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Sólheimajökull

REPORT OF
THE DURHAM UNIVERSITY ICELAND EXPEDITION 1948

BY
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WITH AN INTRODUCTION
BY
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WITH
2 PLATES AND 6 FIGURES
IN THE TEXT

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INTRODUCTION

by J. Eyþórsson

This paper is an extract from the Report on the *Sólheimajökull* (Sólheimar Glacier) by the Durham University Expedition in 1948. Even if the work of this expedition does not span a whole ablation period, the report is so valuable contribution to the knowledge of the Mýrdalsjökull area, that the Museum of Natural History in Reykjavík has thought it justified to publish it in the Museum's Series: Acta Naturalia Islandica. In order to reduce the cost of printing, however, it has been necessary to cut the original report to a bare minimum. This cutting has been carried out in consultation with Dr. S. Thorarinsson. From a report on Höfðajökull by the Durham University Expedition of 1949, a map of Höfðabrekkujökull is published. — The 1949 exepedition was led by H. Lister and the map was made under the guidance of Mr. P. B. Stewardson.
Both these exploring parties from the Durham University have shunned no efforts or hard work to fulfill their programmes.

As an introduction to the above mentioned reports I want to publish some observations from the Mýrdalsjökull, carried out by the present author and the late Secretary of the National Research Council, mag. scient. *Steinþór Sigurðsson.* Our investigations were only possible as holiday work and comprise mainly the topography of the ice cap, height of firn line and the snow accumulation.

TOPOGRAPHY

The Glacier Cap Mýrdalsjökull (Fig. 1) covers an area of about 700 km^2. The central cap consists of a shallow E-W orientated trough between a southern ridge (about 1490 m) and a semi-

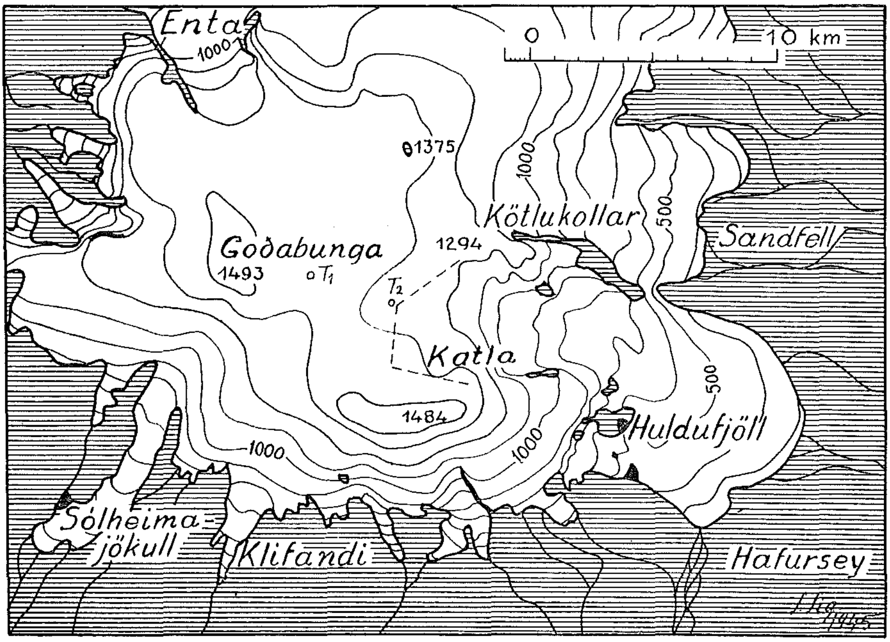

Fig. 1. — Map of Mýrdalsjökull drawn by Steinþór Sigurðsson.
(Margin of glacier according to the Danish General Staff maps).

circular northen ridge reaching the height of 1493 m at Goðabunga. The southern ridge is steep towards the coast, while the northen one is sloping gently down to the Mælifellssandur plain north of Mýrdalsjökull.

Outlet glaciers

From the above mentioned trough two outlet glaciers are descending in almost opposite directions down to the coastal low land: The Sólheimajökull facing SW and the Höfðabrekkujökull or Kötlujökull towards E. The intake areas, seperated by a low col (1345 m) in the western part of the trough, are about 15 and 60 km² respectively for the outlet glaciers.

Climate surroundings

The nearest climatological stations to the Mýrdalsjökull are *Vík* and *Loftsalir* on the South coast 13 km off the southern margin of the ice cap. Vík has the highest annual records of precipitation of all Icelandic weather stations. Established about 1920 the calculated normals for the period 1901—1930 are:

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Temp. C°													
Vík	0.9	1.2	1.5	3.1	6.2	9.3	11.0	10.5	8.0	4.9	2.3	1.3	5.0°C
Loftsalir	0.5	0.9	1.2	3.2	6.3	9.7	11.6	10.8	8.1	4.5	2.0	1.2	5.0°C
Precipit.													
Vík	222	199	190	140	136	126	119	119	216	205	197	224	2093 mm

In Sept. 1947 a totalizer was erected at the southwestern margin of the Mýrdalsjökull at ca. 750 m ab. sea level and some 3 km E of Sólheimajökull.

The results have been as follows:

Period	Totalizer		Vík
18/7 1948 — 30/8 1948	560 mm		199 mm
31/8 1948 — 13/6 1949	3780 —		2059 —
14/6 1949 — 19/9 1949	910 —		786 —
20/9 1949 — 14/6 1950	2479 —		1596 —
15/6 1950 — 28/8 1950	476 —	(?)	789 —
29/8 1950 — 19/6 1951	3346 —		1621 —
30/6 1951 — 29/9 1951	518 —		660 —
	Total 12069 mm		7710 mm

The total precipitation during a period of 1168 days has been 12069 mm at the ice margin and 7710 mm at Vík. The increase of precipitation seems thus to be about 57% pr. 750 m elevation.

Accumulation

1943, July 25: 1. East of Goðabunga, 1345 m a. s. l. 400 cm snow layer was found from the previous winter.

2. West of Goðabunga, 1245 m a. s. l. a pit was dug, 625 cm deep. The snow layer from last winter was 300 cm thick. Beneath it was a 290 cm thick layer of firnificated snow with many thick ice bands from the winter 1941/42. At the bottom of the pit there was still coarser and harder firn.

3. Same place. Pit dug to 625 cm. Firn with many thick ice layers from the winter 1941/42 290 cm.

The map (Fig. 1) was made by Steinþór Sigurðsson in 1943—1944. It certainly gives a more correct picture af the topography of the Ice Cap than other map as yet made. In order to correct the map with the trigpoint at Hafursey and Stakkur new trigpoints were established at *Sandfell* and *Vörðusker* (1009 m) in the upper Katla glacier.

In Sept. 1943 several 500 cm high stakes were left on the glacier in late Sept. for future measurements of accumulation and movements. They were not to be found the next summer.

1944, Aug. 5: Intake area of the Höfðabrekkujökull, T_2 on the map, about 1280 m a.s.l.: Snowlayer of 785 cm was found from the winter 1943/44 (cf. Fig. 2). The snow stakes might thus have been buried in snow!

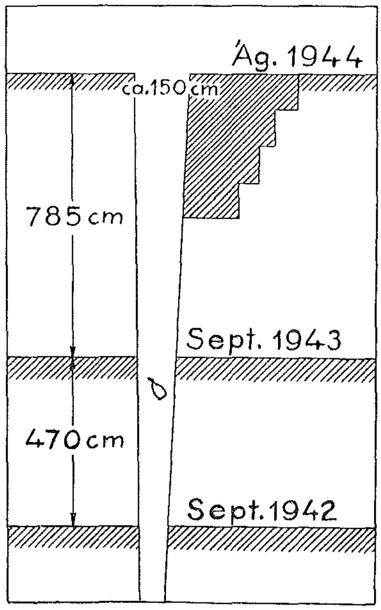

Fig. 2. — Section through a crevasse on Mýrdalsjökull 1280 m above sea level (T_2 on the map Fig. 1).

The water content of the snow from 25—345 cm below the surface averaged 62.9% which would mean a precipitation of more than 4900 mm of water in solid form pr. year.

The ablation in 9 days, 4—12 Aug. amounted to 38.7 mm snow or 4.3 cm pr. 24 hours.

1945, Aug. 16: Near T_2. Snowlayer from last winter 550—600 cm, average 575 cm. Unusually little snow on the lower parts of the glacier.

1948, July 18: Flag No. 22. 1290 m. Snowlayer from last winter about 500 cm. Cf. p. 28.

Movements

1946. At the end of July the movements of the ice were measured from *Vörðusker* (1009 m) in a section across the upper Katla glacier. Speed was found 18—24 m in 14 days.

Recession of Sólheimajökull 1930—1951

Measurements have been made in 4 places:

A:	E of Jökulhöfuð,	about 130	m above sea level
B and C:	W of —	— 100	— — — —
D:	on the —	— 200	— — — —

	A	B	C	D	
1930/31	—52	+2	—8	—	
31/32	—35	—27	—17	—9	
32/33	—47	—91	—52	—46	
33/34	—10	—20	—83	—	(3 years)
34/35	—40	—50	—15	—	
35/36	—25	—108	—97	—30	
36/37	—40	—50	—10	—	(2 years)
37/38	—45	—50	—30	—14	
38/39	—75	—28	—15	—65	
39/40	—53	—30	—40	—30	
40/41	—42	—34	—9	—11	
41/43	—35	—30	—41	—24	(2 years)
43/44	—5	—13	—60	—10	
44/45	—25	—55	—20	—65	
45/47	—20	—60	—35	—65	(2 years)
47/48	—20	—50	—10	—10	
48/49	—25	—40	0	+20	
49/50	+10	—10	+20	+15	
50/51	+10	+25	+6	—5	
1930/51	—574	—719	—514	—349	metres

Average recession pr. year 26 m.

GENERAL REPORT

by H. Lister

Much that is contained here would be superfluous in a formal report, yet to the University Exploration Club the technical results are of no more value than the experience gained. It is this experience which, though forming a worthy part of our programme, is very difficult to set down briefly in a report.

Some possible field work in many countries had been under consideration for some time, but Iceland offers much scope for work, is not too distant and is almost ideally suited as a training ground for more ambitious exploratory work in the future.

Via the Scott Polar Research Institute at Cambridge a contact was made with Mr. Jón Eyþórsson, the Icelandic Government Meteorologist, whose suggestions and invaluable assistance were most helpful throughout. To gather interested people in the University and with a hope of continuity into future years, the Exploration Club was formed and under the guidance of Professor Daysh, the criticism was sought of the Expedition Council, a fatherly body of Professors and senior lecturers in the University. Without the unremitting devotion of Professor Daysh to our cause we could never have overcome the numerous obstacles met with when on a job of this nature.

Objects

1. To gain experience in carrying out field work in polar latitudes.
2. To make a special study of an outlet glacier (skriðjökull) of the Mýrdalsjökull, i.e. to map this glacier and measure its movements (as suggested by Mr. Jón Eyþórsson who was in close touch with the work at all stages).

3. To observe and record plant life within the area studied.
4. To make local weather observations.
5. To establish a photographic record.

The above was part of the programme submitted to the Royal Geographical Society, who kindly gave their approval and financially supported the expedition. We are deeply indebted to our Rector, Lord Eustace Percy, who was most patient with us, and to the University Court for meeting the greater part of the cost of the expedition.

Personnel

Many people were interested, but few were available, so rather than choosing people, any really keen volunteer was welcomed, though it was hoped that in these people a compromise was made between qualification, experience and availability in the future. Since not one of the men was a graduate and a girl displayed much enthusiasm in abstracting papers, we included 2 girls, graduates, who were doing research work and who were outdoor enthusiasts. It was hoped that their qualification would give our party some prestige and help in the recognition we were then seeking. Again, it would be interesting to note how they responded to the work and conditions, to prove how much is prejudice and how much justifiable convention that generally excludes girls from work of this kind. In most cases they behaved admirably and though they cannot compare with men for sheer physical doggedness, they did a very fine job indeed.

Members of the Expedition:

Miss M. McDonald — Meteorology.
— J. Sutton — Crystal Rubbings and Quartermaster.
Mr. I. Paterson — Glaciology and Transport.
— R. Jarvis — Botany and Geomorphology.
— R. Walker — Silt Samples.
— H. Lister — Geology and Leader.

Equipment

Much suitable equipment was available in ex-service supply stores. Lightness and weather proofing were the motive in their compilation. Our own experience of winter camping in British hills, supplemented by reading reports of other expeditions taught us as much as was really necessary about equipment for Iceland.

Food

Pemmican is expenive and unnecessary during the summer in Iceland. We found it convenient and palatable to use corned beef and thus carry a little more than minimum weight of food. Our 2 lbs per day ration, though not satisfying for the first few weeks was sufficient and proved very suitable.

Transport

More than a years search by correspondence did not result in our finding a cheap passage to Iceland. It was essential to begin our programme there at the earliest opportunity since weather in September can often hold up any serious work and the ablation measurements should be begun as soon as possible after the spring melting had begun. Thus we booked a single passage in the Icelandic vessel M/S "Esja" taking tourists on cruise to Iceland. This was more expensive than a trawler but a little cheaper than the regular steamer service. Reliance was placed on, and success achieved in finding a return passage in a trawler. This is more possible in September than early in the summer.

From Reykjavík to Sólheimar, the co-operative farm truck was the cheapest method of transport. The young driver was very cooperative indeed and drove his truck through rivers and over steep moraines to put the baggage as near the glacier as possible. Some of the party sounded in front of the truck through the boggy patches.

To set up camp 4 at the margin of the ice-cap, two ponies were hired from the farm Sólheimakot. The Icelandic pony is a very sure footed climbing animal and each carried 140 lbs., apparently without discomfort. Four other subsidiary camps were set up at different times and maintained. The difficult nature of the country made 50 lbs. the maximum that the boys could carry for long periods and continue to work effectively.

Camps

Base camp was situated on a large island, mossy and moraine ribboned, between the two rivers from the glacier. To the glacier snout was 1 kilometre.

Field Work

The programme of work was with minor addition and modification, completed, latterly in rapidly deteriorating weather. The major difficulty was the frequent mist and rain, temporary high winds and, at the higher altitudes, snow-storms. With better weather, the work could have been completed in little more than half the time.

Had the programme been drawn up on site, it probably would have included more work on special aspects of the broad subjects studied generally, for the country invites observation and investigation at every new turn of the landscape. Details of the work will be found in each separate report.

At the end of our stay in Iceland, a week-end trip was made to Hrútafell, a small ice cap close to the NE end of Langjökull in the centre of Iceland. A report of this brief excursion is not here included since this, though relative to, was outside our programme.

SURVEYING

by H. Lister

The main object of the surveying operations on the Sólheimar glacier was to discover the amount the ice had decreased since the time of the last map which was made in 1907.

The best existing map of the area is from a Danish survey of 1907, but it is on a scale of only 1:50,000. As this scale was too small for the required purpose it was decided to make a completely new survey of the area on a scale of 1:5,000 which was considered large enough to show the necessary geomorphological features, particularly the lateral moraines, in sufficient detail.

The Sólheimar glacier and its surrounding land occupies an area, roughly rectangular in shape, about eight kilometres by two kilometres wide, but in the whole of the area, the longest possible stretch of reasonably flat ground allowed a measured base of only 400 metres length. From this base, measured with a 50 metre steel tape, a plane table triangulation of the area was constructed. The triangulation was carried from plane table sheet to plane table sheet — 10 sheets in all — two points on the border of one sheet being transferred to the adjacent sheet as a base for continuing the triangulation.

Heights are all referred to the base cairn which has been assumed to be 100 metres above map datum. As the position of this cairn can be indentified on the published map it is considered that this assumed height is unlikely to be more than 10 metres in error; but it is hoped its exact height will be determined by Mr. Jón Eyþórsson by theodolite obervations from surrounding trig. points.[1]) Heights were carried forward by a series of Indian clinometer

1) The actual height of the cairn is 104 m.

spot heights, and from these spot heights contours at 10 metre intervals were sketched in by abney level. Owing to difficulty of access the contours on the surface of the glacier are considerably less accurate than elsewhere and, in general are sketched in from rough spot heights obtained by simultaneous observations from pairs of plane table stations, made by alidade and abney level to a man walking up the middle of the glacier. In the immediate vicinity of the measured base and the datum base cairn the heights were determined by dumpy level.

The orientation of the survey depends on magnetic bearings observed within the area of each plane table sheet by prismatic compass.

The apparently superfluous detail shown in the southwest part of the map was surveyed because an interesting icedammed lake formerly existed in the area.

In addition to the 1:5,000 survey, the glacier intake area was surveyed on a scale of 1:40,000 by a compass traverse made on skis; the distances were estimated by time and the heights depend on aneroid barometer readings corrected for temperature.

In spite of its inaccuracies the survey does show that considerable changes of land and ice have occurred since the 1907 survey. Observations for ablation and rate of flow during our stay, recorded only very small changes.

We must state that we owe a great deal to the ever patient guidance of Commander Fryer with this survey work. He is, of course, in no way responsible for any errors or omissions either on the map or in the report.

REPORTS ON THE GEOMORPHOLOGY OF THE SÓLHEIMAR DISTRICT, SOUTH ICELAND

by R. Jarvis

A description of the physical features of Sólheimar district is best taken under three headings: —

Uplift.
Glacial Geology.
Post-Glacial Weathering and Erosion.

UPLIFT

The coast is characterised by pronounced features of recent uplift — a raised beach, spits, lagoons, former sea-cliffs, islands and sea-stacks, now well inland. The raised beach is, on the average 3½ km. in width, and rises from HWM to an average of 90 m. It consists mainly of shingle, with scattered large boulders up to 1½ m. in diameter — a formation known in Iceland as *sandur*.

The land rises sharply behind the raised beach as sheer cliffs in many places, these formerly rising straight from the sea. They form the southern edge of the deeply dissected plateau of South Iceland.

GLACIAL GEOLOGY

Position of the ice. Glacially-sculptured landscapes

The Mýrdalsjökull ice-cap is almost circular in area, and lies above the 800 m. contour, extending to 1493 m. above sea-leval. Its summit is 22 km. from the coast From the ice-cap there flows a radial system of glaciers.

At the time of maximum glaciation, the area would be covered by ice flowing downwards from the dome of Mýrdalsjökull. Later, when mean temperatures were higher, a position would arise comparable to that seen in parts of the coast of Greenland at the present day. i.e. nunataks, isolated hills, would appear as the quantity of ice diminished, and the downward-flowing ice-sheet would resolve itself into definite streams of ice, cleaving themselves against protruding land summits, and rejoining again. Later still, when the volume of ice had further diminished, the position was one of a few main glaciers, very much shrunken — Sólheimajökull for instance, with numerous short tongues of ice reaching 1—7 km. from the edge of Mýrdalsjökull. This is the position at the present time.

Much evidence of the former total glaciation exists in the ice-scoured topography of the plateaux lying between the gorges of present or past glaciers. The area known as Hvítmaga is a good example. Bounded on two sides by deep, glaciated valleys (one of them containing the Sólheimajökull), it stands high above the present level of the glacier and yet has an ice-scoured surface, with large roches moutonées and former ice-flow channels.

The Sólheimajökull itself flows in a gorge, the sides of which are, in places, 100 m. high, though the eastern side of the gorge is broken by several valleys that were formed by distributary glaciers in earlier days when masses of ice in this area were vastly greater than now.

These off-shoot valleys are an interesting phenomenon. There are four of them on the east side of the Sólheimajökull, the one nearest the ice-cap appearing like a hanging valley in the crags high above the glacier.

The second is similar, but lower, relative to the glacier, and wider than the first.

Both are dry valleys, each containing stream-beds formed by the glacial stream from the distributary glacier after its snout had receded almost to the main glacier.

The third valley, called Hólsárgil, is at a stage reached earlier by the first two. Instead of being open, its upper end is blocked by the side of the glacier and, although all vestige of a snout has gone, a stream flows from the wall of the glacier down the valley.

The fourth valley is similar to Hólsárgil though wider and it has a well-developed snout with lakes and *jökulá* (glacial river).

These four valleys form an interesting series illustrating their own development.

On the western side of the Sólheimajökull there is one distributary valley at the same stage of developement as number 2 valley on the opposite side.

Drift. Ablation Moraine

The Sólheimajökull has a discontinuous ablation moraine in the form of "dirt cones", irregularly distributed over the glacier and covered with basaltic dust and volcanic ash from the surrounding land and from the volcano Katla.

Small pebbles are also found on the surface of the ice, and they can be seen inside the ice wherever sections are exposed e.g. in crevasses.

Ground-moraine and End-moraines

The valley-floor down-stream from the glacier snout is deeply covered with ground moraine, continuous with and of the same sort of material as the raised beach. On this there is a succession of well-defined end-moraines some reaching to 5 m. in height, running roughly in a crescent across the valley, marking points at which the glacier snout made a temporary halt in its recession. There are no end-moraines within 1 km. of the snout, and it must be assumed that the snout has receded steadily since the formation of the last end-moraine.

Some end-moraines have been washed away at their eastern ends by the stream flowing from the fourth distributary valley, mentioned above, which rejoins the main valley 1 km. down-stream from the main glacier snout.

Among the end-moraines the present-day drainage system is indeterminate and there are several small lakes and marshes in the area.

A considerable section of the ground-moraine is exposed, due to the down-cutting of the main river, and some good examples of stratification are visible.

Lateral Moraines

Between the third and fourth distributary valleys is the only stretch on its eastern side where the Sólheimajökull is not bound by sheer cliffs, and on this more gentle slope there is a series of some twelve well-defined lateral moraines; evenly spaced and of similar size. Their form is emphasized by their vegetation, which has left the ridges bare.

One interesting formation, observed in the second of the eastern distributary valleys and in the one on the opposite side of the glacier, is a dam-like structure composed of loose morainic material, blocking the head of the valley.

This may be the lateral moraine material swept into this position when the glacier-edge was on a level with the end of the distributary valley, and left high and dry when it was reduced to a lower level.

POST-GLACIAL WEATHERING AND EROSION

A noticeable feature of the Sólheimar district is the rapid rate of weathering and erosion in those parts recently uncovered by ice.

Frost-action is the most effective weathering agent. Quite considerable basalt screes have accumulated below cliffs of the parent rock that would be concealed beneath the glacier only a century ago.

Almost every boulder in the district is in the process of fragmentation: — showing lines of fracture, or shattered into many fragments but not yet fallen apart, or split up into a series of plate-like divisions, usually standing on edge.

The most powerful agent of erosion is water, and the work of fluvial erosion is best seen in the super-deepening of the U-shaped valleys. In the valley of the former tributary glacier on the west side of the Sólheimajökull a deep gorge has been cut by the powerful glacial river to a level far below that of the floor of the U-shaped valley.

Hólsárgil, the third of the series of distributary valleys on the east side of the glacier, is a fine U-shaped valley, considerable superdeepened, as in the first example, by a stream endeavouring to reach a new base-level after a regional uplift.

The small stream which flows down Hólsárgil from the wall of the glacier is considerably aided in its down-cutting by a very powerful tributary, Lakalandsgil, which flows from a short ice-tongue near the ice-cap.

GLACIOLOGY REPORT

by M. McDonald

(For Ice Movement and Ablation see separate report)

ICEDAMMED LAKE

The 1907 Danish map of the Sólheimar region shows a lake dammed up against the ice in the tributary valley of the Jökulsá; in 1948 this lake was not in existence. A historical survey has been made of its formation and disappearance (Ref. 1), the latter being closely related to the *jökulhlaup* in the main Jökulsá valley. At present the valley is drained by a river, which has cut a deep gorge for itself, and flows to the main valley via a tunnel through the ice. Periodically this tunnel becomes blocked, causing a lake to form. The re-opening of the tunnel seems to occur very suddenly, giving rise to a rush of water from the glacier, a *jökulhlaup,* and the lake is completely drained.

Evidence of the lake can be seen high up on the valley sides. Above the present level of the glacier, on the south side of the valley, are four former shore lines very clearly marked (see the map Pl. I) and in a section of the lake bed which is now deeply cut by the river, some varved clays were found; on the north side is one terrace, probably partially due to the presence of the lake. At the same level as the highest of the shore lines there is a narrow channel between the main ridge of the Skógafjall and a very small outlier; this was apparently the outlet when the glacier was much thicker and at the period of maximum extent of the lake.

ICE FORMS.

The Sólheimajökull is a typical valley glacier, receiving its supply of ice from the south western part of Mýrdalsjökull. The form of the glacier depends almost entirely upon the terrain beneath and on either side of it. In its central portion it slopes relatively gently and is deeply crevassed only along the margins where it is in contact with solid rock. In its extreme upper reaches a wide band of transverse crevasses extends right across the glacier indicating the fairly steep slope of the substratum. The Sólheimajökull at present has two snouts, the second and minor one being at a higher altitude and lying to the east of Jökulhaus (Glacier head). A third snout is shown on the 1907 Danish map in the distributary valley of Hólsárgil. Since that time the glacier has retreated considerably and the remnants of the snout can be seen in the ice wall which exists at present. The surface of both descends rapidly to the morainic material which has been left uncovered as the glacier has retreated. In this region the glacier is very much broken up by longitudinal crevasses which became much wider and deeper as the summer went by. Constrictions due to more resistant bands of rock caused the ice to pile up. In such places the level of the ice near the margin of the glacier may be considerably higher than in the centre. The flatter part of the glacier is covered with numerous small streams which have not cut deeply into the ice. There were one or two large streams which have cut down to a depth of one or two metres; these usually have a rectangular course, following stress lines in the ice. Swirl holes are common features, the stream suddenly falling vertically an unknown distance through the ice.

The surface of the glacier is covered with very fine black dust. This dust is windblown in the first instance, and much of that on the glacier probably originated in the basaltic areas lying on either side of the glacier. The distribution of the dust is not indiscriminate; it is most abundant along the edges of the glacier and in the region of the snout. It is concentrated into series of cones lying nearly parallel to the sides of the glacier, the cones consisting of solid ice with a layer of dust about 1—2 cm. thick covering them more or less completely. The size of the cones varies from about 10 cms. to 4 metres in height. They probably owe their origin to the transport of loose material on to the glacier by wind and its concentration into definite lines by water flowing on the ice surface. The black dust protects the ice beneath and hastens the melting of the surrounding ice during sunny periods. The eventual size of the cones seems to depend on the area which is initially covered by dust. It is possible that some of the material of which the dirt cones are made is thrust upwards from lower levels in the ice; in several places along the ice margin the different ice layers can be clearly seen, with a well defined dirt layer between them.

Apart from the longitudinal alignment of dirt cones there is a curved arrangement of debris on the glacier. These curves extend furthest down the glacier in its centre and are clearly related to the differential rate of movement which produces radial stresses.

Between the moving ice of the glacier and the rocky exposed valley sides there is often a zone of dead ice. This appears to be quite detached from the glacier itself and is almost unrecognisable, being covered by gravel and debris.

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REPORT ON GLACIER

by I. W. Paterson

The glacier is about 8 km. long and from 1 to 2 km. wide. The snout is 8 km. from the sea and its altitude is about 100 metres.

There is a deep gorge on the east side of Skógafjall in which the dangerous river *Jökulsá á Sólheimasandi* has its head spring. It disappears through an ice tunnel under the glacier and comes out on the west side of the snout.

Much of our work was connected with recession of the ice, which has speeded up in recent years. In 1820 *Jökulhaus* was completely covered by ice. In 1930 ice covered the top ridge on this isolated hill and there was ice well down the Gil to the east of Jökulhaus where there is now only a very minor snout. (Ref. 1.)

The snout was very crevassed and there were numerous dirt cones. High up, the crevasses were less common and it was possible in places to walk easily on to the glacier, the dirt cones were also fewer but in groups until one reached the top of the glacier where they were concentrated at the sides of the glacier and were very much bigger than those at the snout. The size ranged from a few inches to twenty feet.

Direction of crevasses seemed to be in the main, at right angles to the line of flow save at the snout, where they moved round fan-wise so that all those in front-centre of the snout were parallel to the direction of flow.

ICE MOVEMENT

Total Movement of glacier over a period 22nd July until 31st August, 1948 — a period of 40 days is shown in the following table.

The stakes or flags are located as shown on the map of the snout of the glacier.

The results tabulated are for the lower part of the outlet glacier, from calculations made by taking compass bearings from stakes in the ice on to fixed points on the ground.

The stakes were to have been placed at intervals along the centre of the glacier from the snout. This was not however possible due to the nature of the surface of the ice. The first problem encountered was in drilling the ice, the drill made by an expert firm was unsatisfactory — since pressure at the drilling points produced meltwater which did not permit the drill to bite. Grit from the dirt cones was fed to the drilling point but this achieved very temporary success. It was discovered that the handle was much more effective than the actual drill. It became neccessary without delay to find some means of making holes in the ice and under Mr. Eyþórsson's guidance another drill was devised. The new drill was a cold chisel fitted into the end of a hollow steel shaft; with this apparatus it was possible for one person to make a hole half a metre deep in about 8 or 9 minutes — though at greater depths the shaft would stick in the ice unless vigorously agitated. Thus we were able to measure the movement of only the top layer (2—3 feet) of ice but at the snout this layer will have the most rapid movement. We are aware of Demorest's work and Streiff-Becker's hypothesis asserting that the substrata move more quickly than that at the surface — at the snout, however, where the glacier is not in such a deep trough it is improbable that differential movement will be greater than surface flow. (Ref. 2.).

The next problem was caused by the numerous difficult crevasses in the lower part of the glacier. It was desirable to have stakes situated along a not too difficult route so that they could be inspected and ablation measurements taken every few days.

Commencing at the snout it was not a practical proposition to proceed beyond Flag No. 7. Furthermore, it was impracticable to get on to the glacier anywhere other than at the snout or at the head of the glacier. Thus the intention of setting up a continuation to the series of stakes was abandoned. Once on the glacier away from the snout and ice margin the surface was much less broken by crevasses and the dirt cones more localised. The direction of movement at a casual glance would appear far from satisfactory but it can in my opinion be explained by the obstruction of the hill Jökulhaus, the nature of the crevasses and the position of the planes of slip in the vicinity of each stake or flag.

Considering each flag independently:—

MOVEMENT OF SÓLHEIMAJÖKULL

Flag No.	Total Movement (in metres). 22. July—31. Aug.	Resultant Directions. (Magnetic).	Speed in metres per day. (Average over the whole period).
1.	30.60	272°	0.765
2.	50.30	227°	1.238
3.	22.60	248°	0.565
4.	42.60	253°	1.065
5.	43.00	288°	1.075
6.	25.00	308°	0.625
7.	36.00	351°	0.900

Comments on the Movement of the Stakes

Flag 1. No comment.

Flag 2. The movement appears rather high. The stake was placed on a high ridge near the head of a deep crevasse which was continually opening up. This may have affected the direction as well.

Flag 3. Movement rather low. The stake was placed amongst crevasses and dirt cones.

Flags 4—6, no comment.

Flag 7. The direction can be explained by the affect of Jökulhaus cutting into and slightly deflecting the glacier.

RECESSION OF ICE EDGE AT GLACIER SNOUT

Measurements from 29th July, 1948

DATE	RECESSION	TOTAL RECESSION
29.7.48	—	—
7.8.48	2.00 m	2.00 m
13.8.48	2.17 m	4.17 m
16.8.48	1.87 m	6.04 m

Average recession of snout — 26.4 cm/day.
— — in August (7th—16th) — 44.9 cm/day.

It was decided to measure the recession of the snout at an arbitrary point.

At a point marked X on the map, a stake was placed exactly 2 metres from the ice in a particular direction. By taking all measurements in the same direction and by moving the stake from time to time over a period of 23 days, it was possible to make an assessment of the present rate of recession of the glacier tongue.

The period 7th—16th August was probably the warmest period of the summer, and it was very apparent during this warm spell, even from a casual observation, that the whole ice edge at the snout was retreating about half a metre per day. The thinning of the snout was most marked as will be seen in the ablation results. (Ref. 4).

An attempt was made to measure local differential movement in various crevasses. The pins driven into the ice and aligned with a plumb-line, did not stay in the ice but were squeezed out in only a few hours. Long screws should be used on any future occasion. (Ref. 3.).

ABLATION ON THE GLACIER

The results tabulated are a record of ablation from 22nd July to 31 August 1948, a total period of 40 days. Commencing on the first day the figure under each date gives the total melt for the particular stake. From this data the average daily melt in July and August has been deduced.

ABLATION ON SÓLHEIMAJÖKULL

(Readings in cm)

Flag No.	Height ab. S. L. m.	22/7/48	24th	27th	29th	31st	2/8/48	7th	10th	11th	13th	16th	18th	21st	24th	26th	31st
1.	120	—	14	46.4	61.5	74.4	76.5	118.5	132.9	137.4	154.9	174.3	190.3	213.3	229.9	235.9	276.7
2.	160	—	11	26.2	39.2	56.2	63.4	102.9	108.5	113.3	130.3	147.9	162.6	183.1	197.1	202.1	242.1
3.	185	—	12	42.5	57.3	76.3	86.0	120.8	133.7	140.3	156.3	160.4	172.1	193.1	204.8	210.2	246.2
4.	210	—	10.5	36.7	50.5	55.7	62.0	89.0	102.0	105.6	114.0	120.9	131.1	149.6	160.9	170.1	214.1
5.	225	—	10.5	38.5	52.5	61.5	70.0	100.7	115.4	118.9	131.4	145.1	156.5	173.6	179.3	182.4	221.4
6.	238	—	13.5	46.3	63.1	71.3	80.6	113.6	129.6	136.5	150.6	169.9	182.6	203.1	215.5	222.6	264.6
7.	248	—	12.3	49.5	70.8	81.5	90.7	125.2	137.4	142.7	153.4	161.1	175.0	198.0	210.6	218.1	264.6

AVERAGE MELT IN CENTIMETRES PER DAY

FLAG No.	JULY 22nd. — 31st.	AUGUST 1st. — 31st.
1.	8.27	6.52
2.	6.24	5.99
3.	8.48	5.45
4.	6.19	5.11
5.	6.83	5.15
6.	7.93	6.22
7.	9.05	5.90

Rain caused more ablation than increasing temperature, because the rain tended to remove the broken surface of the ice and to wash away all grit and dirt which was providing a partially insulating blanket.

According to Sigurdur Thorarinsson in his "Ice Dammed Lakes of Iceland" the glacier snout has thinned more than 4 metres per year in the 1930ies. The figures given in this report also tend to suggest a higher figure than 4 metres per year. (Ref. 5.).

PIT NUMBER 1

The Pit was situated at Flag No. 22, about 1290 m above Sea level, near the Summit of the Ice Cap and just within the Intake Area of the Sólheimajökull. (Ref. 6).

Depth in Cms	*Account of Pit Profile by Mr. Jón Eyþórsson*
0 — 56	Wet snow.
56 — 78	Finer and more homogeneous layer.
78 — 170	Coarse snow with thin ice layers.
170 — 172	Ice layer.
172 — 180	Tightly packed snow.
180 — 185	Diffuse ice layer.
185 — 200	Fine grain snow.
200 — 345	Snow with ice layers.
345 — 355	Coarse wet layers of snow with slight brown dust.
355 — 420	Snow.
420 — 424	Thick hard ice layer with large very distinct crystals.
424 — 524	Coarse crystalline snow with some hard ice layers.
524 — 600	Firn.

On 18th July, 1948, Pit no. 1 was started at Flag no. 22 on the high plateau. Digging commenced under the very worst conditions and the following day, the 19th, it was continued under Mr. Eyþórsson's guidance. It was a pit over 3 meters deep at this stage. On the 20th July the weather improved and the depth was increreaced to about 6½ metres. Here Mr. Eyþórsson completed his account of the snow and ice layers.

It had been hoped to establish the amount of accumulation for one year by measuring from the datum line of the Hekla ash layer. Hekla erupted March 29th, 1947, and some of the dust cloud was blown to the South. This ash should appear as a black line beneath the accumulation which had fallen since the ash was laid down, but no such layer was found. Although pumice grains from Hekla were abundant at the main Camp near the snout of the glacier, local people stated that Mýrdalsjökull itself had remained "white" during the eruption, while its neighbour towards the west, the Eyjafjallajökull, had been quite "black".

A number of snow densities were taken at various depths (Ref. 3 and 4) but before further work could be done this pit was levelled off by a storm.

RECORD OF SNOW DENSITIES

Depth in Cms	Density
50	0.49
150	0.61
250	0.62
350	0.60
450	0.60

CONCLUSION

Owing to the very high precipitation it was necessary to dig very deep for a few results. In other parts of the world it is often possible to examine several years' accumulation in a pit of similar depth. (Ref. 7). The high precipitation accounts for the existence of ice caps in such a temperate area.

PIT NO. 2

This pit was situated at Flag No. 18 at the approximate Snow Line on the western slope of the ice cap. Digging was started twice because of the same storm which levelled off Pit No. 1., but it was finally completed to a depth of 6.5 metres. No Hekla ash layer

PIT NO. 2

Depth in Cms	*16.8.48*
0—17	Coarse granular snow.
17—17.4	Ice band.
23—23.4	Ice band.
17—44.	Coarse granular snow.
44—44.8	Ice band.
44.8—83	Snow is more granular.
83—83.6	5—6 mm. Ice band. } More granular type snow with thicker ice bands.
115	8 mm. Ice band.
130—132.5	2.5 cm. Ice layer.
132.5—150	More homogeneous — granules forming closed chains.
195	8 mm. Ice band.
205	1 cm. Ice band.
150—230	Coarse granular snow.
230—248	Globules of ice in the snow with obvious air pockets.
248	6 mm. Ice layer.
248—287	Thin ice layers every 1 cm. (2—4 mm. thick).
287	6 mm. Ice layer.
287—309	Non-horizontal ice layers in coarse grain snow.
309—350	Thicker ice layers at increased intervals. More homogeneous.
350—375	Coars grain more homogeneous (2.5 mm. diam. of grains).
375—380	Coarse grain homogeneous snow with numerous ice layers.
380—450	Grains less apparent but a more solid mass. — *Firn.* Thin ice layers 1—3 mm. thick.
450—490	Firn with thin ice layers 15 cms apart.
490	Two thin ice layers almost coincident (8 mm. thick).
494	5 mm. Ice layer. } Discontinuous ice layers, not horizontal.
497	1 cm. Ice layer.
514	1 cm. Ice layer.
530—531.5	1.5 cm. Ice layer.
560—564	4 cm. Ice layer.
564—566	2 cm. Ice layer.
566—582	Firn.
582—586.5	4.5 cm. Ice layer.
586.5—6.50	No ice layers.

was found in the pit although it was found in a nearby crevasse at 3.5 metres. Mr. Eyþórsson, who was not present, was of the opinion that this ash or dust layer probably was the Hekla ash layer.

The account for Pit No. 2 was made by Messrs. Lister and Paterson with the greatest care and although establishing firn at 3.80 metres may appear a little doubtful, it seems very unlikely that it should not be present until at an even greater depth particularly since this pit was so near the snow-line.

It is possible that the rather unusually high figures for the snow densities is due to thin ice lenses and layers; this is particularly marked at 2.50 metres.

Temperatures were taken at various levels on Aug. 16th with the utmost care. The snow was somewhat waterlogged, so the densities were high and the temperatures were about freezing point, as might be expected.

Crystal rubbings made on the ice band at 5.60 metres showed the air in the ice had become isolated pockets, appearing like distorted bubbles. The air in the firn was interconnecting through the crystal complex. (Ref. 3.).

SNOW DENSITIES

Densities were only taken on one day, 16.8.48. A copper density cylinder was used of capacity 275 ccs. and when packed with snow it was placed in a warm water bath with the open end free to atmosphere.

Depth in Cms	Density
50	0.62
100	—
150	0.81
250	0.80
350	0.72
450	0.70
500	0.68
550	0.76

CREVASSE BETWEEN FLAGS 17 and 18

On the 15/8/48 Mr. Lister was lowered into the crevasse with the aid of a climbing rope to collect the data which are given below and to examine the ash layer. This was a most arduous task owing to falling snow from overhanging cornices, collopsing snow ridges and the severe cold due to the high wind.

The snow density taken just above the supposed ash layer is rather high but it might tend to support our conclusions because it corresponds with the density taken in the Pit just above where firn was found.

It was not possible to make use of crevasses earlier because it was not until August that they began to appear high on the Ice Cap.

OBSERVATIONS

At 3.50 metres depth there was a 1.5 cm. ice layer and just below a 0.5 cm. ash layer; the ash was being washed down into the snow.

DENSITY

A snow density was taken at a depth of 3.35 metres or 15 cm. above the ash layer. — Snow density was 0.70.

RECORD OF ABLATION ON THE ICE CAP

(18th July — 30th August, 1948)

Stakes with flags were placed on 18th July under the guidance of Mr. Eyþórsson using a compass due to bad visibility. These stakes were 10 ft. canes painted with white and black bands, each band being 10 cm. which made it easy to take a quick accurate ablation reading. The figures given under the date 18.7.48 give the depth in cms. to which each stake was sunk into the snow. The results seem to suggest that August is the only month in which there is appreciable melt on the high plateau of the Ice Cap, i.e., flag No. 20, 21 and 22. Readings were discontinued only because no more snow remained at a particular stake and the stake had fallen out and became virtually surrounded by ice.

These results tend to show that the snow line passes between flags 17 and 18 nearer to flag 17. By 21st August only a little snow remained at flag 17 and by 30th August practically none.

Flag 20 was the highest, 21 and 22 were on the Plateau but appear within the Intake Area of the Sólheimajökull.

ALTITUDES AND POSITION OF THE FLAGS

The positions of the flags have been plotted on the map of the Glacier Intake Area from a compass traverse done on skis. Their altitudes were calculated from barometric readings the daily zero being readjusted at the High Level Camp (Camp IV) after its height was established at 2460 ft. above sea level assuming the Base Camp to be 100 metres or 328 ft. above s.l. (Ref. 9.).

JULY

Flag No.	Altitude above sea level in metres	Depth of Stake in Cms on Date Shown					Total Melt	Average Melt per day
		18-7-48	19th	20th	21st	30th	Cms	Cms
11	765	200	190	—	182	115	85	7.08
12	846	115	105	—	100	45	70	5.80
13	973	105	95	—	89	32	73	6.08
14	1,007	150	153	130	145	87	62	5.21
15	1,041	150	145	142	137	85	65	5.42
16	1,070	160	158	155	153	109	51	4.25
17	1,145	150	150	145	145	108	42	3.50
18	1,195	137	130	132	130	105	32	2.66
19	1,251	130	152	150	150	139	ø 9	ø 0.75
20	1,296	150	137	154	155	150	00	0.00
21	1,293	150	154	152	155	163	ø 13	ø 1.08
22	1,291	150	—	165	163	168	ø 18	ø 1.50

AUGUST

Flag No.	2.8.48	5th.	8th.	11th.	16th.	20th.	21th.	30th.	Date on which stake is assumed cut.	Total melt in Aug. Cms	Av. melt in Cms per day
11	99	47	61	47	44	24	13	—	23rd	115	4.79
12	31	12	—	—	—	—	—	—	7th	45	5.63
13	11	—	—	—	—	—	—	—	5th	32	5.33
14	77	x	33	24	15	—	—	—	20th	88	4.16
15	70	x	35	25	10	—	—	—	19th	85	4.25
16	98	x	62	52	40	x	18	—	27th	109	3.91
17	95	x	55	46	36	x	x	—	29th	108	3.61
18	91	x	101	102	x	x	x	33	—	72	2.32
19	20	x	101	102	x	x	x	56	—	83	2.68
20	143	x	115	124	x	x	x	96	—	54	1.75
21	154	x	140	142	x	x	x	101	—	62	2.00
22	163	x	138	142	x	x	x	116	—	52	1.68

x No reading taken on this date.

N.B. ø indicates accumulation, not melt.

TOTAL ABLATION FOR SÓLHEIMAJÖKULL 1907—1948

As a result of a comparison of two maps,

(a)	1907	1:100,000	enlarged to 1:20,000
(b)	1948	1:5,000	reduced to 1:20,000

— it was possible to draw certain conclusions. The results have been set forth in the form of 3 diagrams and 2 tables from which one can more easily assess the difference in the conditions of this glacier over a period of the last 41 years. These results however by their nature can only be approximations and only take into account the actual valley glacier.

From observations made in 1948 it has been asumed that the area of the Intake Area has not appreciably altered but that the ablation area has slightly increased at the expense of the accumulation area. The two nearest weather stations Vestmannaeyjar and

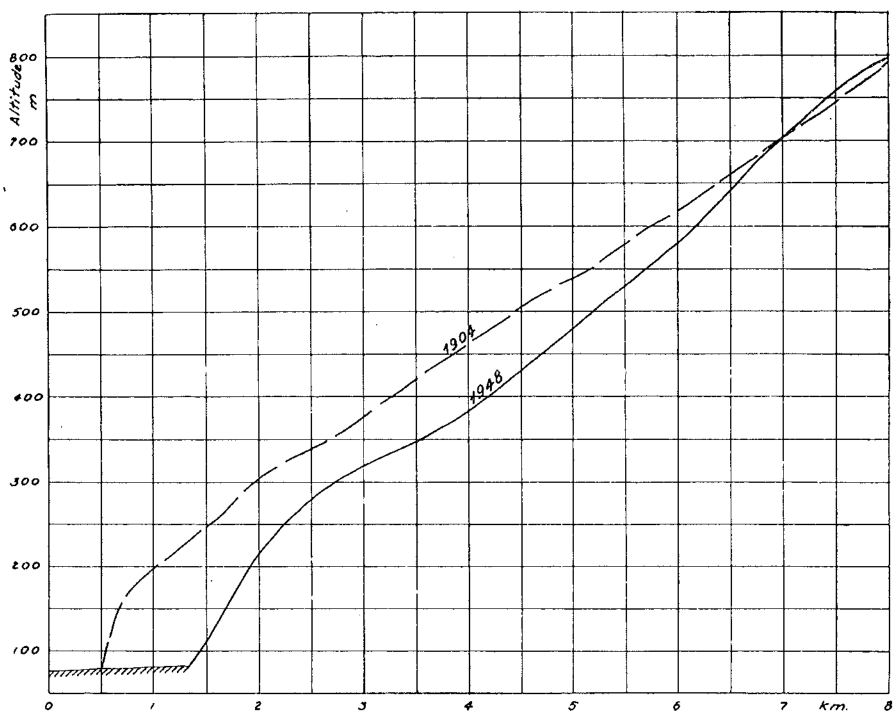

Fig. 3. — Longitudinal section of Sólheimajökull.

Fagurhólsmýri show rises of about 0.7° C and 1.5° C respectively for the mean annual temperature, this would tend to point to an increase in the altitude of the Snow Line. Therefore an increase in ablation and a slight reduction in accumulation area have caused a shrinkage of this glacier.

The diagram Fig. 3 shows a longitudinal section of the glacier from an imaginary view east to west. It is the elevation to scale of a plane passing through the centre of each 20 m contour on the 1907 map and the corresponding plane on the 1948 map.

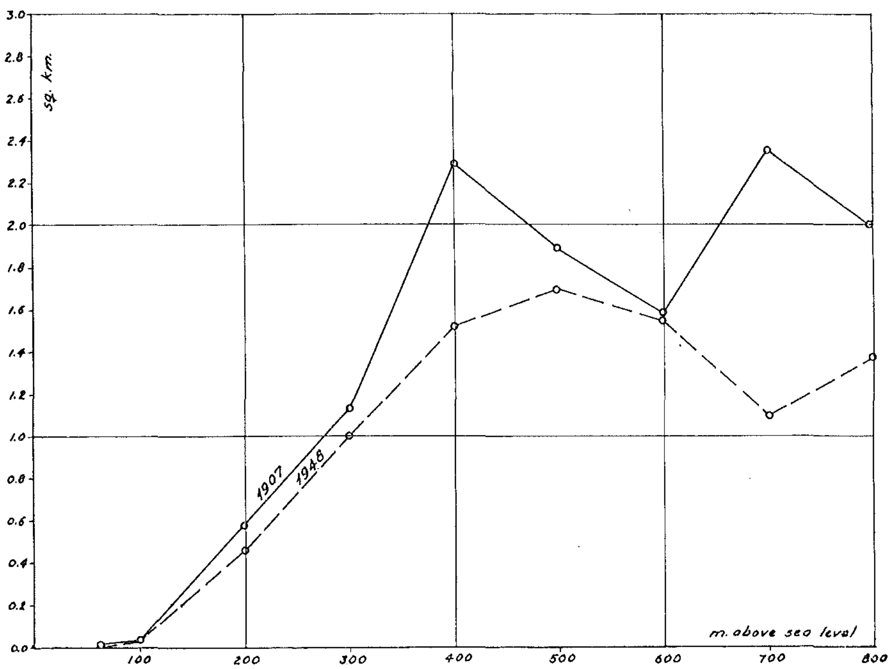

Fig. 4. — A graph showing the areas between 100 m contours.

The diagram Fig. 4 is a graph of the areas between 100 m contours.

The diagram Fig. 5 is a comparison of 100 m contours on both maps from a plane view.

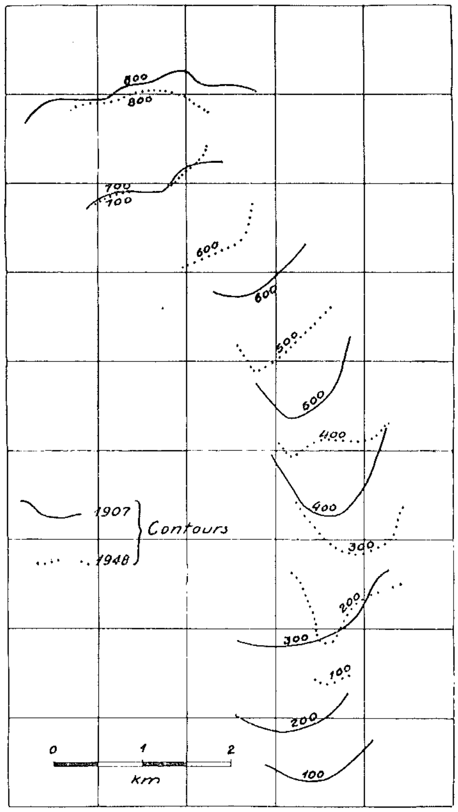

Fig. 5 — A comparison of 100 m contours on the maps of 1907 and 1948.

APPROX. REDUCTION IN THICKNESS AND VOLUME 1907—1948

Contour interval	Area 1907 sq. km.	Approx. Reduction in thickness by 1948	Approx. ablation in cu. metres.
70 — 100 m	0.03	15.0 m	0.45 × 10^6
100 — 200	0.58	62.4	36.2
200 — 300	1.12	137.6	154.1
300 — 400	2.26	82.0	185.3
400 — 500	1.88	67.0	126.0
500 — 600	1.56	37.0	57.7
600 — 700	2.34	16.8	39.3
700 — 800	2.C0	—12.0	— 24.0
	11.77 sq. km.		**474.8 × 10^6 cu. m.**

DIFFERENCE IN AREA 1907 AND 1948

Contour interval	Area in sq. km.		Difference in area
	1907	1948	
70m — 100	0.03	0.03	——
100 — 200	0.58	0.46	0.12
200 — 300	1.12	1.00	0.12
300 — 400	2.26	1.52	0.74
400 — 500	1.88	1.68	0.20
500 — 600	1.56	1.54	0.02
600 — 700	2.34	1.08	1.26
700 — 800	2.00	1.36	0.64
Totals	**11.77**	**8.67**	**3.10**

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REPORT ON THE SILT CONTENT OF GLACIAL RIVERS

by R. Walker

As collection of silt was undertaken at short notice, it was impossible to obtain properly designed collecting vessels (indeed there are no very efficient means yet devised) or to analyse the samples fully, nor could the discharge of the streams be measured with the available equipment — the speed of the Jökulsá makes this a difficult undertaking. Concentration on the main work of the expedition made the silt sampling a very secondary duty. Thus, the results are neither full nor accurate but they do serve to show the great variation of silt with variations in weather.

Samples were collected in tins holding 600 c.c., and these were filtered to obtain the insoluble silt. Owing to the absence of non-corrosive containers, the samples could not be brought home for the analysis of soluble matter.

THE RIVER JÖKULSÁ

Then river has several sources. The eastern glacier tongue is the origin of one arm of the river which joins the western arm below the points at which samples were taken. This arm is also fed by several non-glacial streams.

The western branch has a more complex origin. It is fed by the river from the ice-cap which flows through the ice-tunnel of the western snout (See Geomorphology Report) by the streams emerging at the snout itself and by a non-glacial stream from the western ridge of the Sólheimar valley joining the main stream at the point where it emerges from the glacier snout. Thus, except for the sample taken at the snout, none of the samples obtained were from rivers of purely glacial origin.

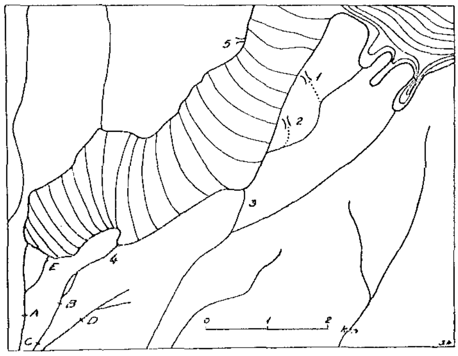

Fig. 6. — Sketch map showing the position of Silt collections and the distributary valleys mentioned on p. 19.

The sampling points (cf. Fig. 6) were: —

A — on the western arm of the river 1,200 metres from the glacier snout.

B — on an equivalent place on the eastern arm.

C — on the eastern arm 2,750 metres from the eastern snout.

D — on a non-glacial tributary, 2 metres from C.

E — 2 metres from the glacial snout.

A sample was also taken on the coastal plain in the Hólsárgil, the origin of which are several streams emerging from the ice-cap to the east of the Sólheimar Glacier and many non-glacial tributaries rising in the uplands between the ice-cap and the coastal plain.

The presence of non-glacial water partly accounts for the lower percentages of silt obtained than in the Austurfljót to the south of the Vatnajökull by the Swedish-Icelandic Expedition. (Ref. 1).

An analysis of the results indicates that the silt content is low during periods of dull weather and high during periods of heavy rain and fine weather when ablation on the glacier and ice cap is high. At both these periods the river is full, its speed is higher and the amount of detritus carried is greater as shown by Oldham. (Ref. 2).

Lewis (Ref. 3) has shown that in braided glacial streams, an increase in the amount of water does not materially affect its speed but in the Jökulsá, particularly in the western arm, at point A, the river is not extensively braided. A is situated in a gorge cut through the moraines and consequently the river is concentrated

RESULTS

Sample	Date	Time	Point at which taken	Silt cont. mgm/litre	Remarks
1	1/8	18.30	B	256.0	After 3 days of
2	1/8	19.00	A	283.3	fine weather.
3	22/8	16.30	A	42.3	A dull day.
4	23/8	11.00	A	24.7	A dull day.
5	23/8	17.00	C	303.3	Glacial stream after a period of heavy rain.
6	23/8	17.00	C	2.8	Non— « « etc.
7	24/8	14.00	E	371.5	After a fine
8	24/8	14.30	A	40.8	morning following dull weather.
9	24/8	19.30	Hólsár — gil	17.3	After an hour's heavy rain.
10	26/8	14.00	A	40.8	A dull day.

into one channel. In no place is the Jökulsá as extensively braided as are the sandur rivers to the south of the Vatnajökull.

Samples 5 and 6 show the great difference in the silt content of the glacial and non-glacial streams, an indication of the difference in the snout of fine material available for transportation.

Samples 7 and 8 show the large amount of suspended material at the glacier tongue as compared with a point 1,200 metres away. Sample 8 indicates that the silt content that day was not high. Unfortunately no sample could be taken at E when the river was high.

River Speed.

The speed of the river was obtained by the somewhat primitive method of timing pieces of the wood floating on the surface over a measured distance. The average of the results obtained gave a speed of 9.7 km/hour. This was done on the 29th of August when the river was full.

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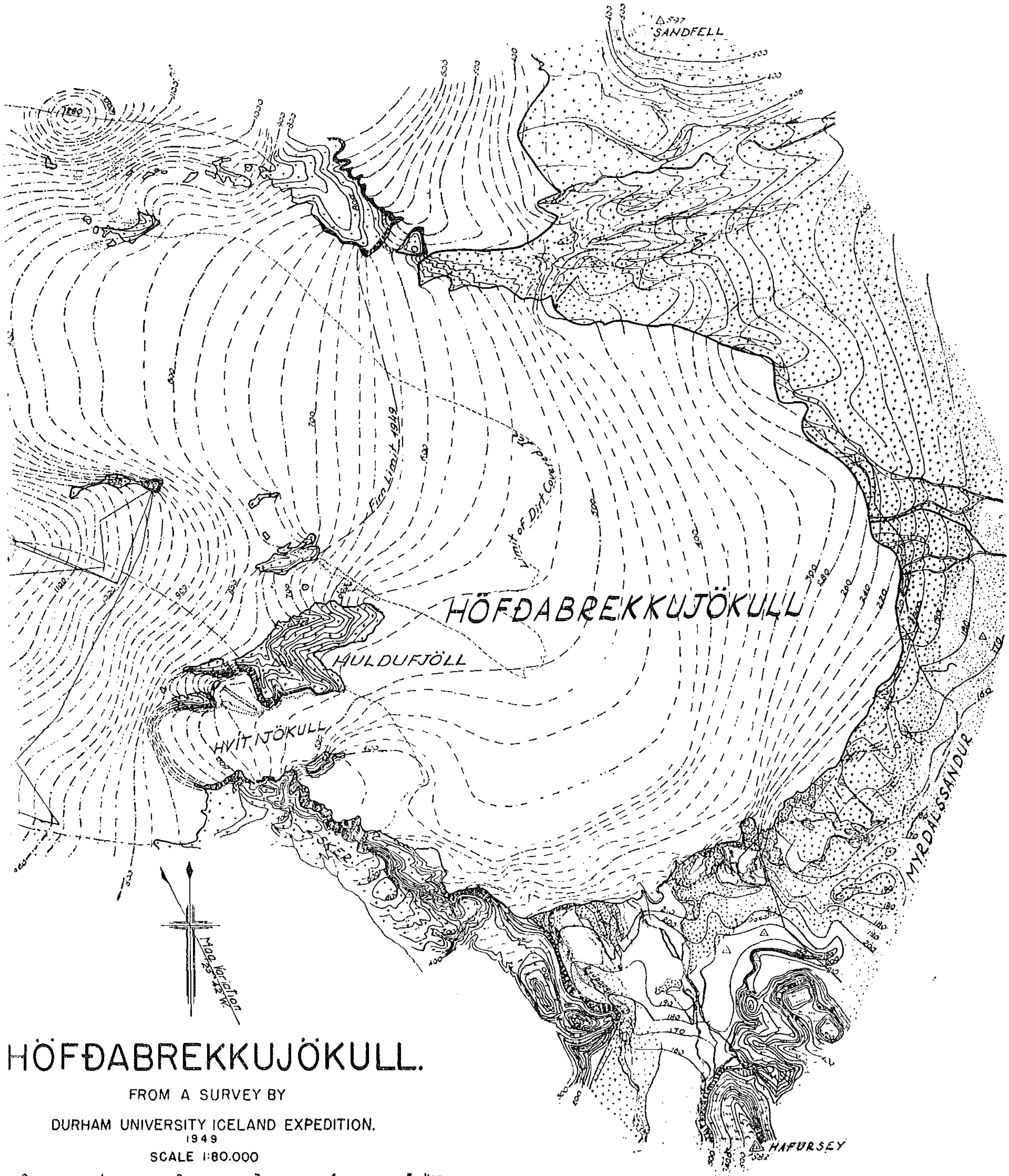

HÖFÐABREKKUJÖKULL.

FROM A SURVEY BY

DURHAM UNIVERSITY ICELAND EXPEDITION.
1949

SCALE 1:80.000

0 1 2 3 4 5 Km.

SÓLHEIMAJÖKULL

FROM A SURVEY
BY
DURHAM UNIVERSITY ICELAND EXPEDITION
1948

SCALE 1:20.000