HYDROLOGY AND TRANSPORT OF MATERIAL IN THE SERMILIK AREA 1972

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Investigations of water discharge and transport of material have been carried out in the area around the Mitdluagkat glacier in East Greenland. Precipitation and snow-melt were measured and compared with the discharge. The relationship between stage, discharge and concentration of suspended sediments were found, and the results were used to calculate hourly values of suspended sediment transport. In a few cases bed-load and dissolved load were measured at the same time as suspended load. The ratio between the transport components has been used to estimate the total load into the sea.

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Introduction

The investigations are part of the research in the Sermilik area undertaken by Geographical Institute at the University of Copenhagen (B. Fristrup 1961). They are carried out from the field station at the Sermilik Fjord belonging to the institute.

The discharge of the glacial stream has previously been investigated (H. Valeur 1959). In 1958 the area of the glacier was about 30 sq. km, and the drainage area of the stream was between 19.6 and 5.6 sq. km, most likely 8 sq. km.

It was found by Valeur that the water discharge in August was dominated by meltwater caused by radiation, which resulted in regular diurnal variations from 2 to 4 cub.m/sec. In September however, the discharge was determined by precipitation and rapid drainage from ice-dammed lakes. Finally, Valeur discusses the influence of different weather situations on the discharge.

The main purpose of the 1972-programme was to initiate new measurements of parameters important for determining the material budget of the glacier. The discharge of the glacial stream and its transport of material, which had not been included in the previous investigations, were to be determined. Furthermore the conditions in the area, only partly influenced by the glacier, should be investigated.

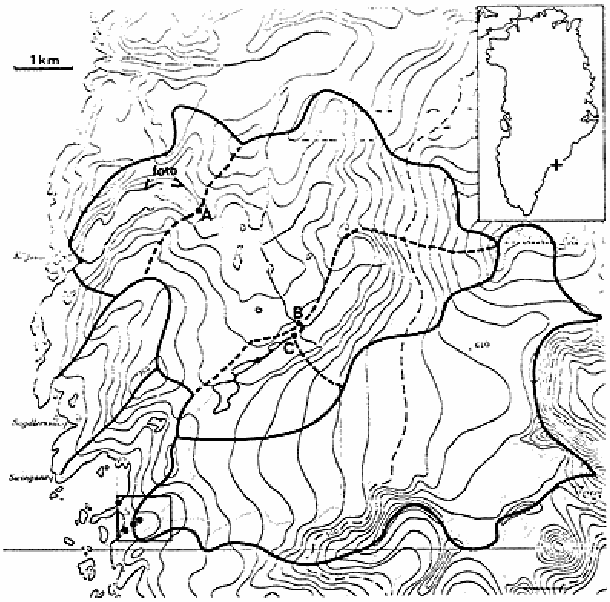

Fig. 1. Survey map. Lines indicate watersheds, dots indicate measuring stations. The area within the frame is shown in fig. 2.
Fig. 1. Oversigtskort. Linierne angiver vandskel, punkterne angiver målesteder. Det indrammede areal er vist på fig. 2.

Methods

Measuring sites

The sites of measurements are indicated on the survey map fig. 1 and on the air-photo fig. 2. If possible the discharge was measured where the whole amount of water passed in a single stream furrow. The selected stretches of watercourses were as straight as possible and without larger obstructions. The measuring section in the Mitdluagkat stream was almost identical with the one from 1958, a sand bar sometimes dividing the stream into two may be of some inconvenience. The water level was measured a bit farther upstream where the recorder could be placed more safely. Concentration of suspended material was measured just below a stretch with strong turbulence. It proved later that the place was not ideal because deposition of suspended material took place just before the measuring site in periods with high sea level.

Determination of drainage areas

Where possible, the topographic divides have been surveyed in the field and else established, by maps at a scale of 1 : 50.000 and aerial photographs as well as ordinary photos. When finished, the map drawn on the basis of aerial photographs will no doubt give a more accurate determination of the watersheds. The areas were measured by means of a planimeter.

Length profile and slope

All measuring points in the valley of the glacial river were connected with the datum of the station. Along the north side of the stream stakes were placed into the bank and the distance between them was measured with tape-measure or with controlled length of pace, cf. fig. 2. The error of the distance determination is therefore about ± 2 m.

The water table at each stake was measured with a maximum error of ± 2 cm. The slope gradient was determined on the basis of the length profile fig. 5.

Water level

Stage-recorders of the type Ott XX with a height scale of 1 : 5 and 1 : 10 were set up as shown on fig. 2. At the measuring section for discharge the water level was measured manually. For the calculations of discharge a relation between the water level at the two places was found. The lowermost stage-recorder was later used for measuring of sea level.

Water discharge

Velocities were measured with current-meters of the type Ott Labor and C 31, and, where possible, in cross sections at right angles to stream direction. At oblique flow an angle correction was made. The discharge was calculated according to American standard procedure. A good correlation was found between water level and discharge, the latter being calculated for each hour and cumulated per 24 hours by means of EDP. The error of the indicated values is ± 5% to 10%.

Description of material

Three bottom samples and three samples of the bank material were taken in the glacial river. The bank samples were of a known volume. Size distribution of particles, loss on ignition and specific gravity were determined after standard procedures.

Suspended sediment transport

The samples were taken by means of a Swedish hand sampler (Nilsson 1969) at the location shown in fig. 1 and 2. The suitability of the sites will be discussed later.

The water samples were filtered in the field by means of a filtering apparatus of Norwegian type (G. Østrem and A. Stanley 1969). As prefilter, Munktell 00M filter, was applied and next, a 00H filter. The filters were brought to Copenhagen in moistured condition in photo pockets and ashed at 550° C. This should be justified as there is not much organic material or lime in the area. The method is without systematic errors, but great care must be exercised especially by rinsing the bottles. Uncertainty by the method is ± 0.5 mg/l. The short-term variations in the concentration of suspended material determined by nature may be great; some samples taken at short intervals showed: 358 ± 29 mg/l (average and standard deviation of 5 samples from August 19) and 267 ± 17 mg/l (average and s.d. of 5 samples from August 27). The standard deviation seemed to be greater by increasing concentration.

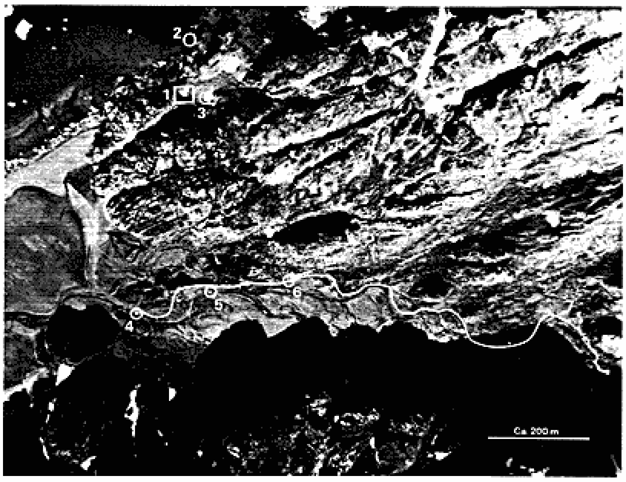

Fig. 2. Air-photo of the Mitdluagkat glacier-stream. 1: Field station. 2: Stage recorder at sea. 3: Precipitation and snowmelt. 4: Concentration of suspended sediment. 5: Discharge and bed-load. 6: Stage recorder. 7: Path of lengthprofile.

Fig. 2. Foto af Mitdluagkat gletscherelv. 1: Feltstation. 2: Vandstandsmåler. 3: Måling af nedbør og snesmeltning. 4: Måling af suspenderet materiale. 5: Vandføring og bundtransport. 6: Vandstandsmåler. 7: Længdeprofil.

Bed-load transport

On the basis of the collected data the bed-load transport can be calculated by means of for example Meyer-Peter's formula, but this has only been done in a few cases.

The dimensions of the bed-forms and their migration velocity were measured on two different dates, and the results were used to calculate the transport by the formula: $Q_B = 2{,}86\,(1-n)\,c \cdot hm \cdot B \cdot 1440$ t/day, where n is the porosity, c mean velocity, and hm mean height of bed-form, and B is the part of the streamwidth through which the material is transported. For an evaluation of the uncertainty of the measurements the average and standard deviation ascertained for some of the parametres are indicated: dune height: 10 cm ± o,7 cm, velocity: 2.9 cm/min. ± 0,25 cm/min. measured on Aug. 19.

Fig. 3. Mitdluagkat glacier stream at st. 5. looking downstream.
Fig. 3. Mitdluagkat gletscherelv ved st. 5 set nedstrøms.

Transport of dissolved load

Three water samples were brought to Copenhagen for chemical analysis. They were taken on different dates and at different times of the day, but are so homogenous that it should be justified to conclude that the chemical concentration has been indentical for the whole period. The analyses were carried out at the Danish Geological Survey in Copenhagen.

Precipitation and snow-melt

Precipitation and snow-melt were measured in a snow-patch just behind the station, cf. fig. 2. The precipitation gauge (Hellmann) was placed under the best possible lee conditions and with the orifice about 10 cm above the snow surface.

The melting was determined by measurements of snow height morning and evening and of density in the morning. At the same time the rain gauge was emptied, if necessary.

Results

Hydrology

Water discharge in the Mitdluagkat glacier stream: In the cross section the mean velocity varied between 0.39 m/sec. and 0.62 m/sec., and the highest velocity measured was 0.90 m/sec. At the sediment station velocities above 2 m/sec. were measured a few times.

Ten measurements of discharge were made so that very different water levels were included. The highest measured discharge was 5.16 m^3/sec. and the lowest one 2.44 m^3/sec. The relationship between stage and discharge is calculated to be $Q = 27.66 \cdot h^{3.89}$, where h is the water depth. The correlation coefficient 0.9774 is significantly different from 0 at a 0,01 confidence level. The residual variation is not systematical, and the highest difference between measured and estimated value is 9%. Together with hourly water levels read from the curves, the relationship was used for a calculation of the discharge during the period of investigation. The calculations were made by EDP and the results appear from fig. 6. Highest discharge: 10.33 m^3/sec. was found for July 27 and the lowest: 1.29 m^3/sec. for August 28. This indicates the extra-polation range for the applied relationship.

Discharge in the drainage basin of the Kugssuag stream: The discharges were measured during a 3-day expedition to the area. The purpose was to investigate a possible drainage to this stream from the Mitdluagkat glacier and to find the watersheds. Measurements were made on August 7 and 8, two measurements were started at 10 a.m. and one at 1.30 p.m. The weather conditions were stable and dry, and the results therefore comparable. The measuring sites appear from fig. 1. On August 7, the discharge at A was: 2.12 m^3/sec. On August 8 at B: 1.08 m^3/sec. and at C 0.441 m^3/sec. Maximum velocities at A, B and C were 0.51 m/sec., 0.50 m/sec. and 0.80 m/sec. respectively with a similar water temperature of 8° C. against 1° C. in the Mitdluagkat stream.

Run-off in the Sermilik area

Calculations of run-off were based on preliminary watersheds which will be better established when a map on the basis of air photos taken in 1972 has been made.

The run-off in the Mitdluagkat glacier stream varies between 62 l/sec./sq. km and 500 l/sec./sq. km for an area of 20.68 sq. km.

If, for the glacier, only areas with melting are included, the run-off values will be considerably higher. For the measuring period the mean run-off was 190 l/sec./sq. km.

The Kugssuag drainage basin was divided into three sections: A, B and C. At A the run-off was 97 l/sec./sq. km; for the area between A and B: 75 l/sec./sq. km, for C: 133 l/sec./sq. km, and for the two areas above B 133 and 134 l/sec./sq. km respectively. On August 7 at 10 a.m. the run-off in the Mitdluagkat stream was: 175 l/sec./sq. km, and the following day at 10 a.m. 166 l/sec./sq. km and at 3 p.m.: 186 l/sec./sq. km. It appears that the glacial drainage constitutes a minor part of the discharge in the Kugssuag area. The higher values for the upper part are due to melting of larger accumulations of snow.

Precipitation

In fig. 6. the results of the precipitation measurements are shown. The highest value ascertained was 3.54 mm/hour during one measuring interval. The precipitation values at the Sermilik station are often higher than those for Angmagssalik, where 81.2 mm were measured for the

Fig. 4. St. 5 looking upstream.
Fig. 4. St. 5 set opstrøms.

month of August against 139.2 mm at Sermilik. Apparently the precipitation is higher for the west side of the island in some situations.

Snow-melt

On August 11 when the measurements were started, the density was 0.47 g/cm³. The density was found to be rather constant for the measuring period with an average of 0.52 g/cm³. The highest value recorded was 0.58 on August 29, but at that time there was probably free water in the snow. The results of these measurements appear from fig. 6, indicated as melting intensity, mm H_2O/hour. The diurnal variation is distinct for days with radiation, mean intensity being about 0.9 mm/hour, highest intensity 3.2 mm/hour.

Variation in discharge

It appears that the discharge varies in good accordance with the precipitation and the snow melting measured at the camp (see fig. 6). For rainless periods a regular diurnal variation caused by melting was ascertained. Contrary to the earlier investigations no rapid drainage of ice-dammed lakes during this period was ascertained, the high discharge about July 27 was due to precipitation and a marked rise of temperature. It was at first presumed that the high discharge was due to rapid drainage of an ice dammed lake, but since no drained lake could be found the hypothesis was rejected.

Transport of sediments

The result of three samples taken in the riverbed and from the bank at the discharge measuring section appear from table 1.

table 1.

	Riverbed			Bank		
	I	II	III	I right b.	II right b.	III left b.
d_{50} (mm)	0,75	1,22	0,85	0,058	0,065	0,17
d_{35} (mm)	0,52	0,80	0,64	0,50	0,057	0,14
d_{65} (mm)	1,10	1,83	1,18	0,072	0,082	0,22
Trask coef.	1,88	1,98	1,63	1,54	1,36	1,38
Wet bulk density	-	-	-	2,00	1,98	2,04
Water % vol.	-	-	-	40,7	38,9	41,8
Porosity % vol.	-	-	-	44,4	44,4	41,9
Organic Content %of dry matter	-	-	-	0,14	0,13	0,16
Particle density	-	-	-	2,87	2,86	2,83

The material in the riverbed consists exclusively of bad-sorted rather coarse sand. In the bank the material is considerably more fine-grained and originates probably from suspended material which has been deposited here, and which might return to the river by erosion. An alluvial stream is defined as a stream where the transported material is the same as the bed material; the stream may well be characterized as alluvial but it is difficult to indicate a representative grain diametre.

Suspended load transport

At least one sample was taken per day when possible. Furthermore samples were taken to show short-term variations in the concentration at the measuring point. The diurnal variation was investigated by samples taken

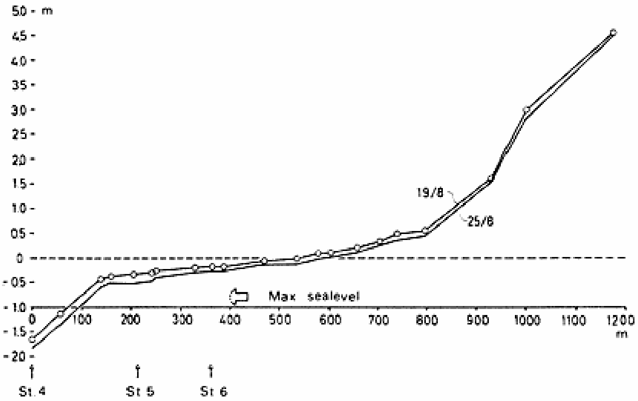

Fig. 5. Lengthprofile.
Fig. 5. Længdeprofil.

each hour during 24 hours. The highest concentration measured was 1305 mg/l on July 27, and the lowest value 67 mg/l on August 31. Average and standard deviation for 5 samples taken at the same place during five minutes before noon on August 22 were 267 mg/l and 17 mg/l, and in the afternoon on August 19, 358 mg/l and 29 mg/l respectively. The lateral variation is within the standard deviation stated above.

A relationship between discharge and concentration of suspended load has been determined by logarithmic regression, expressed by the equation: $C(mg/l) = 46.27 \cdot Q^{1.51}$ (m^3/sec.). The correlation coefficient: 0.9097 is different from 0 at a 0.01 confidence level.

The regression line is shown in fig. 7. There is no systematic distribution of the residuals, highest single deviation being 45%, and standard error of the estimate is 19%. It is indicated whether the sample has been taken at rising or at falling stage. It is obvious that there is a tendency toward a higher concentration with the same discharge at rising stage. The points are too few, however, for drawing separate regression lines for rising and falling stages.

The results of the diurnal measurement appear from fig. 8. The curves showing measured and calculated suspended concentration accord reasonably well except for August 24 from 1 to 6 p.m. and August 25 from 2 to 5 a.m. The simultaneous measurements of water level and current velocity show that during these periods the water level was high and the velocity low. The tide influences the conditions at the measuring point thereby that part of the suspended load will settle before reaching the measuring point. Just after the tidal influence ceased, high concentration values were observed because the deposited material will be suspended again. This has been taken into account when selecting the concentration values which were used when the functional relationship between discharge and concentration was found. It is reasonable only to include values free of tidal influence. Some of the concentration measurements sorted out are shown in fig. 7. By future measurements it will be more appropriate to remove the measuring point 100 m upstream.

It further appears from fig. 8 that the measured concentration is higher than the calculated one at increasing discharge and the opposite at decreasing discharge. This is in good accordance with the point distribution around the regression line. Therefore the calculated hourly transport values will show the same error, because the regression line gives an »average value«. The calculated diurnal transport values will however be reasonably realistic.

The concentration of suspended material was measured at a place where the stream is non-alluvial and the gradient is high; therefore part of the material which is transported as bedload at st. 5 (cf. fig. 2) will be suspended here and will be included in the suspended load at st. 4. The amount of sediments being suspended will depend on the discharge if the grain size distribution and the gradient are constant. If all the material transported as bedload at st. 5 is suspended, the transport at st. 4 will be an expression of the total load of particle material in the stream. If it continues as bedload transport downstream, the total transport into the sea will be the sum of suspended load transport measured at st. 4 and bedload transport measured at st. 5.

Bedload transport and calculated total load

In two cases bedload transport was determined on the basis of the size and migration velocity of the bed-forms. The particle density and porosity from the bank samples in table 1 are supposed to be valid for the bed-load material too. In both cases the bed-forms were »dunes«. During the measuring on August 19 the rate of flow increased from 3.88 to 3.94 m^3/sec. Average of discharge, height and velocity of dunes were: 3.91 m^3/sec., 10.0 cm, and 2.91 cm/min. The dune height varied between 9.3 and 10.7 cm, and the speed between 2.66 and 3.27 cm/min. Calculated bed-load transport was 34 t/24hrs. when the material-transporting width was 10 m.

On August 22 the average discharge, the dune height and velocity were: 3.75 m^3/sec., 8.3 cm and 3.05 cm/min. Now the dune height varied between 7.6 and 11.0 cm and the speed between 2.24 and 3.48 cm/min. The width was unchanged 10 m and the calculated bed-load was 29 t/24hrs. The figures hint at a relationship between discharge and bed-load, but the measurements are too few to allow a calculation.

The bed-load has been determined by means of Meyer-Peters formula on the basis of data from the sediment investigation and the length profile fig. 5 together with water level data. When applying data from August 19, the result was 6.7 t/24hrs., which is considerably less than stated above; the method has therefore not been applied.

By calculation methods stated in F. Engelund and E. Hansen (1969) the total load with exception of wash-load can be calculated for an alluvial stream. It is assumed that the stream at this place can be considered alluvial. It should be noted that the sorting coefficients found in this investigation are slightly higher that those used by Engelund and Hansen.

The calculated total load is 24 t/24hrs. for August 19. This is less than the measured diurnal load found at the sediment station, which is 151 t. The difference between the calculated load value and the measured value is 127 t/24hrs., which can be considered an expression of the wash-load; e.g. in this case the material which the glacier brings into the system besides the load quantities being a consequence of the hydraulic conditions and sediment characteristics.

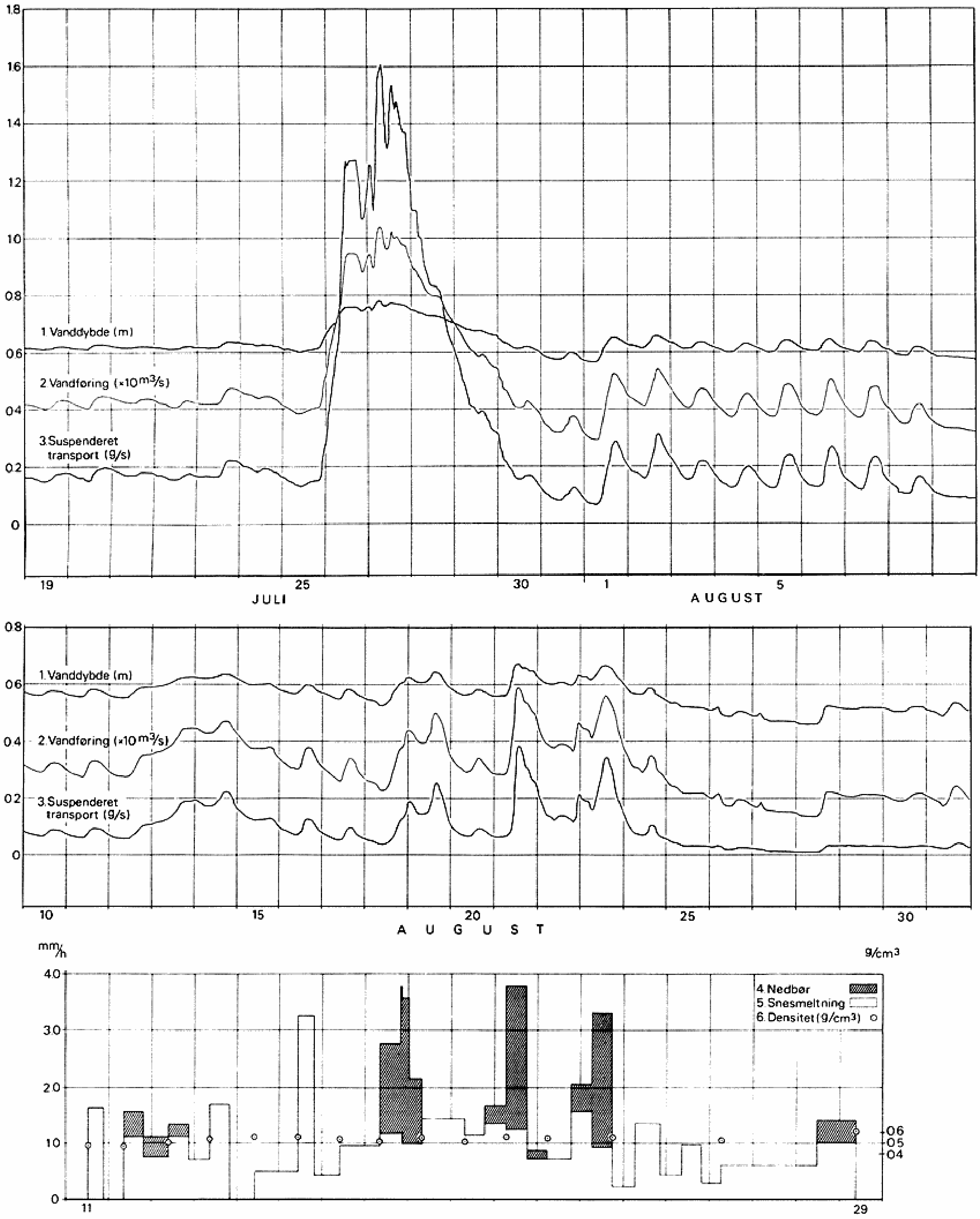

Fig. 6. 1: Stage. 2: Discharge. 3: Suspended load. 4: Intensity of snowmelt. 5: Intensity of precipitation. 6: Density of snow.
Suspended load (g/s · 10^4)

Fig. 6. 1: Vandstand. 2: Vandføring. 3: Transport af suspenderet materiale. 4: Intensitet af snesmeltning. 5: Nedbørsintensitet. 6: Sneens vægtfylde. Suspenderet transport (g/s · 10^4)

Transport of dissolved material

On three different dates at the end of the investigation period water samples were taken for analysis in Copenhagen. As the sample variations are within the accuracy of the analysis, table 2 shows the result of the analysis, from August 29 only. The concentration of dissolved matter is found by summation of the single components. The sum varies between 24.9 and 27.2 mg/l. The concentration is equally low, presumably for the whole period, which was also to be expected when the water mainly originates from melted glacier ice and snow. The average concentration: 25.6 mg/l and the discharge values were used to calculate the load.

Table 2.

	mg/l	milliequiv./l
HCO_3^-	6,7	0,11
SO_4^{--}	8	0,17
Cl^-	2,8	0,080
NO_3^-	0	0
Ca^{++}	1,7	0,09
Mg^{++}	0,58	0,048
Fe^{++}	0,18	
Mn^{++}	0	
NH_4^+	0,7	0,038
Na^+	2,3	0,10
K^+	0,7	0,02
pH	6,40	
Hardness total	0,39	
Hardness temporary	0,31	
Hardness permanent	0,08	

The different transport components

Assuming that no material will be suspended at st. 5, the share of each transport component at st. 5 can be stated: suspension 78%, bed-load 17%, and dissolved load 5% of the total load of 194 t/24hrs. measured on August 19, and 77%, 18%, and 5% of the 164 t/24hrs. on August 22. If all bed-load were suspended, the corresponding figures for st. 5 would be 73%, 21% and 6% of 160 t/24hrs. on August 19, and 72%, 22% and 6% of 135 t/24hrs. on August 22. The transport of suspended and dissolved solids is rather exactly determined at st. 4, and the percentual distribution of transport components found both days is rather constant; bed-load and total load can therefore be calculated for the whole period under the assumption that this percentual distribution remains constant.

If no material is suspended between st. 5 and st. 4, the total transport into the sea will be 9380 t of which 7360 is suspended load, 1640 t bed-load and 380 t dissolved load. If all the bed-load at st. 5 goes into suspension the transport into the sea will be the sum of suspended load measured at st. 4 and the dissolved load, i.e. 7360 t suspended material and 380 t dissolved matter, totally 7740 t.

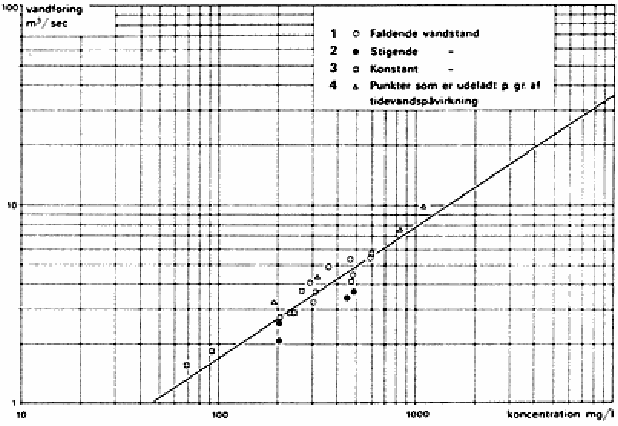

Fig. 7. Discharge and concentration of suspended sediment at st. 4. 1: Falling stage. 2: Rising stage. 3: Constant stage. 4: Points excluded because of tidal influence.

Fig. 7. Vandføring og koncentration af suspenderet materiale ved st. 4. 1: Faldende vandstand. 2: Stigende vandstand. 3: Konstant vandstand. 4: Punkter udeladt i beregningen pga. tidevandsindflydelse.

In fact bed-load can be observed at st. 4, the correct total load will therefore lie somewhere between the two indicated values. In order to make it easier to follow the calculations, apparently exact figures are stated. Considering the uncertainties mentioned earlier, it is more realistic to indicate the load in whole 1000 t and percentage rounded to nearest 5%.

Transport of material in the drainage basin of the Kugssuag stream:

In connection with the investigations of this drainage basin some water samples were taken simultaneously with the discharge measurements. The concentration of suspended load in the area above the lake Kugssuag Sø was rather homogeneous, 13 to 17.6 mg/l with a single exception for station C, where the concentration was 9 mg/l. The water depth was low at st. C, the unsampled zone therefore constitutes a higher share of the water depth, and the resulting concentration will consequently be low. The concentration at the outlet of the lake was 11.6 and 11.9 mg/l for two samples, the average concentration at the inlet of the lake was 16.4 mg/l. The net amount of material delivered to the lake was on the day of measurement, August 8, 825 kg/24hrs. corresponding to a trap efficiency of 28% for the lake. This is only valid for suspended material, however. The concentration values are considerably lower than in the Mitdluagkat stream; this shows that the Kugssuag stream only receives small quantities of meltwater from the glacier. The concentration values are considered representative for streams practically uninfluenced by recent glacial erosion and melting.

Fluvial morphology in the Sermilik area

Several fluvial morphological elements could be observed in the area. At the measuring section in the Mitdluagkat stream dunes were observed in the deeper part of the cross section and ripples in the lower part. Antidunes were only observed at the outlet of a lagoon in connection with low tide, but may possibly be found elsewhere in the mouth area because of the great tidal amplitude.

For the greater part of the valley bottom the Mitdluagkat stream may be characterized as a braided river; near the glacier there is however a deposit cone at the transition into the proper valley. Above the cone the water is streaming over large blocks.

The bottom relief of the Kugssuag stream, is determined by moraine deposits and rocky thresholds in some places, but the stream has mainly a braided pattern with meandering in between. At the outlet of the stream into the lake there is a well-developed delta. The river runs into the sea through an almost straight-lined stretch in solid rocks with many small thresholds.

Discussion, Hydrology

The investigation shows that a hydrological programme with routine measurements will be possible to establish in the future. It was not the aim to investigate the influence of climate on the discharge, the results are however in good accordance with the dependence on climate which was demonstrated in the earlier investigation (Valeur 1959). It should be noted that precipitation measurements from the meteorological station at Angmagssalik will probably not be well-suited for a description of the material budget of the glacier. A comparison between run-off values from the Mitdluagkat and the Kugssuag area shows the dominating influence of the glacier on run-off and discharge. For the period July 19 to September 1, the discharge in the glacial stream corresponded to a water column of 721 mm melted from the total drainage area.

The measurements of melting from a snow patch can be applied partly as an expression of melting in areas without glaciers, if the extent of snow patches is known, and partly as an indicator of melting from glaciers so that favourable measuring periods may be found. Such measurements may be applied for a determination of the relationship between climate and melting.

Transport of material

Measurements of sediment transport have not been made earlier in this area. The concentration of suspended sediment was moderate compared with other glacially influenced streams (Fahnestock 1963), and the order of magnitude seems to be reasonable when considering the higher gradients in White River. A comparison with Icelandic streams (Tómasson, H. et al. 1973) also shows that the found concentrations are reasonable. Evaluation of bed-load transport is difficult, the difference between bed-load transport calculated after Meyer-Peter and after measurements of dune migration velocities is great. The calculated total load is less than the measured suspended load and still less than the sum of this and measured bed-load. This indicates that the glacier supplies the stream with material exceeding the quantity induced by the hydraulic conditions. The transport of dissolved matter is apparently no problem, but it would be of interest to measure the ion concentration in the precipitation of the area prior to an estimate of the chemical decomposition in the area.

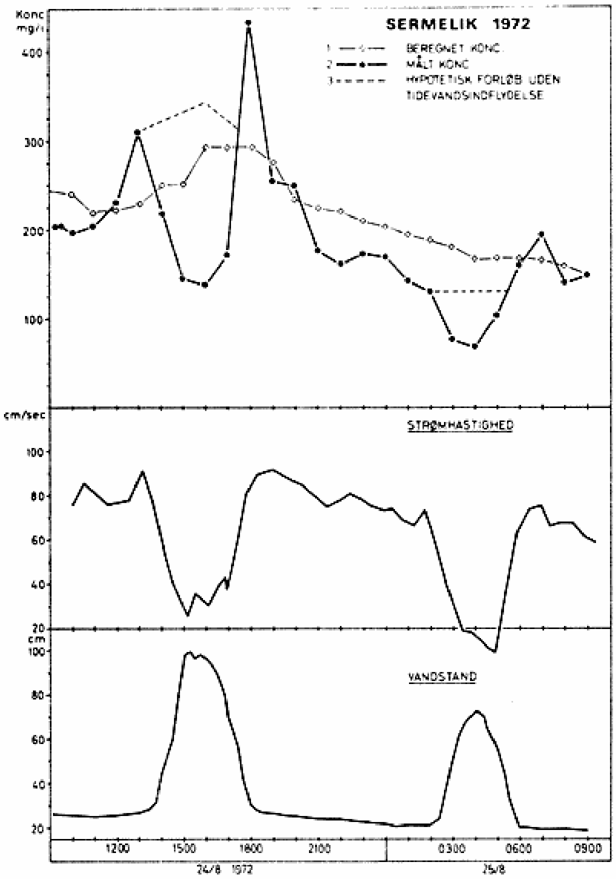

Fig. 8 Measurements at st. 4. 1: Computed concentration. 2: Measured concentration. 3: Hypothetical concentration with no tidal influence.
Fig. 8 Døgnmåling ved st. 4.

For future measurements it would be an advantage to move the sediment station somewhat upstream so that the tidal influence is avoided. On the basis of the present investigation it will be possible to chose sampling periods to allow a calculation of a Q, Q_s curve for falling as well as rising stages.

General

The greatest problem is to get knowledge of the natural annual cyclus. This will need self-registrating equipment, local labour and inspection of the area in the climatically harsh part of the year. Observed high-water lines in the system considerably above the present water level indicate the necessity of such investigations.

Conclusion

1. The applied methods have proved to be well-suited and a reasonable accuracy can be obtained. In future it will therefore be possible within reasonable time to establish and carry out the routine measurements that will be necessary for a determination of these parts of the glacier's mass balance.

2. It was found that the precipitation records from Angmagssalik are probably less suitable for a description of the precipitation conditions at the glacier.

3. The average water discharge of the Mitdluagkat stream was for the measurement period 3.92 m^3/sec. corresponding to a run-off of 190 l/sec./sq. km. From the Kugssuag area, where the glacial influence is much less, the run-off was 58% of the figure found for the Mitdluagkat stream on August 8.

The discharge of the stream was influenced by melting caused by radiation, advection and condensation. Maximum discharges were observed in connection with high temperature and heavy rains; no drainage of ice-dammed lakes was observed.

4. At station 4 the average suspended load was 167 t/day and the transport to the sea of both particles and dissolved material is 8-9000 t for the period July 19 to August 31.

5. The share of each transport component varies from place to place in the stream. The coarser material deposits in the coastal zone.

6. The greater part of the glacial stream can be characterized as a braided river.

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Nedbør og snesmeltning er målt ved st. 1 og st. 2 i perioden 11/8-31/8, se fig. 2. Resultaterne af målingerne er vist på fig. 6, det ses, som det kunne forventes, at vandføringen varierer i overensstemmelse med variationerne i smeltning og nedbør.

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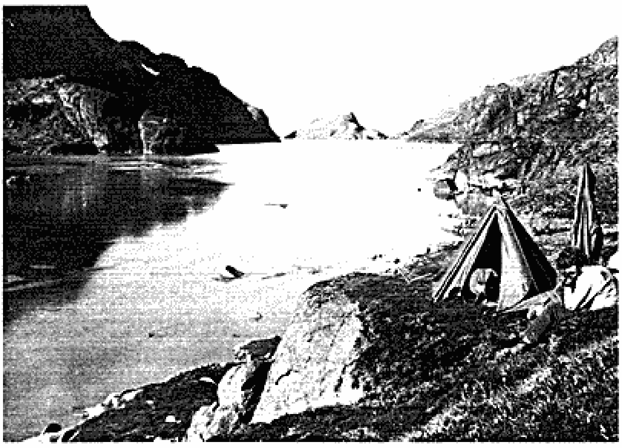

Fig. 9. Lake at Kugssuag.
Fig. 9. Sø ved Kugssuag.

Fig. 10. Delta at the eastern end of the lake at Kugssuag.
Fig. 10. Delta ved østenden af søen ved Kugssuag.

derfor tages som et udtryk for overskydende materiale tilført fra gletscheren.

Transport af opløste stoffer er beregnet ud fra kendskab til koncentrationen af opløste stoffer, se tabel 2, og vandføring. Gennemsnitskoncentrationen var 25.6 mg/l.

Materialet i elven transporteres på forskellig måde, der er gjort et forsøg på at bestemme de enkelte transportmåders andel i totaltransporten. Den 19/8 og den 22/8 måltes bundtransporten ved st. 5 og suspenderet transport ved st. 4. Hvis alt materiale, som bundtransporteres ved st. 5, går i suspension på vej til st. 4, vil den suspenderede transport, som måles her, udgøre den samlede partikulære transport. Hvis derimod intet materiale går i suspension på vej til st. 4 vil vandløbets totaltransport af partikulært materiale til havet være summen af bundtransport ved st. 5 og suspenderet materiale ved st. 4. Da der rent faktisk kan konstateres en bundtransport ved st. 4, må sandheden søges et sted mellem de to ovennævnte alternativer.

Under forudsætning af at intet materiale, som bundtransporteres ved st. 5, siden suspenderes, vil den procentvise fordeling ved st. 5 mellem suspenderet transport, bundtransport og opløst transport være: 78, 17 og 5% af totaltransporten. Hvis alt materiale går i suspension, vil den tilsvarende fordeling ved st. 5 være: 72, 22 og 6%. Den procentvise fordeling er ret konstant for de to måledage, denne antages derfor konstant i hele måleperioden. Transporten af opløste stoffer og suspenderet materiale er kendt ved st. 4, ved hjælp af procentværdierne kan totaltransport for de to alternative situationer beregnes til henholdsvis 9380 t og 7740 t i perioden fra den 19/7 til den 31/8. Når metodeusikkerhed tages i betragtning, er en angivelse af transporten i hele 1000 t mere rimelig.

I Kugssuag elven er de målte koncentrationer af suspenderet materiale væsentlig mindre: 9-18 mg/l. Dette bekræfter, at tilførslen af vand og materiale fra gletscheren er ringe. Søens opfangseffektivitet bestemmes til 28% af den tilførte mængde suspenderet materiale.

Undersøgelsens resultater er i god overensstemmelse med tidligere resultater, hvad angår vandføringsmålingerne. Resultaterne af materialetransportmålingerne er i rimelig overensstemmelse med resultater fra andre gletscherpåvirkede vandløb, omend koncentrationsværdierne er ret beskedne. Det fremgår af fig. 7 og fig. 8, at en nøjere bestemmelse af koncentrationen som funktion af vandføringen vil være ønskelig og nødvendig ved fremtidige undersøgelser.

Det største problem er imidlertid at få kendskab til forholdene i hele den frostfrie periode, således at total årsbalance kan opgøres.

Konklusion

1. De anvendte metoder har vist sig egnede, og en rimelig nøjagtighed kan opnås. Det vil derfor fremover være muligt relativt hurtigt at etablere og gennemføre de rutinemålinger, som er nødvendige for at bestemme disse dele af gletscherens materialehusholdning.

2. Det er sandsynligt, at nedbørsmålinger fra Angmagssalik er mindre velegnede til beskrivelse af nedbørsklimaet ved gletscheren.

3. Elvens vandføring var i gennemsnit i måleperioden 3.92 m^3/sek. svarende til 190 l/sek./km^2. Fra området i Kugssuag, hvor gletscherpåvirkninger er stærkt begrænset, var afstrømningen den 8/8 58% af Mitdluagkat elvens.

Elvens vandføring påvirkes af smeltning som følge af stråling, advektion og kondensation. Maksimale vandføringer konstateres i forbindelse med kraftige regnskyl — der har ikke kunnet konstateres tegn på tapning af isdæmmede søer.

4. Suspenderet transport var i gennemsnit 167 t/døgn ved st. 4.

5. Vandløbets transport af partikulært og opløst materiale er 8-9000 t i perioden 19/7-31/8. De enkelte transportmåders andel varierer fra sted til sted i vandløbet. Det grovere materiale aflejres i kystzonen.

6. Størsteparten af Mitdluagkat elvens forløb kan betegnes som braided river.

General

The greatest problem is to get knowledge of the natural annual cyclus. This will need self-registrating equipment, local labour and inspection of the area in the climatically harsh part of the year. Observed high-water lines in the system considerably above the present water level indicate the necessity of such investigations.

Conclusion

1. The applied methods have proved to be well-suited and a reasonable accuracy can be obtained. In future it will therefore be possible within reasonable time to establish and carry out the routine measurements that will be necessary for a determination of these parts of the glacier's mass balance.
2. It was found that the precipitation records from Angmagssalik are probably less suitable for a description of the precipitation conditions at the glacier.
3. The average water discharge of the Mitdluagkat stream was for the measurement period 3.92 m^3/sec. corresponding to a run-off of 190 l/sec./sq. km. From the Kugssuag area, where the glacial influence is much less, the run-off was 58% of the figure found for the Mitdluagkat stream on August 8.

The discharge of the stream was influenced by melting caused by radiation, advection and condensation. Maximum discharges were observed in connection with high temperature and heavy rains; no drainage of ice-dammed lakes was observed.

4. At station 4 the average suspended load was 167 t/day and the transport to the sea of both particles and dissolved material is 8-9000 t for the period July 19 to August 31.
5. The share of each transport component varies from place to place in the stream. The coarser material deposits in the coastal zone.
6. The greater part of the glacial stream can be characterized as a braided river.

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