling bottle, to enable the concentration of sediment in suspension at different levels in the lake to be calculated. In addition, water samples from sites of sediment input into the lake were collected; preliminary figures incidate that the sediment load of two streams entering Jökulsárlón close to the ice front was 1.8 and 2.5 gm/litre.

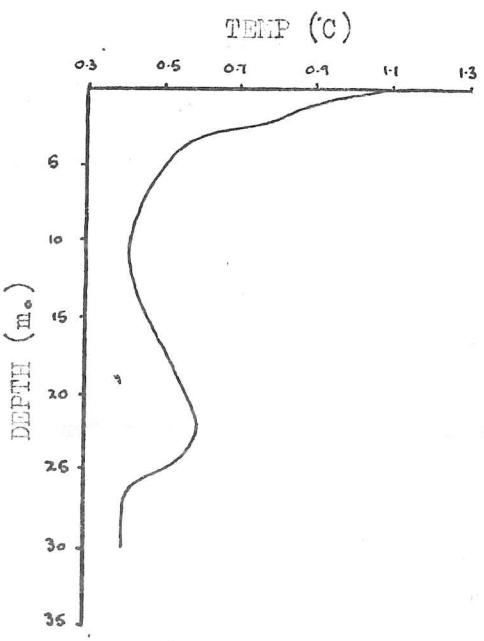
The turbidity of the surface water in Jökulsárlón was determined with the aid of a secchi disc. These measurements have revealed, inter

JOKULSARLON- Selected Temperature- Depth Profiles.









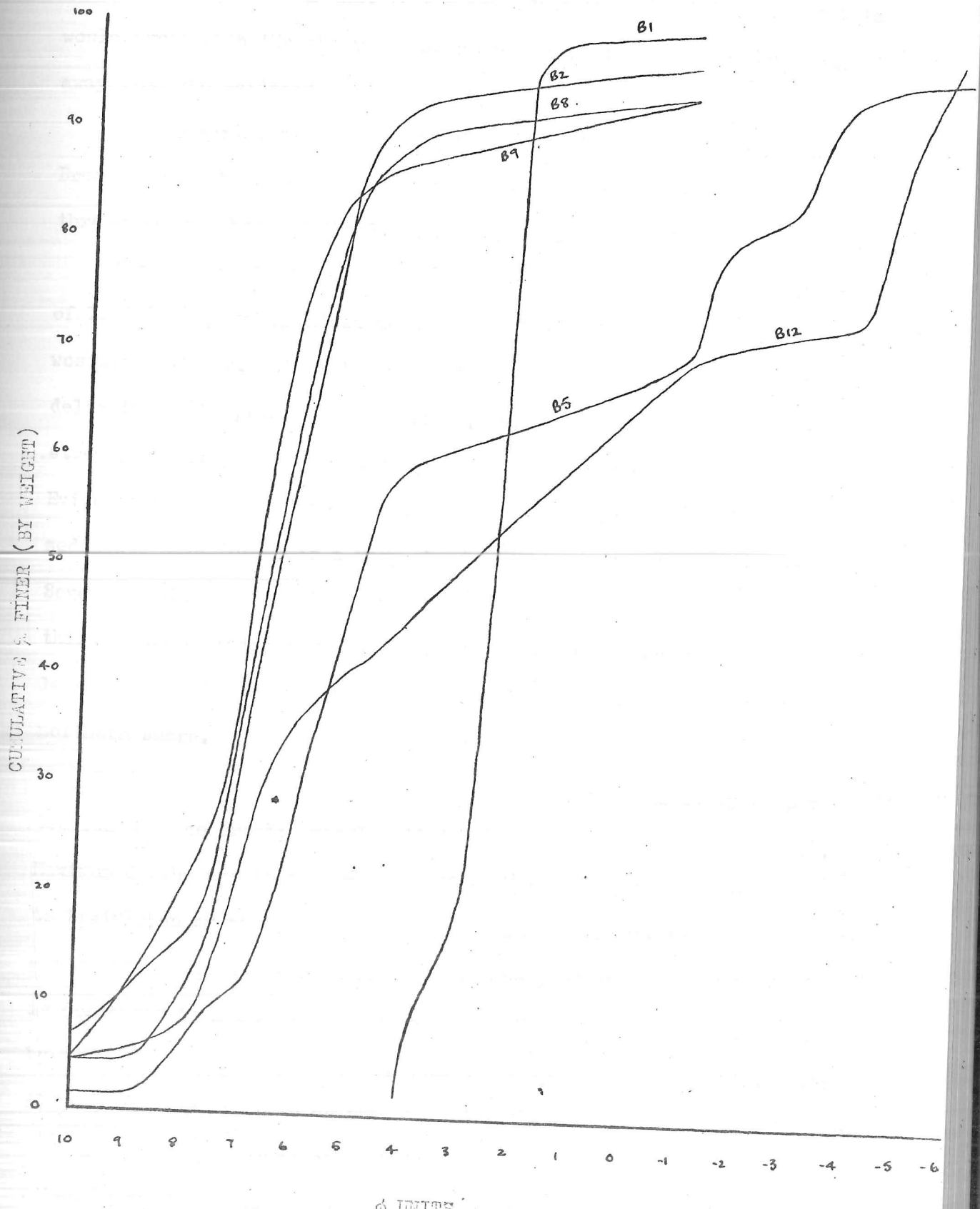
alia, that during the early part of July 1974 two distinct areas of surface water turbidity were present in the lake. The surface waters of the western and south-western parts of the lake were thick with suspended sediment; secchi disc readings of 8 cm. or less were recorded. In contrast, the northern and eastern parts of the lake were comparatively clear at the surface (secchi disc readings 25-33 cm.) This difference is in the main accounted for by the north-west inlet stream of Jökulsárlón entering the lake as an overflow during this period in July.

Amongst other work undertaken in Jökulsárlón, mention should be made of the recording of diurnal lake level fluctuations (up to 80 cm.), the profiling of the outlet stream bed and estimates of water volume input and discharge from the lake basin.

Breidárlón. Breidárlón has a surface area of between 4.5 and 5 sq. km., but the lake is generally less than 25 m. deep. In the centre of the basin, however, the depth does reach over 80 m. A large area of the lake lies below sea level. The southern margin of Breidamerkurjökull forms the northern shore of the lake, and in contrast to Jökulsárlón, the ice front slopes gently and meets the lake at a low angle. It is interesting to note that the base of Breidamerkurjökull is itself probably below sea level in this area.

As mentioned previously, similar work to that done on Jökulsárlón was undertaken on both Breidárlón and Fjallsárlón. On Breidárlón, however, it was only rarely possible to collect core samples, and such samples were usually less than 0.25 m. in length. The lake bottom sediment here is extremely unconsolidated, and this points to a very rapid rate of sedimentation. Indeed, concentrations of suspended sediment in the upper layers of the lake water were greater than those in Jökulsárlón.

BREIDARLON- Cumulative frequency curves of sediment samples.



Over twenty bulk grab sediment samples, each of about 5 kg. in weight, were collected from all areas of Breidárlón. Concentrations of iceberg dropped material incorporated in these sediments appears to be very much less than that in the sediments from Jökulsárlón, and this would agree with the observed lower frequency of ice masses breaking away from the northern ice margin of this lake.

Little variation in water temperature with depth was found in Breidárlón. The water temperature appeared to be generally homogeneous throughout the body of the lake, at about 3.0 to 3.5°C.

A number of depth soundings were made close to the ice margin of Breidárlón, and greatest depths were found along its central and western sections. Close to the eastern parts of the ice front a large delta is in the process of formation, being fed from a large meltwater stream, entering the north-east part of the lake from beneath the ice. Evidence from previous workers in this area indicates that these deltaic sediments have formed in a very short period of time (less than 15 years). Several small bedrock "islands" were observed close to the ice margin, this may be an indication that with further retreat of the glacier the lake may soon loose its proglacial nature, and rock and/or till form its northern shore.

Fjallsárlón. This proglacial lake becomes progressively deeper towards the ice front; nearly all the lake floor is below sea-level. Maximum depths are of the order of 50 - 60 m. This lake is connected to Breidárlón by the river Breidá which flows into Fjallsárlón and enters it at its northern end. The main body of the lake Fjallsárlón is connected to a smaller basin to the north (about 15 - 20 m. deep.) by a narrow north-south channel, only 1 - 2 m. deep. The Breidá river flows south through this channel to enter the main basin of Fjallsárlón.

A similar programme of work to that described previously for the other lakes was carried out here. Ten sediment samples were collected

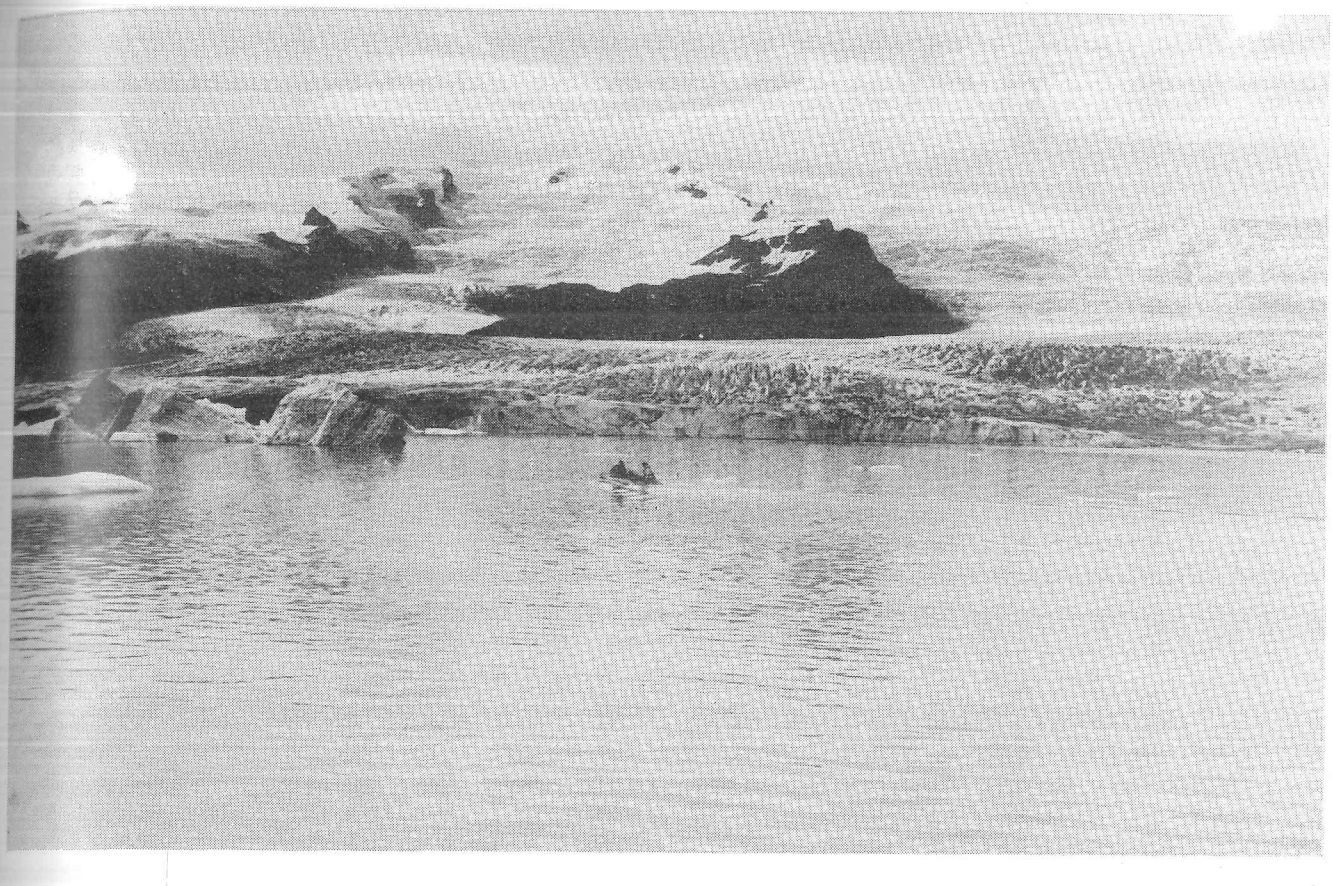


Fig 3 On glacial lake Fjallsárlón; Öraefajökull in the background

Fig 4 Getting ready to start work on Jökulsárlón

and numerous water temperature profiles recorded. Surface water temperatures were generally around 2.5°C (but colder near the ice front) and decreased fairly uniformly to near zero at depth. The nature, volume and discharge of a stream entering the northernmost point of Fjallsárlón from the glacier Fjallsjökull was the subject of particular investigation, and the tendency for icebergs to cluster in particular areas of the lake was also noted.

Conclusions. The modern glacial lake is one of the few sensitive indicators of glacial conditions. A study of such lakes has broader implications for the whole glacial environment, and for glacier hydrology and glacial sedimentation in particular. Work on modern, actively-forming sediments may give an indication of how similar, ancient sediments were deposited. A process-oriented approach may provide valuable information on the mechanisms by which sediments and landforms were formed; in particular, a study of glacial processes may yield a better understanding of the nature of Quaternary Ice-Age deposits, which exist in many parts of the world, as well as adding knowledge to the little-understood, modern glacial environment.

P.W.V.H.

Studies on fluted ground moraine near Breidamerkurjökull.

1. Measurements on large clasts in an area of fluted ground moraine south-west of Jökulsárlón.

The measurements were made in an area 100 metre square bounded on the south by the 1890 moraine. The till in the area is about 0·6 m deep and lies over fluvial gravel. The work was designed to be part of an investigation of the roughness of till surfaces and the consequent drag on the base of a glacier moving over them. The roughness of the surface of a material formed of particles of various sizes may be calculated theoretically.[1] When this calculation is made for the Breidamerkurjökull till it is found that the roughness is so large that given a maximum basal shear stress of 1 bar, the yield stress for ice, the basal sliding velocity would be much less than the actual value. Thus either the basal sliding velocity is produced by shearing within the top layers of the till, as suggested by Boulton, Dent and Morris,[2] or the surface of the till is smoothed by the presence of stagnant ice. In the first case the shear stress over most of the glacier bed will be the rather low stress required to produce failure in the till. Most of the retardation of the glacier will arise from large boulders deeply embedded in the sub-glacial material which will not move with the shearing top layer of the till. Thus it is important to know the distribution and shape of large boulders in order to be able to estimate the average shear stress on the bed. In the second case it should be possible to estimate the thickness of any layer of stagnant ice by measurements of the orientation of striae on the surface boulders.

Hence the following measurements were made on 128 boulders in the area. All boulders with long axes greater than 20 cm in a central area of radius 30 m were studied with all boulders with long axes greater than 50 cm in the rest of the 100 m square.

(i) Length of major and intermediate axis.

(ii) Position of stone.

(iii) Direction of long axis.

(iv) Directions of sets of striae on the stone.

Sets of photographs were taken of 22 boulders with the distinctive whale-back shape and heavy striations.

It was found that for all clasts in the sample with a ratio of major to intermediate axis of greater than 1·35 there were two preferred orientationsof striae separated by $30^{\circ} \pm 5^{\circ}$. The presence of two sets of striae, the directions of which remain constant for all clasts of a certain size in the area, indicates that these clasts have been embedded in the till and that the ice has moved over them. Striae formed while a clast is in transport are likely to follow the direction of the long axis of the clast since this axis is preferentially aligned in the direction of flow of the glacier. Thus the second set of striae, evidently formed when the direction of flow of the glacier changed locally by about 30°, could not have been made during transport since the clasts would have rotated so that the long axes were in the new direction and the new striae would lie in the same direction as the first. Thus in this area quite small clasts can be shown to have been in contact with moving basal ice capable of producing striations. This means that if there is a layer of stagnant ice protecting the smaller stones and reducing the roughness of the bed its thickness is not greater than about 7 cm in this area.

2. Measurements on flutes

Flutes are the parallel ridges of tillrunning in the direction of flow found in front of many retreating glaciers. A theoretical analysis of their formation has been made by Morris and Morland[3] and the results of this field-work will be published in their paper. They have suggested that flutes are generated by sub-glacial cavities formed on the lee sides of boulders or other bed-rock obstacles. The sub-glacial material flows into the cavity and then, under certain conditions, acts itself as an obstacle and generates a cavity on the downstream side. This cavity is filled in its turn and the flute grows by addition of material at its downstream end. The flute does not form by flow of material into a preëxisting subglacial tunnel. The tunnel is kept open by the resistance of the flute material to the over-burden pressure of the ice and would not otherwise exist.

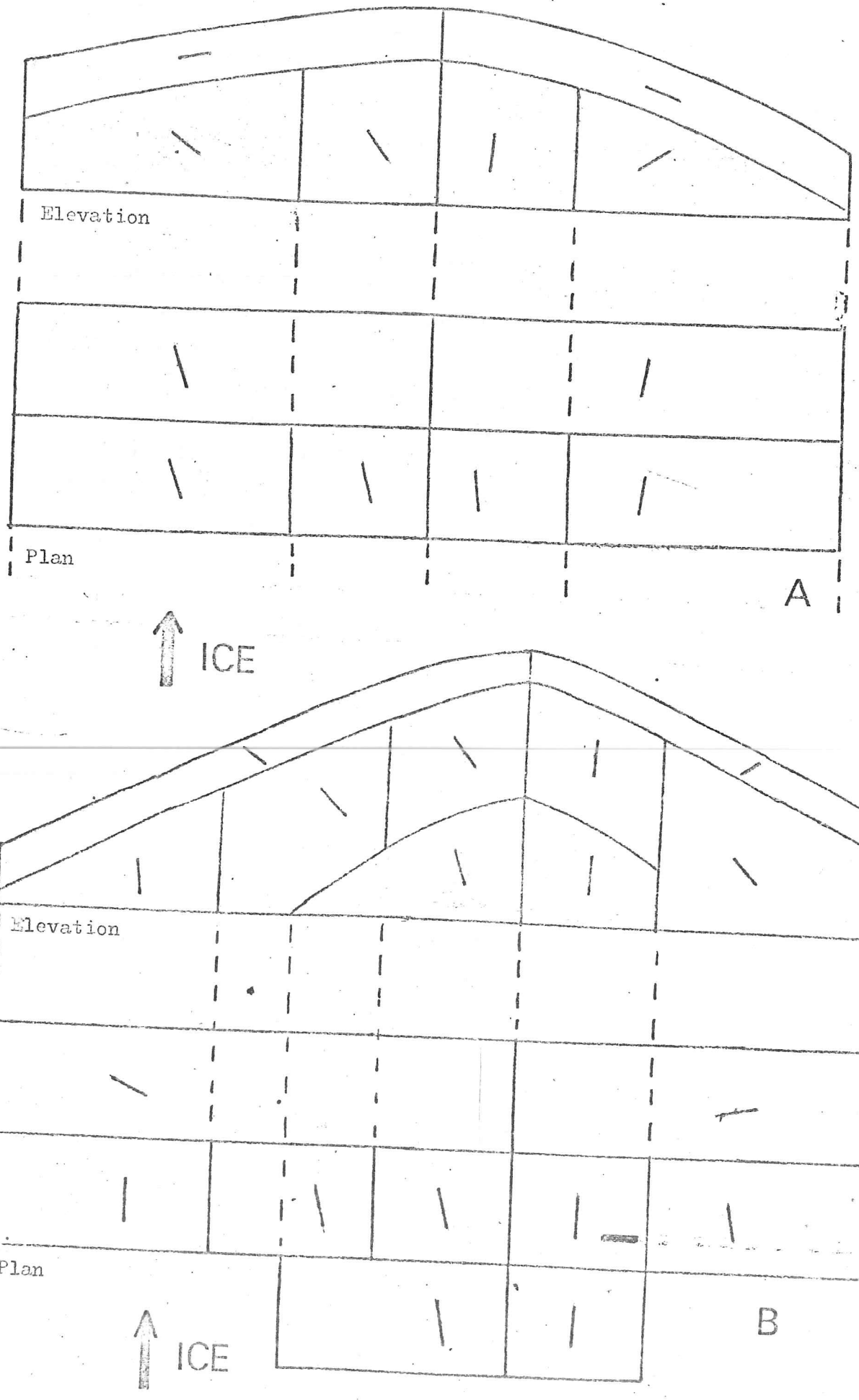
The pattern of flow of material into the sucession of cavities is reflected by the pattern of orientation of the long axes of stones in the flute. Measurements were made on two flutes both at

Figs 5 and 6 Fluted ground moraine at the margin of Breidamerkurjökull; (flutes perpendicular to the ice front; moraine ridges parallel to the ice front.)

the glacier margin near the north-east corner of Breidárlón. A section was made across each flute at 4 m from the boulder at its head and the size, position and orientation of the long axis were measured for 203 stones and 300 stones for flutes A and B respectively. Figure 6 shows the two components of the preferred orientation of the long axes, parallel and perpendicular to the longitudinal axis of the flute for various parts of the two sections. Near the surface of the flutes the stones lie with their long axes parallel to the plane of the surface and forming a herring-bone pattern. Inside the flute the dip of the long axes is greater and increases towards the centre of the flute. This pattern is consistent with the pattern of flow predicted by the theory. Magnetic remanence studies on the till samples taken from these and other flutes should give more data on the flow patterns.

The maximum height of a flute as a function of the mechanical properties of its material is also predicted by the theory. Hence measurements of the shear stress at failure of flute material under various drainage conditions were made using a field shear vane and samples were collected for unconfined compression tests. Very wet till close to the edge of the glacier north-east of Breidárlón had a failure stress of $0 \cdot 04 \pm 0 \cdot 02$ bar. The moraine in this area was not fluted. The wettest fluted moraine was found north-east of Jokulsarlon where the material in the centre of flutes was found to have a failure stress of $0 \cdot 08 \pm 0 \cdot 05$ bar. The failure stress was larger for material on the sides and crests of flutes because these parts were generally drier and because the material had been leached of fines. The maximum height of a flute of material with failure stress $0 \cdot 08 \pm 0 \cdot 05$ is predicted to be $1 \cdot 3 \pm 0 \cdot 8$ m. The maximum flute height measured was 0·67 m.

It is suggested in the theory that below this maximum the height of a flute is equal to the height of the cavity formed on the lee side of the initiating boulder. For many of the flutes investigated the height of the cavity could be estimated since the parts of the boulder which had been in contact with the ice were easily distinguished from the parts of the lee sides which had not been in contact. However it was difficult to estimate the original height of the flutes since material had been lost from the crests. The correlation between the flute heights and boulder



Scale: 1:10

Fig 6

heights is weaker than the correlation between flute heights and estimated cavity heights. One new flute with an initiating boulder just revealed by the retreating glacier was found north-east of Jokulsarlon. The maximumheight of the boulder and the estimated height of the cavity were 25 cm and the flute height 21 cm.

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(1) "The roughness and autocorrelation function of a till surface" E. M. Morris (to be published)

(2) "Sub-glacial shearing and crushing and the role of water pressure in tills from South-east Iceland" G. S. Boulton, D. L. Dent and E. M. Morris (in press, Geografiska Annaler)

(3) "A theoretical investigation of the formation of flutes" E. M. Morris and L. M. Morland (to be published)

SHORT NOTES.

MOUNTAINEERING ACTIVITIES

The mountaineering programme of the expedition fell roughly into two main parts:

(1) attempts on mountain peaks on the western flanks of Öraefajökull, and

(2) excursions on the Breida glacier and the Vatnajökull ice-cap.

The high peaks of Öraefajökull lie immediately to the west of the Breidamerkursandur; the glaciers Fjallsjökull and Hrútárjökull descend steeply from these peaks to the western edges of the sandur. Öraefajökull is a dormant volcano, which last erupted in 1727. The summit of the massif is a large snow plateau covering the volcanic crater. The highest point is Hvannadalshnúkur, 2119 m. high, the highest peak in Iceland.

An attempt was first made on the mountain Rákartindur (795 m.) which lies in the south-east of the Breidamerkurfjall massif. This imposing mountain dominates the western Breidamerkursandur, with the glacial lakes Breidárlón and Fjallsárlón and the river Breidá effectively blocking access to it from the sandur. However, an ingeniously constructed overhead ropeway spans the river Breidá in its middle section; built by local farmers it provides the easiest access to that part of the Breidamerkursandur between the lake Breidárlón and the mountain Rákartindur. This construction was used on this occasion and the mountaineering party reached the base of the mountain from the Breidá hut in about 2½ hours. The route selected was that of the steep, but grassed, south-east flank, gaining the north-east ridge at about 300 metres. From the bottom of the mountain to the summit took about three hours. Once on the north-east ridge excellent views of Jökuldalur (ice-dammed lake now drained) and of the whole sandur area

may be appreciated. Descent to the sandur took just 1-1½ hours, and the whole excursion from the Breidá hut and back again about 10 hours.

After this successful climb, by all members of the expedition, sights were set on higher things - the Öraefajökull mountain itself. The party was split into two, each with its own separate objectives. Whilst one was to attempt Rótarfjallshnúkur (1026 m.), the other was to try and reach the summit plateau of Öraefajökull itself, and if possible, the highest peak of that plateau (2119 m.). Both parties started from Kvísker - a farm at the extreme western end of the Breidamerkursandur - but at different times.

The summit plateau party left the camp site at Kvísker at 7 p.m., hoping to reach the snow line late in the evening, when a crust would have had time to form on the surface, thus making the ascent very much less tiring. After steep climbing (about 300 m. per hour) the party arrived at the snow line at 9 p.m. - earlier than was thought. A crust had not yet formed on the snow surface and going was rather difficult. A height of about 1100 m. was reached, and the party halted at 11 p.m. in the region of Hellutindur. To go further was considered both unattractive and exhausting, due to the persistent poor snow conditions and the descent was started after a short rest. Although this attempt did not achieve its objective, ample reward was obtained in the form of excellent views of the sandur and the coast.

The party atterpting Rótarfjallshnúkur left at approximately 10 p.m. the next day and headed N.E. from Kvísker. After several hours and the gaining of considerable height it was found that further progress was blocked by a huge ravine which cut the party off from the Rótarfjall slopes. Massive, time-consuming detours were the only solution - but decided against for safety's sake. The party returned

to the camp-site, somewhat frustrated, but satisfied with an enjoyable day's walking.

Towards the end of the expedition, a two-man party undertook a three-day excursion to Esjufjöll and Máfábyggdir - two nunataks high up on the Breida glacier. Excellent weather prevailed throughout, giving excellent views of the ice-cap to the north and Öraefajökull in the west.

The first day was spent walking up-glacier to a region of Esjufjöll called Tjaldmýri. Six hours continuous walking covered about 20 km. on the glacier, not including numerous detours forced by large crevasses.

The large medial moraine running south-east from Esjufjöll was followed for a large part of the way, and this eliminated any problem of navigation. A small detour was necessary at the south-west flank of Tjaldmýri to avoid a large glacier-dammed lake. A camp-site for the evening was selected on the slopes of Tjaldmýri - just a few yards from the edge of the glacier.

Next day the party headed NW, traversing the steep scree slopes of Skálabjörg. After a few hours the head of Fossadalur was reached and a traverse made to the Vesturbjörg ridge, which was gained near the peak Snókur (1304 m.). From here one could obtain magnificent views of the ice-cap to the north and of Máfábyggdir to the south-west. After photographs and a rest, the course was set south-westwards for the Fingurbjörg ridge of Máfábyggdir, which was gained after a tiring three hours. Another overnight camp was set up here.

The third day consisted of the descent to the Breidamerkursandur, which proved quite trying through a vast sea of crevasses, some 3-5 km. south-east of Máfábyggdir. It is interesting to note that in this region the glacier surface steepens considerably to reveal two rock steps, each about 200 m. in height and neither of which are marked on any maps of

the glacier. Dangerous crevasses are associated with these features and the whole area is to be avoided, if possible. The party arrived back safely on the sandur after a walk of about 22 km.

During this three-day excursion a total of 60 km. was walked on the glacier, attaining a height of over 1300 m. For the sake of clarity, a summary of this excursion is given below.

Summary: Vatnajökull excursion

Day 1 Breidá hut ——→ Tjaldmýri on Esjufjöll
22 km (20 km on glacier)
gain in height approx. 800 m.
time (excluding rests): 6¼ hours.

Day 2 Tjaldmýri on Esjufjöll ——→ Head of Fossadalur
Then to Vesturbjörg ridge
Then to Fingurbjörg on Máfabyggdir
16 km.
gain in height: 700 m.
time (excluding rests) 7¾ hours.

Day 3 Fingurbjörg on Máfabyggdir ——→ Breidá hut
22 km
time (excluding rests): 6¼ hours

J.B.S.

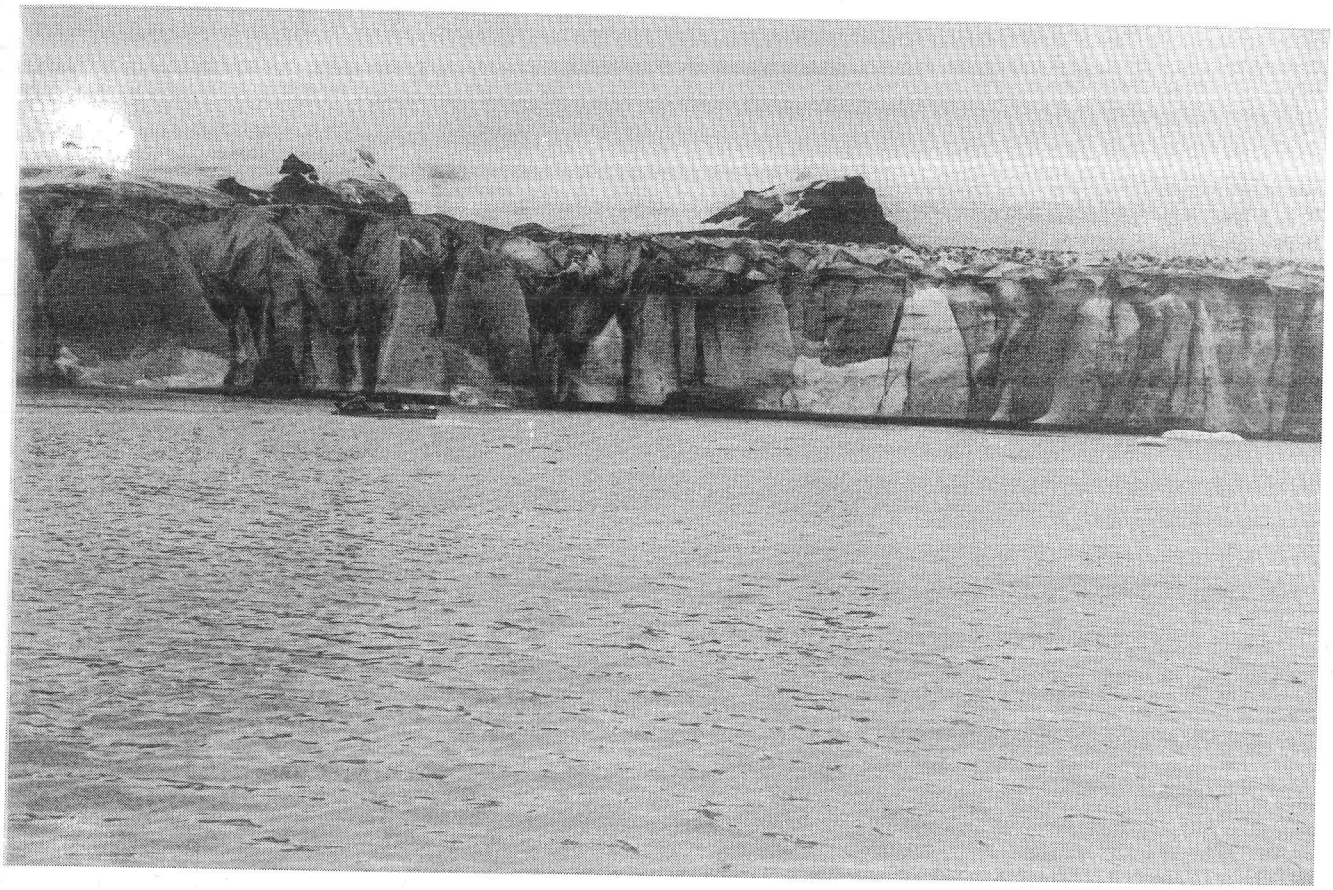

Fig 7 Working under the ice cliffs of Fjallsjökull

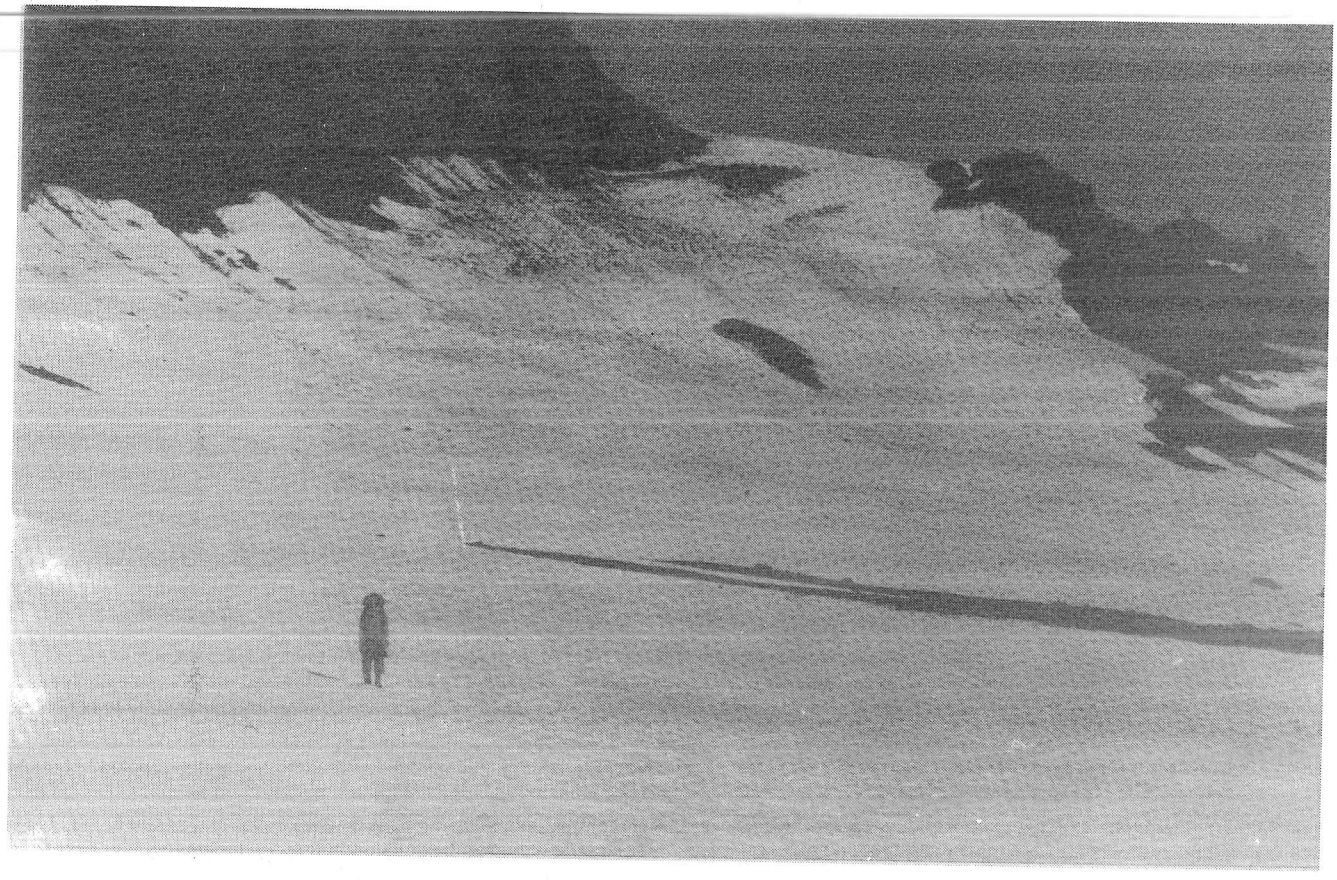

Fig 8 At the head of Fossadalur, in Esjufjöll (altitude approx 4,000 ft)

ON THE FLORA OF THE BREIDAMERKURSANDUR AREA

Plants and flowers of the area fall broadly into two groups, those found on the sandur surface and those on the lower slopes of the surrounding mountains. Some members of this second group were to be found on the banks of abandoned stream channels on the sandur.

Mosses and sedges cover a vast area of the outwash plain of the Breida glacier, becoming sparser on the more recent deposits nearer the margin of the glacier, and giving way to grasses in some well-watered and sheltered parts. Interestingly, patches of lush, green grass were found wherever there were nests of Great Skuas ("manuring" of the ground with bird droppings). Moss Campion, Purple saxifrage and Thrift were the most widespread flowers on the sandur. A list of flowers identified on the Breidamerkursandur includes:

Moonwort (Botrychium lunaria)
Alpine Woodsia (Woodsia Alpina)
Mountain Sorrel (Oxyria digyna)
Iceland Koenigia (Koenigia islandica)
Moss Campion (Silene acaulis)
Alpine Mouse-ear chickweed (Cerantium alpinium)
Northern Rock-cress (Arabis petraea)
Hairy Stonecrop (Sedum villosum)
Purple Saxifrage (Saxifraga oppositifolia)
Tufted Saxifrage (Saxifraga groenlandica)
Alpine Lady's Mantle (Alchorilla alpina)
Harebell (Campanula rotundifolia)
Dwarf Fleabane (Erigeran uniflorum)
Thrift (Armeria maritime)
Vivaparous Knotweed (Polygonum vivaparum)

On several days spent at the base of the mountains flanking the Breidamerkursandur, both on the southern and western slopes of Öraefajökull, a different flora was observed. In particular, during the ascent of Rákartindur, a wide variety of flowers was found. Away

from the gravels of the sandur, grass was more established, together with dwarf birch and black bearberry. A surprising number of flowers familiar in Britain were seen on particularly sheltered and well-watered slopes of the mountains, including varieties of buttercups, daisies, gilly flowers etc. A list of some flowers identified in the Rákartindur area follows:-

Dwarf Birch (Betula naria)
Mountain Queen (Saxifraga cotyledon)
Grass of Parnassus (Parnassia paluntris)
Black Bearberry (Artostaphylos alpina)
Snow Gentian (Gentiana nivalis)
Wood Forget-me-not (Myosotis silvatica)
Rock Speedwell (Veronica fruticans)
Alpine Speedwell (Veronica alpina)
Common Butterwort (Pingiucula vulgaris)
Alpine Butterwort (Pinguicula alpina)
Autumnal Hawkbit (Leontodon autumnalis)
Alpine Hawkweed (Hieracium alpinum)

An interesting botanical project could be carried out in an area such as this, distinguishing the differences between plant communities at different heights.

A.J.G.

METEOROLOGICAL RECORD

A continuous meteorological record was kept over the period of seven weeks in the field. Maximum and minimum air temperatures were taken each day, and the mean daily temperature calculated. Precipitation amounts were recorded using a standard 5-inch diameter raingauge. Direction and speed of the wind was recorded with a simple "ventimeter", and the amount, type and height of cloud cover was observed. Brief notes on the general daily weather conditions were also kept.

A period of dull, overcast weather greeted the expedition on arrival at the beginning of July. A few days of rain followed, but by July 12th bright and sunny weather had set in. With just the odd, intermittent shower and the occasional dull day this fair weather continued for nearly a month - until early August. After this a period of heavy rain, often with low mist, occurred for a period of four days, from August 7th-10th. 94 m.m. of rain fell during the 24 hours of August 9th. Unsettled, but generally dull weather followed, until the expeditions departure on August 20th.

Maximum daily air temperatures during the expedition were on occasion in excess of 25°C; minimum (night) temperatures were generally around 5 or 6°C. No minus temperatures were recorded. Wind direction was invariably from the north - off the glacier; wind speeds were usually small, about 6-10 m.p.h. Unusually, the strong katabatic winds which characterise the Breidamerkursandur, even in summer, were not experienced at all.

Details of the daily meteorological observations are given on the following pages. The abrevviations used for the cloud types are as follows:

CIRRUS - Ci
CIRRO-CUMULUS - Cc
ALTO-STRATUS - As
STRATUS - St
NIMBO-STRATUS - Ns
CUMULUS - Cu
CUMULONIMBUS - Cb

P.W.V.H.

DAILY METEOROLOGICAL OBSERVATIONS

LOCATION: Breiða Hut.
ELEVATION: 30 metres a.s.l.
PERIOD OF OBSERVATION: 4/7 – 22/7

DAY	DATE	TIME OF OBS.	Observr.	AIR TEMP. °C MAX	MIN	MEAN	PRECIPITATION mm.	WIND DIRECTN.	SPEED mph	m/s	beaufort	CLOUD COVER	TYPE	HEIGHT h.	m.	l.	WEATHER	REMARKS
HOR	4 JUL	9 a.m.	PWVH	+10.5	+2.5	+6.5	6.0	—— CALM ——				7/8	As		✓		Overcast.	
RI	5 JUL	9 a.m.	AJG	+18.0	+4.0	+11.0	tr.	NORTH	8	3.4	3	8/8	St			✓	Dull.	
AT	6 JUL	9 a.m	AJG	+16.5	+5.5	+11.0	tr.	—— CALM ——				7/8	St			✓	Dull, some rain	
UN	7 JUL	10 a.m.	PWVH	+14.5	+4.5	+9.5	0.5	NORTH	7	3.3	2	8/8	St			✓	Dull, low cloud.	
ON	8 JUL	9 a.m.	PWVH	+9.5	+3.5	+6.5	36.0	EAST	12	5.4	3	8/8	St/Ns			✓	Continuous rain; mist.	
UE	9 JUL	9 a.m.	PWVH	+10.5	+4.5	+7.5	47.0	NORTH	6	2.8	2	8/8	St/Ns			✓	" " "	
VED	10 JUL	9 a.m.	PWVH	+12.0	+5.5	+8.8	0.5	NORTH	6	2.8	2	8/8	St			✓	" " dull.	
HUR	11 JUL	9 a.m.	PWVH	+12.0	+5.0	+8.5	0.5	NORTH	9	3.8	3	7/8	St		✓		Dull, some rain	
RI	12 JUL	9 a.m.	PWVH	+17.5	+5.5	+11.5	tr.	NORTH	18	7.9	4	5/8	Cu	✓			Windy.	
AT	13 JUL	9 a.m.	JBS	+18.0	+8.5	+13.3	Nil	NORTH	8	3.4	3	7/8	Cc	✓			Dull.	
UN	14 JUL	9 a.m.	JBS	+28.0	+4.0	+16.0	Nil	NORTH	4	1.6	2	1/8	Ci	✓			Mist early, but sunny.	
ON	15 JUL	9.15 a.m.	JBS	+21.5	+6.5	+14.0	Nil	NORTH	11	4.6	3	5/8	Cc/Ci	✓			Sunny.	
DE	16 JUL	9 a.m.	JBS	+22.0	+11.0	+16.5	Nil	NORTH	20	8.4	5	1/8	Ci	✓			Bright, windy.	
ED	17 JUL	9.30 a.m.	JBS	+27.5	+6.5	+17.0	Nil	NORTH	10	4.2	3	1/8	Ci	✓			Bright in afternoon.	
UR	18 JUL	8.30 a.m.	JBS	+23.0	+6.0	+14.5	Nil	—— CALM ——				7/8	As		✓		Dull, close.	
RI	19 JUL	8.30 a.m.	PWVH	+18.5	+6.0	+12.3	Nil	—— CALM ——				0/8	-	-	-	-	Clear.	
AT	20 JUL	9.15 a.m.	PWVH	+19.0	+9.0	+14.0	2.5	—— CALM ——				7/8	Cb		✓		Dull, rainy	
N	21 JUL	10.15 a.m.	PWVH	+24.0	+7.0	+15.5	Nil	—— CALM ——				7/8	Ci	✓			Dull.	
ON	22 JUL	9.30 a.m.	PWVH	+24.5	+5.0	+14.8	Nil	NORTH	7	3.3	2	7/8	Cc	✓			Overcast, some wind.	

DAILY METEOROLOGICAL OBSERVATIONS

LOCATION; Breidá Hut.
ELEVATION: 30 metres, a.s.l.
PERIOD OF OBSERVATION: 23/7 — 10/8.

DAY	DATE	TIME OF OBS.	Observr.	AIR TEMP. °C MAX	MIN	MEAN	PRECIPITATION mm.	WIND DIRECTN.	SPEED mph	m/s	beaufort	CLOUD COVER	TYPE	HEIGHT h.	m.	l.	WEATHER	REMARKS
TUE	23 JUL	10.15 a.m.	PWVH	+17.5	+4.5	+11.0	tr	CALM				5/8	Cu	✓	✓		Misty.	
WED	24 JUL	—— AT	KVISKER	——	——	——	Nil	CALM				1/8	Ci	✓			Bright, hot.	
THUR	25 JUL	9 a.m.	EMM	+21.5	+4.5	+13.0	Nil	NORTH	4	1.6	2	0/8	-	-	-	-	Bright.	
FRI	26 JUL	9. a.m.	EMM	+18.0	+5.0	+11.5	1.0	NORTH	30	13.4	6	8/8	St			✓	Low mist, drizzle.	
SAT	27 JUL	9 a.m.	EMM	+18.0	+6.5	+12.3	0.5	SOUTH	6	2.8	2	8/8	St		✓		Dull, overcast.	
SUN	28 JUL	9 a.m.	EMM	+16.0	+5.0	+10.5	Nil	SOUTH	10	4.2	3	8/8	St		✓	✓	" "	
MON	29 JUL	9 a.m.	EMM	+19.5	+5.0	+12.3	Nil	NORTH	5	2.2	2	0/8	-	-	-	-	Bright, hot, sunny.	
TUE	30 JUL	9.a.m.	EMM	+22.0	+5.0	+13.5	Nil	NORTH	16	6.7	4	6/8	Cb		✓		Dull, rain.	
WED	31 JUL	9 a.m.	EMM	+15.5	+4.0	+9.8	1.0	CALM				7/8	St		✓		Overcast.	
THUR	1 AUG	9 a.m.	PWVH	+15.5	+6.5	+11.0	Nil	NORTH	20	8.4	5	8/8	Cu		✓		Dull, overcast.	
FRI	2 AUG	8.15 a.m.	PWVH	+18.5	+5.5	+12.0	Nil	CALM				5/8	Cb	✓	✓		Dull.	
SAT	3 AUG	8 a.m.	PWVH	+16.0	+5.5	+10.8	tr.	NORTH	5	2.2	2	3/8	Ci/Cu	✓		✓	Low mist early, sunny.	
SUN	4 AUG	9 a.m.	PWVH	+26.5	+6.0	+16.3	Nil	NORTH	5	2.2	2	6/8	Cb	✓	✓		Dull.	
MON	5 AUG	8.30 a.m.	PWVH	+20.5	+6.0	+13.3	Nil	NORTH	6	2.8	2	4/8	St			✓	Overcast in afternoon.	
TUE	6 AUG	9. a.m.	PWVH	+23.0	+4.5	+13.8	14.5	CALM				8/8	St			✓	Low mist, rain.	
WED	7 AUG	9 . a.m.	JBS	+8.0	+4.5	+6.3	21.5	CALM				8/8	St/Ns			✓	" " "	
THUR	8 AUG	9.30 a.m.	JBS	+10.5	+5.5	+8.0	60.5	NORTH	4	1.6	2	8/8	Ns			✓	" " "	
FRI	9 AUG	10 a.m.	JBS	+11.0	+5.0	+8.0	94.0	CALM				8/8	St/Ns		✓		" " drizzle.	
SAT	10 AUG	8.30 a.m.	JBS	+11.0	+5.0	+8.0	14.5	NORTH	5	2.2	2	6/8	Cu		✓	✓	A.m. - sunny. P.m. - o'cast.	

DAILY METEOROLOGICAL OBSERVATIONS

LOCATION: Breidá hut.
ELEVATION: 30 m. a.s.l.
PERIOD OF OBSERVATION: 11/8 — 20/8

DAY	DATE	TIME OF OBS.	Observr.	AIR TEMP °C MAX	MIN	MEAN	PRECIPITATION mm.	WIND DIRECTN.	SPEED mph	m/s	beaufort	CLOUD COVER	TYPE	HEIGHT h.	m.	l.	WEATHER	REMARKS
SUN	11 AUG	8.30 a.m	PWVH	+16.0	+3.0	+9.5	0.5	NORTH	8	3.4	3	7/8	Cb		✓	✓	Overcast.	
MON	12 AUG	9. a.m.	PWVH	+18.0	+6.0	+12.0	tr.	NORTH	6	2.8	2	8/8	St			✓	Low mist early; bright	
TUE	13 AUG	8.45 a.m.	PWVH	+20.5	+5.0	+12.8	tr.			CALM		8/8	St			✓	Low mist	
WED	14 AUG	9 a.m.	PWVH	+10.0	+4.0	+7.0	tr.			CALM		8/8	St			✓	Low mist	
THUR	15 AUG	9.30 a.m.	AJG	+20.0	+3.5	+11.8	tr.			CALM		7/8	Cb		✓		Dull, overcast	
FRI	16 AUG	9 a.m.	AJG	+24.5	+4.0	+14.3	Nil	NORTH	5	2.2	2	1/8	Ci	✓			Bright, sunny.	
SAT	17 AUG	9. a.m.	AJG	+22.5	+3.5	+13.0	tr.	NORTH	6	2.8	2	1/8	Ci	✓			Bright, sunny.	
SUN	18 AUG	10 a.m.	AJG	+22.0	+4.5	+13.3	Nil			CALM		5/8	As	✓	✓		Dull.	
MON	19 AUG	8.30 a.m.	AJG	+17.0	+5.0	+11.0	0.5	NORTH	5	2.2	2	8/8	St			✓	Low mist, overcast.	
TUE	20 AUG	10 a.m.	AJG	+9.0	+5.0	+7.0	26.0	NORTH	9	3.8	3	8/8	St			✓	Low mist, rain.	

APPENDICES.

NOTES ON PLANNING AND ORGANISATION

Permission for fieldwork. This was necessary at the outset of the planning of the expedition. A research permit application form was obtained, completed and returned to: The National Research Council, Laugavegi 13, Reykjavík, Iceland. A research permit was then granted.

Packing of equipment. The bulk of the expedition's equipment travelled to Iceland by sea and for this purpose was packed in either wooden crates or specially constructed heavy duty cardboard boxes, with slip-on sleeves. These cardboard boxes, which proved exceptionally good were supplied by Reed Corrugated Cases Ltd., Aylesford, Maidstone, Kent ME 20 7 PF.

Freight arrangements. Sea-going freight was sent and brought back from Iceland on the boats of The Iceland Steamship Company Ltd., Trelawny House, The Dock, Felixstowe, Suffolk 1P11 8 TT.

1500 kilos of food and equipment was sent from Felixstowe on 9th June 1974 and arrived in Höfn in S.E. Iceland on 1st July, after transshipment at Reykjavík. 703 kilos were brought back from Iceland; this was delivered to Höfn on 21st August and collected at Felixstowe on 19th September 1974.

Costs: including handling, paperwork and all charges: outward £85.78; return £63.56.

Transport within Iceland. After arrival by air in Reykjavik, the expedition flew to Höfn in S.E. Iceland (about 1 hour). A cheaper means of travel is by the daily Reykjavík to Höfn bus (about £8 and 9 hours).

In order to transport the large amount of freight from Höfn to the field location at Breidamerkursandur, a lorry was hired from and driven by, Fridrik Hendrikkson of Höfn. This lorry was again hired for the similar return trip. The cost from Höfn to Breida was

10,000 kr. (about £50) and the same again for the return journey. The daily Reykjavík to Höfn bus was utilised for short journeys whilst the expedition was in the field. Typical charges were: Breidá to Fjallsárlón, 50 kr (about 25p.); Breidá to Kvísker, 100 kr (50p.) and Breidá to Skaftafell, 175 kr (88p.).

Maps. Maps used by the expedition were:

Breidamerkurjökull (E)	: 1965.	1:15,000	Dept. of Geography, Univ. of Glasgow
Breidamerkurjökull (W)	: 1965.	1:15,000	" " "
Fjallsjökull	: 1965.	1:15,000	" " "
Breidamerkurjökull	: 1965.	1:30,000	" " "
Breidamerkurjökull	: 1945.	1:30,000	" " "
Sudausturland (Adalkort Bl.9.)		1:250,000	Uppdratur Íslands
Öraefi		1:100,000 revised 1974	Landmaelingar Íslands
Skaftafell		1:25,000 revised 1974	Landmaelingar Íslands
Ísland		1:750,000 1972	Uppdratur Ferdafelags Íslands

In addition a sequence of 25 vertical aerial photos of the Breidamerkursandur, taken in 1965, were used. These were kindly supplied by the University of Glasgow.

Items of equipment. Some items which proved either exceptionally useful or extremely necessary were: wellington boots, heavy-duty waterproofs (jacket and trousers), snow goggles, plastic adhesive tape, candles, karrimats and large, strong polythene bags.

Water supply on the Breidamerkursandur. To any expedition intending to visit this area a note on the water supply is necessary. Water is very scarce on the sandur and is to be found in several places only. The nearest source to the Breidá hut is from a cluster of "kettle holes", about 1 km. north of the hut. Other expeditions camping in this vicinity have obtained water from ponds, south of the road. No fresh-water streams exist in this area.

The Iceland Unit. This is an information unit for expeditions to Iceland, and proved helpful in several ways for our expedition. Any planned Iceland expedition should get in touch with the Unit, for useful advice. Write to: Tony Escritt, Esq., 86, Dovedale Crescent, Buxton, Derbyshire.

P.W.V.H.

FOOD

The food of the expedition was entirely non-perishable, and was selected on the basis of being light in weight, as well as nourishing and palatable. Weatherproof cardboard boxes with sleeves were used to pack the food into units of 12 man-days, and each box weighed about 30 lbs. Each box was individually "tailored", and complete in itself.

The staple diet consisted of dried meat and vegetables (dinner), porage (breakfast) and biscuits (lunch). This was supplemented by small amounts of tinned meat and fish, as an alternative to the dried meat.

In addition to this diet, a system of "goodies boxes" was also employed. Four of these boxes were taken and used at the rate of one per fortnight, along with the "normal" boxes. Goodies boxes weighed about 60 lbs each and contained luxury items, providing a good variety in the food diet.

Typical contents of a normal food box and a goodies box are given below.

Normal food box

4 portions (8 oz. dried) Batchelors Farmhouse Stew
" " " " " Chicked Supreme
" " " " " Beef Curry
4 portions (4 oz. dried) Batchelors Peas
" " " " " Carrots
" " " " " Mixed Vegetables
12 oz. (dried) Instant Mashed Potato
10 oz. (6 portions) Patna Rice
12 oz. (4 pints made-up) Symingtons Tomato Soup
4 oz. (dried) Ehrin Apple Dessert
1 lb. MacVita biscuits
½ lb. Ry-King Brown Crispbread
½ lb. " " Wheat "

½ lb. Nabisco Snak Crackers
½ lb. Garibaldi biscuits
½ lb. Royal Scot "
1 lb. Digestive "
2 lb. (4 x 8 oz. tins) Blue Band margarine
2 lb. Golden Syrup
2 oz. marmite
6 x ½ oz. processed cheese
1 lb. Quaker Oats
1 lb. Ostermilk
½ lb. Millac dried milk
6 oz. Maxwell House Drinking Chocolate
2 pints (made up) dried grapefruit drink
1 lb. jar Horlicks
3 tubes Horlicks Tablets
3 oz. Maxwell House Coffee
18 tea bags
5 lb. caster sugar
¾ lb. Whitworths seedless raisins
6 mars bars
6 bars Galaxy milk chocolate
1 pkt. 24 boiled sweets
10 pkts. assorted chewing gum
2 boxes matches
1 pkt. Jeyesoft toilet paper

Goodies box

12 cans Whitbread Light Ale
1 lb. tin Ham
1 tin sliced peaches
1 tin sterilised cream
1 tin Tartan Shortbread fingers
2 lbs. 4 oz. "Alpen"
3 x 8 oz. Heinz Tinned Sponge Puddings
2½ lbs. Baked Beans
1 lb. jar pickled onions
2 small tins Nestles Ideal milk
4 wagon wheels
1 bottle Dubonnet
5 pints Long Life Milk

4 pints Lemon Squash
1 tinned Guiness Cake

A "kitchen box" containing salt, pepper, herbs, spices etc., was also taken. Included in this was tomato puree, mango chutney, packs of stuffing, tomato ketchup, brown sauce, vinegar, cornflour etc. A quantity of flour (9 lbs.) was taken, as well as 4-5 lbs. of Atora suet (for dumplings and suet puddings). Two Edam cheese "footballs" (2 x 5 lbs.) were also taken.

A typical day's menu might be as follows:

Breakfast

Instant grapefruit drink
Porage, with sugar and jam/treacle/lemon curd or raisins
Crispbread, with cheese or jam
Tea or Coffee

Lunch

Crispbread, with marmite, cheese or jam
Sweet biscuits and Macvita
Raisins or dried mixed fruit
Mars bar or Galaxy
Sweets/chewing gum

Dinner

Cinzano Bianco/Dubonnet or ½ pint light ale
Chicken Supreme, Peas and Mashed Potato
Erin Whip Supreme
Edam cheese with crackers
Guiness cake
Coffee with cream

Supper

Biscuits
Coffe/hot chocolate or Horlicks

This menu would provide about 3000 or 4000 calories per man per day.

All food was cooked over either petrol or paraffin stoves. A

pressure cooker was taken to facilitate 'quick' suet puddings and other dishes. Useful items of kitchen equipment were a wooden spoon, egg whisk, plastic measuring jug, plastic mixing bowls, ladle and trivet.

A.J.G.

FINANCIAL STATEMENT.

(As at 31st. October 1974.)

INCOME.

Members personal contributions	300.00
Grants: Gilchrist Educational Trust	50.00
Gino Watkins Memorial Fund	50.00
Natural Environment Research Council	200.00
The Royal Society	150.00
U.E.A. Expeditions Committee	320.00
TOTAL:	£ 1070.00

EXPENDITURE.

Travel- air	351.00
Travel- land	135.00
Freight, outward- air	32.00
Freight, outward- sea	85.78
Freight, return- sea	63.56
Food	130.78
Equipment	14.52
First-aid, medical	7.33
Boat, outboard-motor	78.58
Fuel	17.04
Insurance	23.76
Stationery; Administration	11.84
Reports: preliminary	10.32
: final(estimated)	80.00
U.E.A. Expeditions Committee levy	26.00
TOTAL:	£ 1067.51

ACKNOWLEDGEMENTS.

Sincere thanks for assistance in many ways is due to the following;

The Gilchrist Educational Trust
The Gino Watkins Memorial Fund
The Natural Environment Research Council
The Royal Geographical Society
The Royal Society
The University College of Swansea Mountaineering Club
The University of East Anglia Expeditions Committee

Flosi Björnsson

Batchelors Catering Supplies Ltd.
Beecham Foods
The Boots Company Ltd.
Brooke Bond Oxo Ltd.
Bryant and May Ltd.
Colman Foods
General Foods Ltd.
Glaxo Laboratories Ltd.
Jeyes U.K. Ltd.
Mars Ltd.
The Metal Box Company Ltd.
Proctor and Gamble Ltd.
Quaker Oats Ltd.
Reed Corrugated Cases Ltd.
Ronson Products Ltd.
Shippams Ltd.
Tate and Lyle Refineries Ltd.
Unilever Export Ltd.
United Biscuits Ltd.
Whitbread and Company Ltd.
Whitworths Holdings Ltd.
The Wrigley Company Ltd.

FURTHER RESULTS AND FUTURE WORK

Further Results. In addition to this report, and the preliminary report of the expedition (September 1974), accounts of the expedition's work and some of the findings are due to appear in the following forms:

Papers

"The summer season temperature structure of a glacial lake - Jökulsárlón, South-East Iceland".

P.W.V. Harris 1974 (in preparation)

"A theoretical analysis of the formation of glacial flutes"

E.M. Morris 1974 (in preparation)

"Magnetic Remanence studies on fluted till from Breidamerkursandur, Iceland".

E.M. Morris 1974 (in preparation)

Theses

"The sedimentological and hydrological budgets of the Breidamerkurjökull glacial lakes in South-East Iceland"

P.W.V. Harris (provisional title, U.E.A. Ph.D. 1976; in preparation)

Notes

"Joint Universities Expedition to South-East Iceland"

P.W.V. Harris and E.M. Morris

in: ICE (publication of the International Glaciological Society) - final issue for 1974.

Future Work. Work is continuing at Breidamerkurjökull; two further expeditions during the winter and in the summer of 1975 are planned.