GLACIOLOGICAL OBSERVATIONS ON MORSÁRJÖKULL S.W. VATNAJÖKULL

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Concluding glaciological observations of the Expedition to south-east Iceland, 1953, organized by the University of Nottingham Exploration Society.

Part II: REGIME OF THE GLACIER, PRESENT AND PAST

Abstract. Information concerning the supply area of Morsárjökull, a small outlet glacier of Vatnajökull, was derived from a firn profile measured in a pit 6 m. deep.

The conspicuous bulge on the medial moraine is, by extrapolation from the annual movement, attributed to a former glacial recession between 1890 and 1900. This bulge is correlated with discontinuous moraines near the head of Skeidarárjökull.

Moraines indicating a former greater extension of the glacier are mentioned and evidence showing the recent rapid retreat and thinning of the glacier is presented.

Zusammenfassung. Die Kenntnisnahme des Sammelgebietes des Morsárjökull, einem kleinen Auslaufgletscher des Vatnajökull, wurde in einer 6 m tiefen Grube gemessenen Firnseite entnommen.

Die an der Mittel-Moräne sichtbare Ausbauchung wird, durch Extrapolation der jährlichen Bewegung, einem ehemaligen Gletscherrückgang zwischen 1890 und 1900 zugeschrieben. Diese Ausbauchung wird mit diskontinuierlichen Moränen nahe dem Ausläuf des Skeidarárjökull in Beziehung gebracht.

Moränen, die auf eine ehemals grössere Ausdehnung des Gletschers hinweisen, werden erwähnt, und der Beweis für den jüngst reissenden Rückgang und Schwund des Gletschers wird dargelegt.

I. Regime of the Glacier

Observations made on Vatnajökull between 1936 and 1940[1] indicate that the gross accumulation and ablation on the ice cap are very great. In order to estimate the amount of net accumulation in the supply area of Morsárjökull a pit 6·1 m. deep was dug in the firn at the Ice-camp, 2·5 km. north of Midfellstindur, at 1200 m. above sea level (see Fig. 1, p. 479). Two distinct horizons, marked with dust, showed the autumn surfaces of 1952 and 1951. The two surfaces were separated by 2·38 m. of firn, indicating that in this area there was a considerable depth of surplus accumulation left over from the 1951–52 winter. The 1952 autumn horizon was covered by 2·84 m. of firn. This depth, however, would not be surplus accumulation for the 1952–53 winter, as the pit was dug in mid-July and the ablation season in this area may be expected to extend throughout September, according to Ahlmann.[2] Subsequent ablation measured near the pit between 15 July and 11 August accounted for a further 1·113 m. of this, giving a daily average ablation of 40·5 mm. Allowing for a fall in daily ablation towards the end of the ablation period, at least another 0·915 m. may be expected to be lost, leaving a 1952–53 winter surplus of only 0·818 m. in this area.

By mid-July the snow line had risen above the ice fall which feeds the glacier to about 1100 m. Very little solid precipitation was recorded at the Ice-camp between 15 July and 11 August, although rainfall was considerable (493 mm.).

Ablation measurements were made daily during the same period on fifteen stakes placed in the firn running in a straight line from the Ice-camp southwards to the ridge east of Midfellstindur. Average daily ablation for all pegs was 45·3 mm. Variation in daily ablation and from peg to peg was noticeable. The summer has been described as one of the hottest in living memory, so that these figures of ablation are probably somewhat in excess of an average year. Similarly the 1952–53 winter brought mild conditions to the farms on the low ground where snowfall was slight. It may be assumed that accumulation on the firn fields was also below normal.

From the specific gravity measurements shown on the firn profile (Fig. 2, p. 481) the average specific gravity for the two seasons 1951–52 and 1952–53 are respectively 0·610 and 0·575. The total accumulation area has been estimated as 24 sq. km. and 23 sq. km. respectively for the two seasons. This gives a total net accumulation of 34·8 million cu. m. of water for the season 1951–52 and of 10·8 million cu. m. of water for 1952–53.

It is interesting to compare these figures with those recorded by Ahlmann and Thórarinsson [2] for Hoffellsjökull 1935–38. They give a net accumulation of 260 million cu. m. of water in an area of 163·2 sq. km. for 1935–36, and of 90 million cu. m. of water in an area of 75·55 sq. km. for 1936–37. The latter year shows a remarkable correspondence with the figure for 1951–52 for Morsárjökull. With an accumulation area of approximately one-third of that of Hoffellsjökull, the total net accumulation of Morsárjökull is also about one-third. But this was Ahlmann's smallest accumulation measurement. On the other hand the 1951–52 estimate for Morsárjökull is more than three times that of the following year.

These figures show the great variation in annual accumulation on the glaciers issuing from south Vatnajökull. The recent limited observations also indicate a marked amelioration of climate in the eighteen years. 1952–53 has been a particularly lean year in the nourishment of Morsárjökull.

Ablation below the firn line in the "ablation area" itself was not directly measured. Numerous waterfalls of considerable size flowed down the rock wall of the glacier, and much surface water indicated that the amount of ablation even on the upper part of the glacier is considerable. Ablation probably continues throughout the winter on the lower levels of the glacier.

The speed of flow was measured on the upper part of the glacier, where it flows as two distinct streams. The observations were made from 29 July to 14 August, mainly at two-day intervals. The south-east ice stream, which breaks into avalanches, moved somewhat faster than the continuous ice stream.

One conclusion seen from the observations is that the flow is irregular. Considerable variations occur between each two-day period, and the ratio between the flow of individual stakes also varies. It was noticed that movement was greater after periods of heavy rainfall. Increased temperature, as the chief cause of an increased supply of melt water, has been cited as the main cause of increased speed of flow.[3, 4, 5] The temperate nature of this glacier, however, reduces the effect of temperature changes. During the period of observation temperature variation was small, so that the supply of melt water would be fairly constant. The period may be divided into an early dry one and a later rainy one, it was during the later period that speed of flow was noticed to increase. A two-day lag appears to occur between the rainfall and the increase of speed of flow (see Fig. 3, p. 481). The precipitation rather than the temperature in this case probably caused an increase in the amount of percolating water in the glacier. Thus there appears to be a correlation between precipitation, recorded daily at the Base-camp and the Ice-camp, and the speed of flow of the glacier.

II. Evidence of Past Variation in the Glacier

There is abundant evidence to indicate that Morsárjökull is rapidly decaying. The Geodætisk Institut of Copenhagen map, surveyed in 1904, shows the glacier extended to its second terminal moraine and the main glacier fed by three tributaries. Compared with the present position very little of the rock wall was exposed.

Between 1932 and 1947 the glacier snout receded 413 m.[6] Recent figures give the retreat of Morsárjökull for 1947–50 as 93 m.[7] The plane-table survey, made in the summer of 1953, on a scale of 1 : 12,500, of the area between the 1953 ice-front and the outer terminal moraines, shows a total retreat of 1000 m. since 1904 (see Fig. 4, p. 481). This retreat has been accompanied by pronounced thinning, which has seriously affected the present condition of the glacier. The eastern tributary in Birkidalur broke away in about 1934. Between 1937 and 1938 the central tributary disconnected, and during the period 1904–1953 the width of the ice fall of the north-western tributary narrowed considerably. Comparison of photographs taken by Ingólfur Ísólfsson and those taken in 1952 and 1953 shows this gradual process very well. A thinning of about 90 m. during the past fifty years is a rough estimate, based on perched lateral moraines on the south-eastern side of the glacier on the 1904 map and on comparison with the ice level at present.

Dead ice was observed in the moraine at about 30 to 40 m. above the present glacier surface. Although the moraine was inaccessible so that exact measurements could not be made, it does give some indication of the great extent of recent wastage. The glacier has also narrowed considerably in the area where flow was measured.

The recent variations in the state of Morsárjökull have an interesting bearing on the peculiar medial moraine. The moraine, extending down-glacier form the rock wall, and composed mainly of frost-shattered fragments of agglomerate from it, is entirely superficial. A melt water stream had cut through the moraine, exposing a section showing 3·5 m. of clean ice below the thin layer of detritus. More than half-way down the glacier the moraine gradually extends in width and develops an extensive bulge, below which it narrows again. The following explanation of this feature is tentatively proposed. Changing climatic conditions result in the exposure of different widths of rock wall, as indicated above, and this results in a varying supply of detritus for moraine formation. The photographs taken from the summit of Kristinartindur between 1936 and 1948 by Ingólfur Ísólfsson, and in 1952 and 1953 by the authors, show the down-glacier movement of the bulge. The

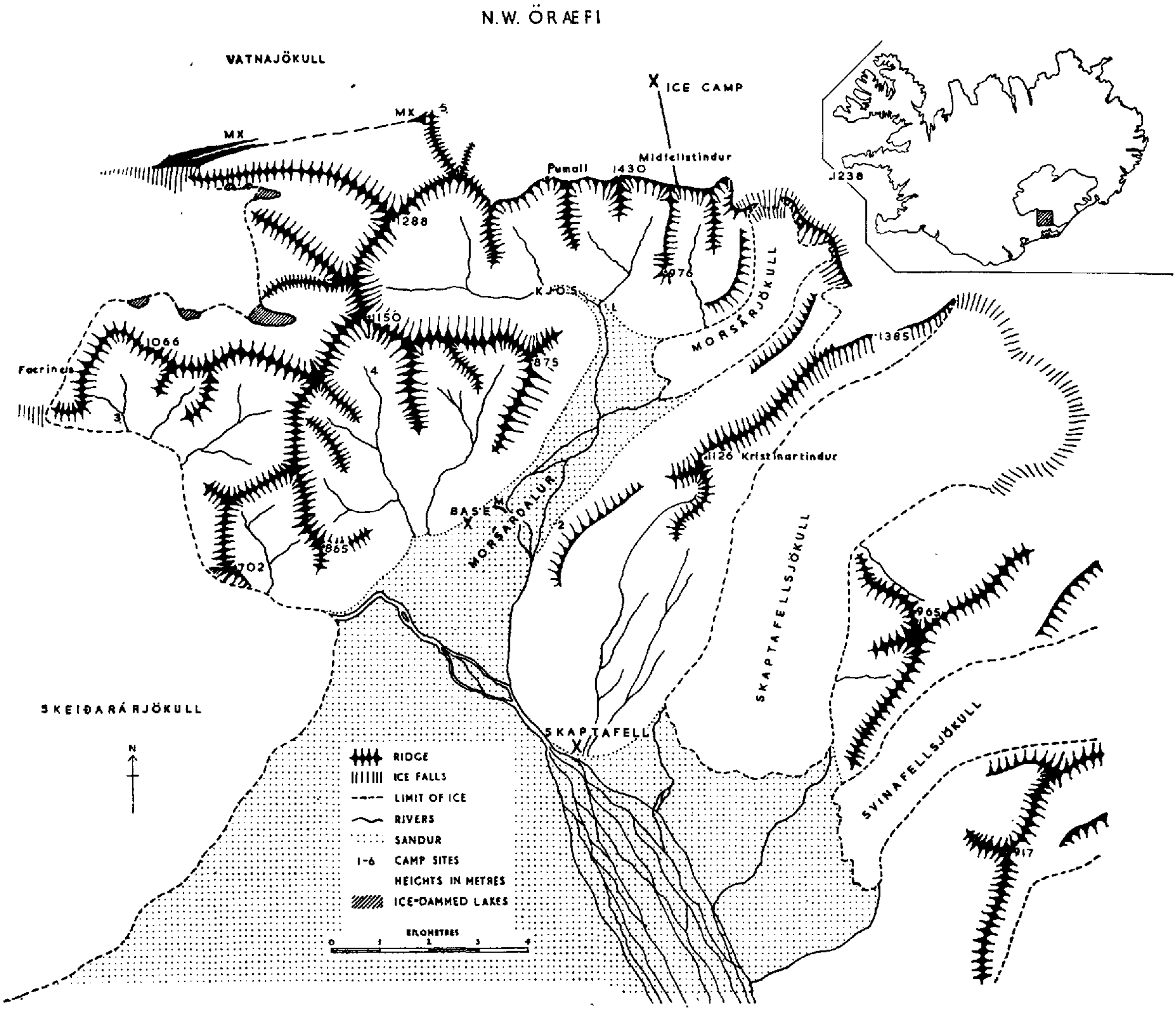

Fig. 1. Location map showing the main features of N.W. Öræfi, Iceland

https://doi.org/10.3189/S0022143000032433 Published online by Cambridge University Press

speed of movement of the medial moraine increases downstream. But the flow measurements, which were made mid-way between the rock wall and the lower limit of the bulge, provide a useful average speed of flow. Assuming that the bulge in the moraine has travelled 3380 m. since its formation at an average rate of 54 m. per annum it should have formed about 1890. According to Thórarinsson,[8] this coincides with a period of milder climate and rapid glacier recession, when much more of the rock wall would be exposed, providing more detritus than in preceding or subsequent years. This might be extended further by anticipating the formation of a second bulge, and certainly there is a much wider extent of moraine beneath the rock wall now than further down-glacier. The estimated position of the bulge for various years is shown on the map (Fig. 4).

An interesting comparison can be made with a suspended moraine which was seen on the upper part of Skeidarárjökull. Here there are two high moraines aligned east–west and disappearing into the ice fall (see M.X. in. Fig. 1.). Traced eastwards for 1500 m. they gradually fall in height until they disappear completely. They are aligned with a rock ridge projecting northwards onto Vatnajökull roughly 3000 m. further east. The map of 1904 indicates that this ridge was then entirely snow-covered. To-day much rock is exposed and its weathered nature permits rapid scree formation on the snow beneath. The scree is being carried westwards so that a short moraine, about 250 m. long, is being formed. It gradually increases in height as the ridge is approached.

No measurements of movement were made, but it appears reasonable to invoke a similar explanation to that of the medial moraine bulge of Morsárjökull. The distance of about 2750 m., which separates the suspended from the newly formed moraine, indicates the length of time during which the moraine-forming ridge has been covered by snow. By measurement of speed of flow an accurate dating of the change in extent of snow could be made. Until this is done it appears reasonable to assume that it correlates with the similar feature on Morsárjökull.

The terminal moraines near the snout of the glacier indicate recent retreat. They are arcuate in shape and 6·1 m. high on a section levelled across them. They consist of very large blocks, largely of agglomerate, and unsorted finer material. The area immediately in front of the glacier snout shows little evidence of terminal moraine formation at present, but this may result from the present rapid retreat of the glacier and the stagnant condition of its snout. It appears that terminal moraines only form effectively during glacial advance, when the ice pushes forward the extra-glacial debris into a ridge.

Other features typical of retreating glaciers were seen near the snout of the glacier. The stream issuing from the south-east part of the glacier into the pro-glacial lake had formed an esker-like deposit. This was an elongated ridge of material in the lake, but if was inaccessible and could not be examined in detail. However, another esker was formed in an englacial tunnel near the snout of the glacier. The tunnel was exposed by the ablation of its roof, revealing the englacial stream. This had deposited a ridge of stratified sediment. The ridge had an ice core so that as melting proceeds further the stratification will be liable to be disturbed. There is little prospect that this feature will survive the retreat and melting of the glacier, but it does indicate that deposition can take place in englacial streams, rather after the manner recently described by Lewis.[9]

The greatly dissected and partially buried remains of a moraine were located in Morsárdalur a short distance up the valley from the Base-camp (see M. on Fig. 1). It extends a distance of 600 m. form the north-western side of the valley in a south-easterly direction. At this point the Morsárjökull drainage swings south-east and converges on the far side of the valley where it joins the Skeidará to flow below Skaptafellsheidi. However, this remnant of moraine indicates the former greater extension of ice in this area. It lies about 5 km. from the present snout of Morsárjökull. As the glaciers have apparently not extended so far in post-glacial times (Thórarinsson [10]) it seems probable that this moraine is of late glacial age and may have marked the junction of Skeidarárjökull and Morsárjökull, being a lateral moraine of the former and a terminal one of the latter.

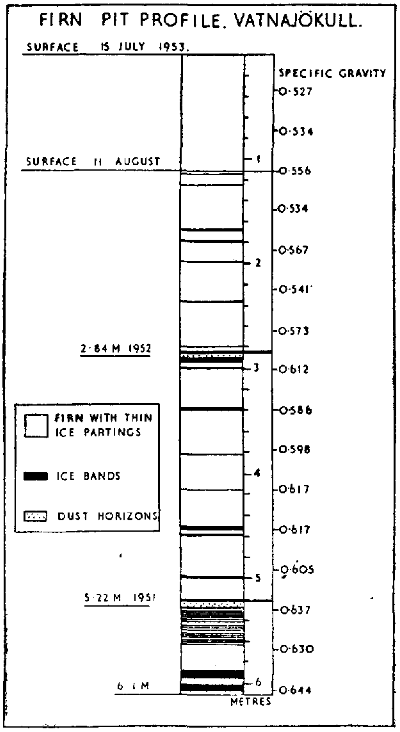

Fig. 2. Firn profile from pit dug at the Ice-camp on Vatnajökull at 1200 m. above sea level

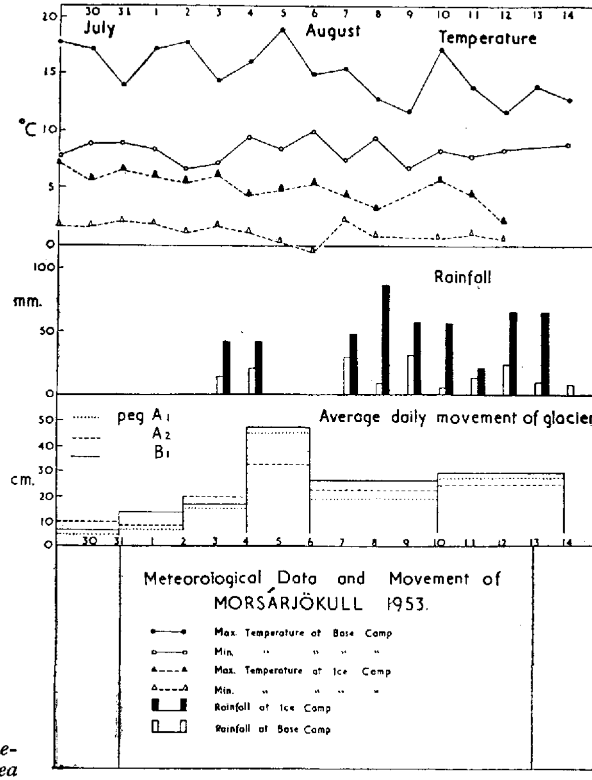

Fig. 3. Graph to show the correlation of weather conditions and glacier movement

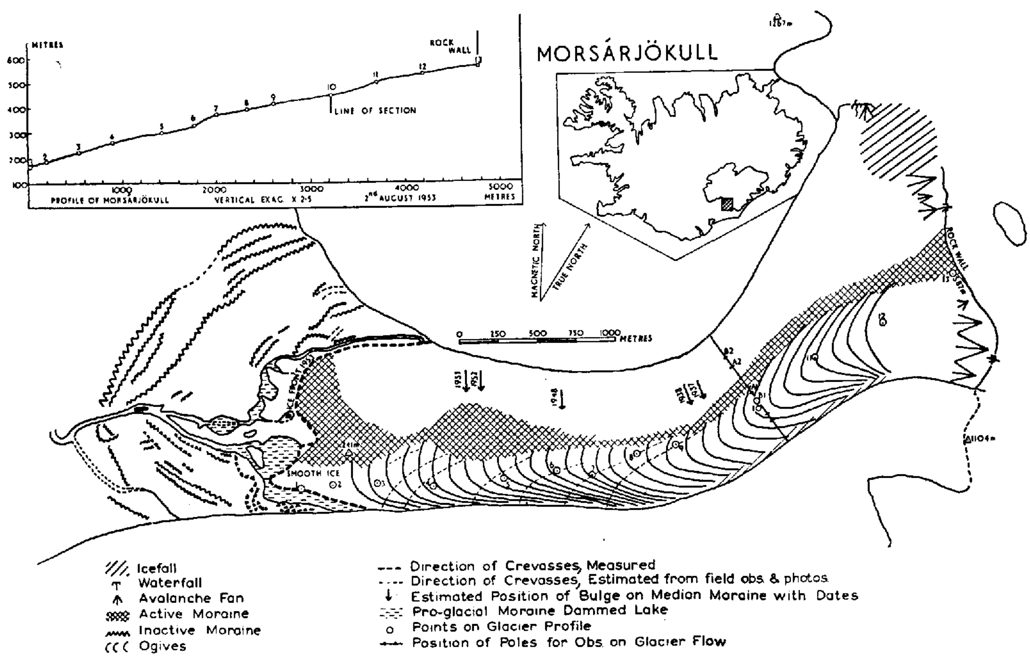

Fig. 4. Map of Morsárjökull. The shape of the medial moraine is shown. The area between the 1953 ice front and the outer moraine was surveyed by plane-table

CONCLUSIONS

1. Ablation during the summer months of 1953 at about 1200 m. above sea level, near the upper limit of the supply area of Morsárjökull, averaged 40 mm./day, but 1953 was exceptionally warm.

2. The net accumulation at 1200 m. above sea level on Vatnajökull for 1951–52 was 2·38 m. of firn, which gives an approximate total accumulation for the supply area of Morsárjökull of 34·8 million cu. m. of water. The corresponding figures for 1952–53 are 0·818 m. net accumulation of firn and 10·8 million cu. m. of water. This indicates the variability of accumulation from season to season.

3. A correlation appears to exist between the rate of flow of the glacier and the weather conditions. The glacier moved faster during rainy weather. The temperature variations during the period of observation were not sufficiently great to affect the movement significantly.

4. The bulge on the medial moraine is attributed to the greater exposure of the rock wall which resulted from the milder conditions between 1890 and 1900. This agrees with the evidence of the rate of movement of the moraine and the evidence of photographs. The discontinuous moraines at the head of Skeidarárjökull can be explained by a similar process.

5. Evidence for the rapid retreat and thinning of the glacier since 1904 is very marked. The plane-table survey indicates the retreat of the snout to be about 1000 m. since 1904.

6. The remains of a moraine near the Base-camp indicate a possible late glacial extension of Morsárjökull and suggest the line along which this glacier may have been in contact with Skeidarárjökull.

MS. received 14 *January* 1954

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INTERNATIONAL GEOPHYSICAL YEAR, 1957–58

FOLLOWING the meeting of the Union of Geodesy and Geophysics at the Congress in Rome in September additional meetings took place to decide on the nature of the Union's participation in the proposed International Year. The Commission on Snow and Ice had already, at the Brussels Congress in 1951, proposed that glaciological observations should be made during the year. At the Rome meetings Professor G. Manley and Professor R. Haefeli were nominated as representatives of the Hydrology Association, in which the Commission on Snow and Ice is included, to attend the post-Congress meetings dealing with the proposals of the Union. These meetings took place on 27 and 28 September.

Later, the Special Committee for the International Geophysical Year (C.S.A.G.I.) met from 30 September to 4 October to coordinate the proposals from the different Associations of the Union. These proposals have now been circulated to the National Committees concerned. They include a report from the Working Group on Glaciology suggesting various ways in which glaciological work should be carried out during the International Year. A more detailed report will be made available later.

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