A WEST GREENLAND GLACIER FRONT

A SURVEY OF SERMIKAVSAK NEAR UMANAK IN 1957

By Jens Tyge Møller

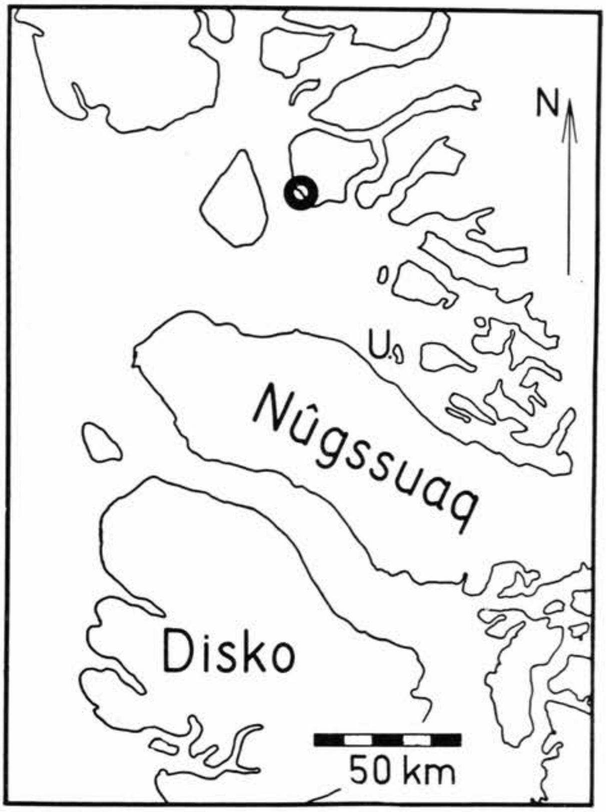


Fig. 1. The camp at Upernivik Næs (marked by a ring). U. indicates the town of Umanak.

A glaciological expedition of three teams was sent out to West Greenland in the summer months of the years 1956 and 1957. It was under the direction of the Copenhagen University Geographical Laboratory and had financial support from The Carlsberg Foundation and the Rask-Ørsted Foundation. The expedition was in charge of Professor NIELS NIELSEN and Assistant Professor B. FRISTRUP, the occasion being The International Geophysical Year. The three teams, whose glaciological researches will not be reported on here, devoted their attention to the Hurlburt Gletscher at Thule, Sermikavsak at Umanak and Sermersoq at Nanortalik respectively. One section of their programme comprised the production of a reliable, large-scale map of the glaciers for use during The Geophysical Year and also to serve as a foundation for establishing the fact of any changes in the glacier surfaces and their extent. It was therefore natural to devote particular attention to drawing a large-scale map of the glacier fronts (fig. 1).

The following is a brief account of the survey of Sermikavsak and of the problems requiring to be solved in conjunction with that geographical field-work. The description is compiled on the background of the fact that the survey is merely a small part of a wider investigation and was carried out by a team which had constantly to bear the total task in mind. From a purely technical point of view, of course, a survey of this nature could be made much more rationally.

The glacier named Sermikavsak (meaning "the paltry glacier") is situated about 70 kilometres northwest of Umanak on the west coast of the small Upernivik Ø (fig. 2. Ø = island). The position of its front may be given approximately as long. 71°12′ N. and lat. 53°03′ W. of Greenwich. It may be mentioned here that there appears to be some vagueness—among the local population too—concerning the name of Sermikavsak, for it is also used of the small glacier (Serminguaq) whose valley debouches into the sea just east of Upernivik Næs, the southwest corner of that island. On the other hand, our glacier is sometimes called Serminguaq ("the little glacier").

Sermikavsak, which is surrounded by chains of mountains 1300—2000 metres in height, extends about 15 kilometres northeastwards into the island, where its highest parts lie at about 1500 metres. The interior part of the valley is in the form of a trough about 2—3 kilometres wide, from which there is a narrower section, about 10 kilometres long and a good kilometre in width, running southwestwards. There is no more than this one outlet, to which the team confined its operations.

Upernivik Ø is occupied entirely by very high mountain ranges which divided it chiefly from northeast to southwest. For the most part the mountains consist of gneiss and other metamorphic rocks. Its southwest corner, Upernivik Næs, forms a stark contrast by being a rounded, relatively low (700 m) hill area consisting of Cretaceous sediments, with sandstone predominating. As a consequence of the shape of the land the glacier has several ice-falls some hundreds of metres in height. At these places the presence of enormous crevasses formed a serious obstacle to the work. The ground ahead of the glacier, whose front lies about a kilometre from the shore, is dominated by a fluvial plain cut up by the ever-changing beds of melt-water streams. Here and there on this plain are very small "islands", no doubt old moraines dating from the period when the glacier last reached out to the sea.

In selecting the glacier to be investigated the following desiderata were set up: It was to be complete in itself. This meant that it was not to be connected with large masses of ice with several tongues, as the size of the expedition prevented the establishment of several stations within the same region; and, as far as possible, the entire glacier was to be under inspection. Furthermore, it should preferably not reach out to the sea, which would make it difficult to measure its outflow. For the same reason there should be as few melt-water streams from the front as possible. Lastly, the glacier should be scalable, with few elements of risk. On Upernivik Island it was very difficult to satisfy these conditions in the very rugged terrain. Sermikavsak complies with them all, but only on the lowest section of the lobe as far as the last-named condition is concerned. That part ascends very evenly and presents hardly any great difficulty at all. It is quite easy to climb and there are but few, insignificant, crevassed areas. But about 5 kilometres northeast of the front there is the first ice-fall, whereafter the difficulties grow immensely, so much so that the work had to be confined to the lower, regular part of the glacier. In particular, the inner parts of Sermikavsak will be very hard to map, for the reason that it is impossible to obtain a view of the glacier without climbing to the mountain tops of the valley sides, and they are so far away from the area as to make a large-scale detail survey almost impracticable. Maps compiled on the basis of aerial photographs could only be on a small scale, as the existing photographs were taken from such a long distance that the pictures are on a scale of about 1:40,000. Another reason why the only map pre-

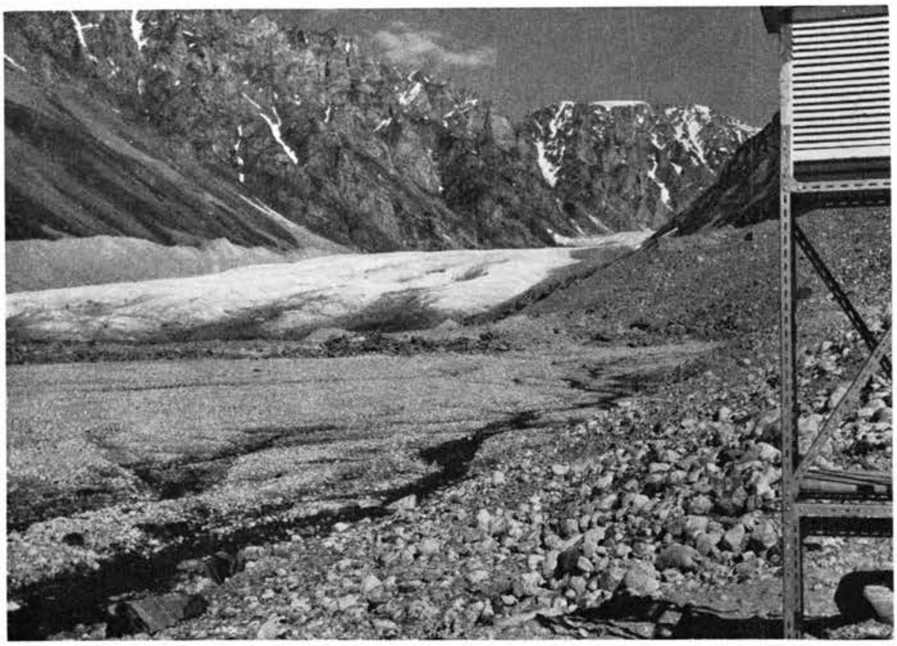


Fig. 2. The glacier front viewed from the camp. In the foreground a glaciofluvial plain. One lateral moraine is clearly visible. A moraine-covered ice tongue to the southeast is partly hidden behind the weather station, of which the left leg only just touches a large stone used as one of the points for detail survey. In the background a glimpse of the westernmost icefall, where the glacier bends eastwards.

pared is of the glacier front is, partly, that the team consisted of only four members, of whom only one could be spared for map-work and only for a short period of the three months of the sojourn on Upernivik Ø.

The survey was planned in July 1956 by a reconnoitring expedition. At the very outset it was found natural to draw a base-line on the flat plain in front of the glacier (fig. 3) and to lay a network of triangles with the apices on the two "lateral moraines" which on both sides separate the glacier from the flanking mountains. It was quickly found, however, that establishing the fixed points was going to be a matter of considerable difficulty, because the lateral moraines are so full of ice as to be quite unstable. Actually, the only real lateral moraine lies on the northwest side of the glacier. Otherwise the margin consists of lobes that are concealed by gravel and stones, on which there could be no question of placing fixed points if they were to be stable. Moreover, the northwest lateral moraine extends only to a point just west of the lowest ice-fall. At the glacier front its highest point lies about two hundred metres above the ice surface, and from there the distance to the top of the moraine diminishes until it disappears at the aforesaid ice-fall. On the southwest side of the glacier and east of the ice-fall the glacier reaches right out to the mountain side, which rises so precipitously as to rule out any possibility of control points there. The tops of the mountains could not be climbed, as the team had neither the equipment nor the technique. In addition, the tops of these flanking heights were so far away from the glacier that, as already stated, a detail survey for a map of such a large scale was impossible. Owing to the differences of the elevations all the sights would run almost parallel with the mountain sides and would thus be obstructed by the shimmer, which already gave rise to many problems.

Fig. 4 is a sketch map showing the glacier front, the glaciological observation post (mast) and some of the poles. The map was compiled on the scale of 1:10,000 from aerial photographs and the map drawn by the expedition. It also shows the situation of the coast ahead of the glacier. The expedition camp was at Point 1. The majority of the control points were established in 1956. The base-line was laid at right-angles to the coast in front of the glacier between Points 9 and 10. Finding an area sufficiently level for a base-line was rather difficult. True, the greater part of the area in front of Sermikavsak may be regarded as a plain, but it is full of moraine blocks and also intersected by melt-water streams which are constantly changing their beds. The base-line was made rather long, 230 metres, as we could not rely upon measurements sufficiently exact to permit of the base being much extended. The distance was measured off with a subsequently verified steel tape with undirectional terminals. The measured line was divided into lengths of just under 20 metres, and the points between these lengths were indicated by a small moraine boulder with the point marked as a cross. The fall was measured with a clinometer (it did not exceed 5° anywhere), and the fall correction was calculated for every length. The base-line was remeasured four times, the greatest deviation between the measurements being 11 millimetres. The mean error of the various measurements of the base-line as a whole was 5 mm. The surveyors took turns in holding the initial point of the tape over the initial point of the various lengths. Moreover, both terminal points of the tape were used as zero.

The base-line was then extended up to the first side in the main system of triangles. It started at Point 1 at the camp to a point (2) on a terminal moraine at the northwest side of the glacier valley. In 1956 at that side four other fixed points were established, all on the aforesaid lateral moraine. Of these, the most easterly one had disappeared in 1957 and it was not re-established later. On the southeast side of the glacier three other points were established in 1956, in addition to Point 1. Point 4 of these had to be set up on the moraine-covered ice-lobe, whereas

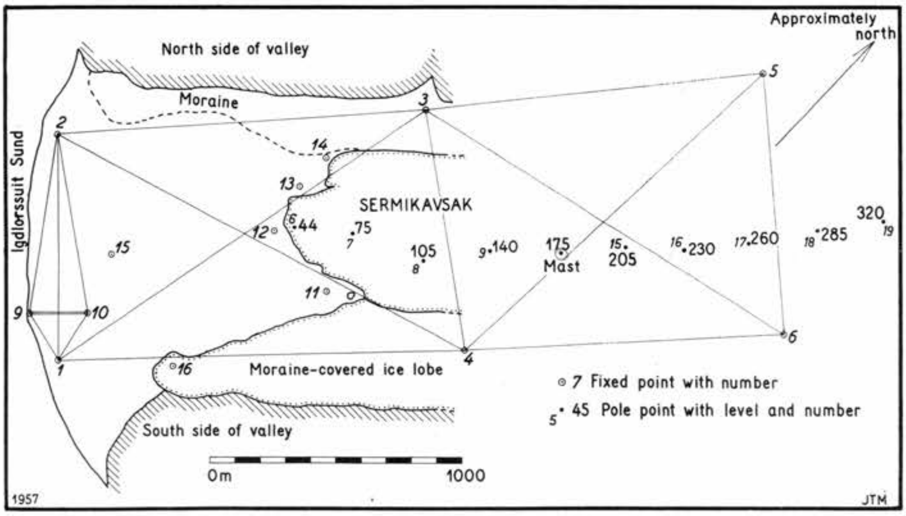


Fig. 3. Map showing the main system of triangles on the lower part of Sermikavsak. The camp was situated at Point 1.

it was possible to place Point 6 on a small rock shelf about two hundred metres up the mountain side. There again the most easterly point was found to have disappeared in 1957. In this latter year a number of fixed points were established ahead of the glacier front to be used in the detail surveys: Points 11, 12, 13, 14 and 16. Point 15 was determined only because from it—on the top of a moraine block four metres high, there is a completely free view of the glacier front; it was employed for photography.

Siting the fixed points proved to be a knotty problem. For the purpose of checking the future movement of the glacier it was highly desirable that they should be recognizable and therefore of a more or less permanent character. At no place was it possible to establish a point on firm rock. Wherever there were outcrops they provided no view over the region, and in addition the rock here is of such a nature that it is doubtful if a bolt driven into would hold very long owing to severe weathering and erosion. Therefore we endeavoured to pick out sites where the ground seemed to be fairly stable, such as old moraines covered with vegetation, with no visible sign of movement at the surface, such as cracks or subsidence. We also tried placing the points upon large moraine boulders lying on nearly horizontal ground and away from slopes. It has to be borne in mind the whole time that we were working in a perma-frost region, where the substratum is very unstable unless it is permanent rock. On the other hand, as long as the points could be sited in a terrain free of steep slopes any movement would mostly be confined to the vertical, unless the glacier advanced at that particular point. But where there is glacier ice below the surface the latter will be anything but stable. Unfortunately, as already stated it was necessary to place some of the fixed points under just these conditions, i. e. in the lateral moraines which, on the northwest side of the glacier valley, lie at a much steeper angle than would have been possible if the moraine had not contained very large quantities of ice. At several places, in fact, the ice is visible where the moraine has slipped. In other words, the lateral moraines are just as unstable as the glacier itself, where in fact one point had to be placed: on the southeast, moraine-covered ice tongue (Point 4).

The fixed points everywhere were established by hewing a copper bolt into the largest moraine block on the spot. At Points 1, 2, 12 and 15 round bronze plates marked "GGU-Maalepunkt" were added. These plates were laid loose over the fixed point and the whole was then covered with heavy stones. At Points 1 and 2 we also built small cairns about one metre in height. Centered pickets with flags were set up at the fixed points during the 1957 survey.

As to the durability of the points established it is possible to say briefly that Points 2, 5, 12 and 15 alone will be stable for a period of ten years or so, and of these only Point 15 can be counted upon for several years more, unless the glacier advances that far.

But even if all points except these four should be lost, it will still be possible to restore the network of triangles, because in that case there will be at least one fixed point and one direction to a known point to build upon. For the purpose of orienting the network and if possible connecting it up with the Geodetic Institute network, resections were carried out in 1956 to points on the island of Ubekendt Ejland west of Upernivik Ø. On the former there are three coordinated points to which observations were made from both Points 1 and 2, whereby their positions and the orienting of the network should be determinable. Resection to the points on Ubekendt Ejland alone will not suffice to restore the network for a map on such a large scale, the distance between Points 1 and 2 being too short in proportion to the distance between the trigonometric stations on Ubekendt Ejland.

The network of triangles was arranged as a frame-work (fig. 4) which, in addition to the base-line network, consists of triangles with their apices at Points 1, 2, 3, 4, 5, 6 and 7. That frame-work was then supplemented with the detail points 11 to 16. Of these, Points 12, 13 and 14 were observed with the side 1—4 as the base, whereas Points 11 and 16 were observed with the side 1—12 as the base. Point 15 has the side 1—2 as its base. At no place does the length of the triangle sides exceed 2 kilometres, whereas the distance from the shore to Point 5 is

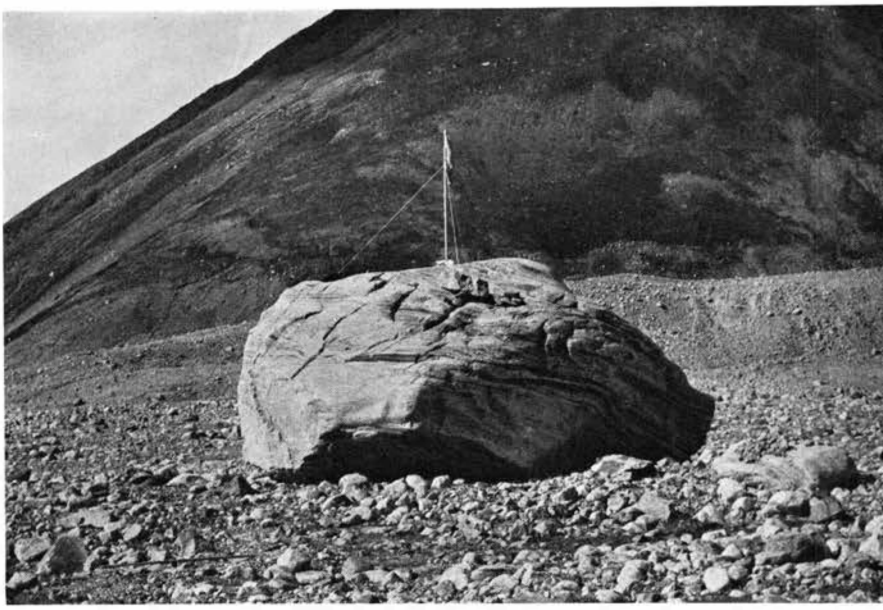


Fig. 4. Point 15 with flag. In the background the lateral moraine to the northwest of Sermikavsak.

only just under 3 kilometres. The little used Point 7 northeast of Point 5 is not plotted on the map.

In order to take the observations farther up the glacier the plan was to carry them out as polygonal surveys with the polygon points situated on the northwest part of the glacier, which in places there is covered with moraine. In the southeast part of the valley the ice as already mentioned is eroding right into the mountain side. It is impossible to establish trigonometric points with any certainty from Point 7 and in any case up to 7 kilometres to the northeast, where the northwest side of the valley is readily accessible with many shelves some way up the mountain side. However, owing to lack of time and labour Point 7 was the most easterly point determined, and the only detail surveys made were in the frontal area.

In the summer of 1956 the whole of the network then established with its base-line was surveyed, so that it should have been possible to build out from it during the following year. In 1957, however, sample observations showed that the angles in the fully measured triangles differed from those of the year before, in some cases by more than half a minute. For the present map these deviations were of no significance; but as it was evident that some of the points must have moved (the entire deviation was one of directions to and from the aforesaid uncertain points), the angle observations and the base-line measurements were carried out afresh. It may just be mentioned that the ultimate length of the base-line, measured in the same manner as in 1956, differed by only 5 mm from the previous one, the terminal points of the base being intact on the fluvial plain.

The angles were observed with a Wild T2 universal theodolite with single second readings. This would seem to be a large instrument to use for so small a network, where one with 1/10th minute readings would have sufficed; but in advance it was impossible to know what problems the surveys would present. If the glacier had had the form of a cap rising up above the surrounding country, much longer sights would probably have been necessary. The same would apply if it had been possible to carry the network of triangles into the inner part of Sermikavsak, which there is much wider than in the more westerly outflow part. In every case angular measurement was carried out as series measurement. All directions to triangle points were measured with three full series. In 1957 the only trigonometrical levellings were made to Points 11, 13 and 14, these points being utilized in the detail survey and there was only time to determine their level by trigonometric levelling. In 1956 trigonometrical levellings were made from all stations in all observed directions, but this was abandoned in 1957 on account of the very strong shimmer whenever the sights were beyond a few hundred metres. This shimmer, which of course also affected horizontal angular measurement, was very difficult to avoid. Owing to the midnight sun and the fact that in point of climate Sermikavsak lies in a region with little cloud, irradiation is very intense, and moreover there is the very sharp reflection from the surface of the ice. At night the glacier lies in the shadow of the northwest chain of mountains, but then the radiation is strong, and into the bargain the valley is so dark that it is impossible to see any signal.

One of the objects of the expedition was to put up a row of bamboo poles in the longitudinal direction of the glacier to assist in measuring the melting and movement of the ice. Poles were accordingly set up in 1956, the first down by the glacier front and the last a short distance northeast of the lower ice-fall, about 6 kilometres from the front. All the poles up to the ice-fall were plotted in the triangulation and were to have been observed again in 1957 for the purpose of obtaining an impression of any movement made by the glacier. However, the glacier melted so much in the late summer of 1956 and early summer of 1957 that all the poles, which had been bored 2 metres down into the ice, had disappeared. Some of them were found in depressions in the surface of the glacier, having been washed or blown there. Thus all chance of measuring the ice movement was lost, there being no time to observe the poles set up at the beginning and the end of the summer work in 1957. As a matter of fact, however, the movement of Sermikavsak is too slight to be registered within so short a period, and therefore the sole purpose of observing the poles that summer was to record their position. It proceeded in the same manner as the other angle observations. It has to be carried out by intersection, because it turned out that stationing on the ice itself was impossible, the tripod feet sinking down into the ice even when the observations were made after the sun had gone and the temperature was just above zero. For the purpose of avoiding serious errors, however, rapid observations were made from each bamboo point but not included in any of the computations.

As stated, in the system of triangles the directions were observed with three full series and all triangles were fully measured. When measuring the angles the degree of accuracy aimed at was such as to permit of a triangle side in the frame-work being determined to a mean error of 10 centimetres. In practice the mean error of the mean of an observed direction was less than 5 seconds everywhere. This was a greater accuracy than was required for the present map, but that standard was maintained for the benefit of any future survey of the glacier. By that time there may be only few fixed points remaining, and at least it should be possible to reconstruct the original network as nearly as possible. It may be added that working to this accuracy of observation cost nothing in the way of time and trouble.

As the cartographic plan had to be carried through in the course of the three months, from triangulation to detail survey, the results had to be worked up continuously as they were arrived at. The computations of the framework itself of course might with advantage have been put off until our return home from Greenland; but as a detail survey in addition to the actual observations had necessarily to be supplemented with the surveyor's personal evaluation of the physical features the map had to be drawn in the field. In other words, the foundation work had to be complete when the detail survey began. As the value of the previous year's observations had proved to be somewhat uncertain the work had to be done against time. Triangulation having been completed and the base-line established, the network of triangles was computed. The expedition had with it a five-place logarithmic table with which all the computations were made. As all sights are less than 2 km the table thus provides a computation accuracy of 0.1 m, which is adequate for a map on the present scale (equal to 0.03 mm). In order to facilitate matters the network was plotted into a co-ordinate system with Point 1 as zero, the ordinate axis coinciding with the side 1—2 and positive direction northeastwards, i. e. in the working direction. The orientation of the co-ordinate system in relation to north is only approximate, being estimated on the basis of rough angular measurements to known points. If necessary it may be determined more exactly by computing the resection to the trigonometric stations on Ubekendt Ejland. The network was calculated by computing the lengths of unknown sides from a known side after distributing the error of the sum of the angles over all three angles. For the base triangle this error is less than 20″ and for the detail network under 30″. No other adjustment was made, because such values as might be arrived at would be so small as to be without significance, with the very short sights and the accuracy of computation employed. Two determinations on the same side were utilized for control wherever possible. For example, side 3—4 was calculated with both side 1—4 and side 2—3 as the base. In no case was there any deviation between the results thus arrived at. The framework (solid line in fig. 4) was computed separately, whereafter the detail points were computed with the sides of the framework as the base. After all sides were computed the co-ordinates of the points were calculated, for each point on the basis of both sides of the triangle as a check on arithmetical errors. The pole points, intended merely for indicating the placing of the poles were plotted with a station pointer with minute readings. As stated, all pole points were checked by means of an orienting observation of the angle from the pole point to the base terminal points employed for the point. In this there were no deviations measurable in the map scale (fig. 4).

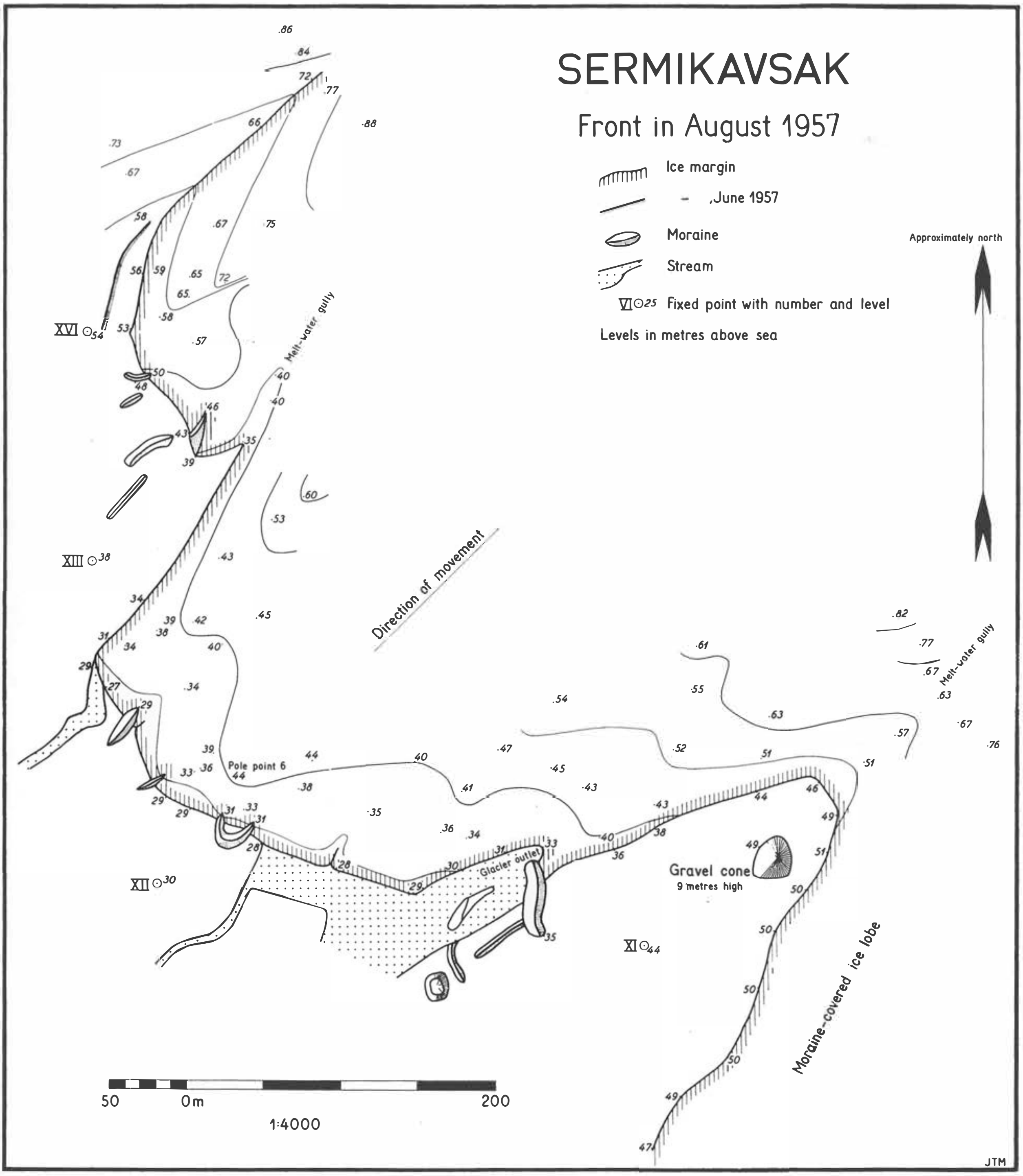
It is a matter of importance to be able to measure not only changes in the extent of a glacier but also variations in heights and relief. The plan therefore included levelling along and across Sermikavsak. Quite apart from the brief time available, it proved to be completely impossible to do any geometric levelling on the ice with the equipment at hand. As was stated in describing the triangulation, the feet of the tripod continued to sink while the instrument was being set up, no matter how well they were stamped down into the ice. In all probability, levelling will be possible if the tripod is provided with a plate on which the entire equipment can be set; the plate could be furnished with small cogs on the underside to prevent slipping. Establishing fixed points should be fairly simple, even if they will scarcely be very durable. The light bamboo poles used for measuring the ice melt could be employed as rods, or short pickets could be bored down into the ice to such a depth as to be frozen fast only as long as the observations are being taken. In the summer of 1957 a number of poles were experimentally fixed in this manner on Sermikavsak right at the front (at Pole 6, figs. 1 and 4). Then for some days, when the temperatures were highly variable, measurements of zenith distances were taken to a permanent mark on each of the five pickets from the very stable Point 12 about 100 metres ahead of the glacier front. It was found that the pickets did actually remain stable as long as they were frozen hard in the ice. There were no deviations whatever between the readings, which were made without removing the tripod between observations. The experiment could not be made to last more than three days, however, the pickets thereafter being loose in the rapidly melting ice. Trigonometric levelling would of course encounter the same difficulties, but it would be possible to set the instrument up at a few permanent stations away from the glacier; from there one could always observe horizontal and vertical angles to selected points on the surface of the ice and thus have the latter's movements under control. However, it would scarcely be practicable by this means to level so many points as to form a working basis for a contour map of the glacier, as the observations must be made with meticulous care if they are at all to show the relatively small movements in question. At any rate it would be necessary to have a tripod permanently set up at each point. It may be stated here that the melting rate for Sermikavsak in the summer of 1957 was 2—3 metres. The levels shown in fig. 4 were observed by means of two aneroid barometers. It was found that the accuracy of these observations had to be rated at ± 5 metres.

As part of the plan (subsequently abandoned) to carry out geometric levelling up on the ice a line was levelled from the sea at the camp back to Point 12 at the glacier front. This latter point was used as the datum for the detail survey. In order to have a datum for the levelling we had to have a zero. There was no time for making immediate water-level observations and therefore the datum point was assumed to be midway between the highest and lowest observed water level within a tidal period. In order to correct this selected datum point a tide staff was later put up in the sea in front of the camp, but its functioning time was only brief, it being impossible to keep it free of drift-ice. However, the observations showed that the level of the selected datum point may very reasonably be put at 0 ± 0.25 metre. Levelling itself was carried out twice with proper observance of the accuracy required of a technical line levelling, with the kilometer error put at 5 mm.

The detail survey was made by tachymetry, this being the only method employable on this very hilly ground, which more over is full of large boulders. The universal theodolite was used as a tachymeter, the second values being immediately converted to tenths of a minute to facilitate computation. The map had to be ready drawn on leaving the locality, especially having regard to the determination of how many details and how large an area were to be included. In addition there was the circumstance that observations of this kind are open to more than one interpretation. If for example the draughtsman who is to construct the map is ignorant of the terrain, he could do it quite correctly from the figures supplied to him and yet the map might not conform to all the details on the spot. Ignorance of the locality requires a very large number of definite points to give the same result as a much smaller number when the map is compiled gradually as the results of the observations are forthcoming. As only one member of the team could be spared for the survey work, it had to be simplified as much as possible. There was no time, for instance, for calculating co-ordinates for the various fixed points, which had to be plotted from the azimuths and the distance from the station. The only aid available was a primitive protractor, but half degrees could be plotted from it without significant error. In order to reduce the uncertainty to a minimum all sights were kept short; only very few were over 150 metres and not one was over 180 metres. Moreover, the directions to the fixed points were selected in advance wherever possible, so that they were in whole or half degrees. The avoidance of long sights made it necessary to supplement the four detail survey points at the glacier front with a number of intermediate points, which were also determined tachymetrically. For control purposes they were determined in relation to two detail survey points and their co-ordinates were computed from the logarithm table. Moreover, at several places the same fixed point was determined from two different stations. When constructing the map it was found that there was no difference of more than 1 mm in these control observations of fixed points.

The tachymetric observations had to be computed with a slide rule. As the inclination of the sights everywhere is under 12° and their lengths under 180 m, the distance from the station to the fixed points concerned could be computed to an accuracy of 1 m, which on the present scale corresponds to 0.3 mm. The elevation differences could be calculated to a similar degree of accuracy, which at first glance seems rather poor. It should be recalled, however, that these are points on an ice surface that is extremely rugged and hummocky. Moreover, during the expedition's working period the ice was melting rapidly, which made the surface very unstable. Consequently, a map, at any rate compiled in summer, can be nothing more than a snapshot. On Sermikavsak it was sometimes possible to see changes from one day to another; as stated above, melting that summer caused the surface of the ice to subside 2—3 m. Therefore the map includes only 10 m contours. A smaller equidistance such as that employed on some glacier surveys right down to 1 m would give a false impression of exactness unless the map were compiled from aerial photographs on a large scale. Determining the levels to the fixed points was done by taking mutual measurements of the vertical angle between the points and the computations were made with the aid of the logarithm table. The map was drawn to the scale of 1:1000 and then reduced to 1:4000, the error at that scale being estimatable at under 1 mm, which corresponds to 4 m on the ground. Care was taken not to include other details than those observed with such certainty as to preclude errors demonstrable in a map on this scale. All summits were plotted and there are many more plotted points than the elevation figures indicate. In the northwest part of the map is a reproduction of the position of the ice margin two months before the actual detail survey. The retreat, very considerable at this spot, was due to the melting from the northwest lateral moraine. There was also a marked retreat at the glacier port, the front in June 1957 reaching right forward to the northeast point of the small island in the meltwater river. The water areas, indicated by stippling, comprise those within which the water flowed. Outlining the courses more precisely was impossible, because they changed from day to day. The term "moraine" comprises the small stone and gravel-covered mounds in front of the ice which probably were not the result of meltwater erosion. They all grew smaller in the course of the summer as their ice content melted. On the map they have a suggestion of shadow, as if the light came from a westerly direction. The many mounds and slopes left as erosion remains by the meltwater streams are not included.

The purpose of this brief description has been to provide an impression of geographical fieldwork in which the task set required more or less ignoring solutions which normally might have been applied. Methods and opinions will be open to many objections, but the possibilities everywhere have been restricted by the short time and labour available and the instruments at hand. For example, a plane-table would have provided possibilities for surveying much larger areas within the same period, but in advance it was not certain that the plane-table could be used at all, and of course equipping the expedition with a complete outfit of instruments would have meant an unreasonable enhancement of the cost. Moreover, it is the intention with this description to make it possible to evaluate the survey with a view to future surveys of Sermikavsak; at that time it might be possible to investigate changes in the glacier surface and extent on a fairly solid foundation.


SERMIKAVSAK
Front in August 1957
Ice margin
- ,June 1957
Moraine
Stream
VI ⊙25 Fixed point with number and level
Levels in metres above sea
Approximately north
Direction of movement
Melt-water gully
Pole point 6
Glacier outlet
Gravel cone
9 metres high
Moraine-covered ice lobe
XVI ⊙54
XIII ⊙38
XII ⊙30
XI ⊙44
50 0m 200
1:4000
JTM