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PROGRESS OF YOUTHFUL SEDIMENTATION IN THE REGION OF HORNSUND

Abstract

Intense melting and outwash induced by climatic changes and deglaciation are operating in the area of Hornsund. Rock-fragment material, carried by short rivers is being largely deposited on the surfaces of abrasional terraces and raised beaches.

It has established that the sediments differ in character dependant on that of the aqueous environment. The composition of the deposits due to near-by transportation shows signs of unformity. An attempt has been made to determine their character on the basis of their mean dimensions and grain-size gradation. Within the periglacial zone of West Spitsbergen, contemporary sedimentation and the resultant development of youthful accumulational land-forms are progressing rapidly.

Extensive, flat surfaces of abrasional terraces and raised beaches are, beside rocky summits and ridges, ice-sheets and moraines, conspicuous features in the landscape of the northern Hornsund coast (Birkenmajer 1958 b; Jahn 1959; Jahn & Szczepankiewicz 1958). On these surfaces there is a predominance of contemporary sedimentation, to which the writer devoted a good deal of attention during the summer season 1959 while he was conducting investigations in Spitsbergen as a member of the expedition organized by the Commission for International Collaboration during the Geophysical Year. The Wrocław group of periglacial-soil experts were at that time carrying on the research work initiated by prof. A. Jahn in 1957.

Evidence of a considerable increase of outwash processes, as ascertained by means of quantitative measurements and that of congelifluction — though perhaps subject to periodical slackening — induced the writer to observe the sedimentary effects of water-action upon the landscape.

Both the increased operation of downwash observed in Spitsbergen and Greenland (Dege 1941; Jahn 1961; Jahn & Szczepankiewicz 1958; Mortensen 1930; Poser 1932) and the large proportions of accumulation by water are due to climatic changes and to the retreat of ice-sheets. Abundant rain- and melt-waters (Kosiba 1958) invade increasingly larger parts of the landscape, that are being gradually released from ice. The remarkable degree to which the shore is deglaciated is probably attributable to the post-glacial climatic optimum. According to Ahlmann (1953) its onset may be dated 2500—3000 years back. Recently, ice-sheets were found to have again receded a considerable distance (Kosiba 1958), leaving vast ice-free areas and thereby promoting a vigorous, both denudative and accumulative activity of waters along the sea-coast. Abrasional terraces and raised beaches became thus frequently local bases of denudation. A large quantity of water-carried material either settles on their surface in the form of cones or fills the depressions and lake--basins. Rivers, that often force their way through gaps breaching the edges of terraces, contribute to the formation of vast accumulational plains over their surfaces. This is not, however, the only manifestation of the influence of the former bedrock and relief. Its effects are diversified, for the old relief, due to erosion and accumulation supplies the material, affords routes for transportation and pre-determines the distribution of the youthful accumulational land-forms.

LOCAL BASES OF DENUDATION AND EROSION

The landscape of the Hornsund coast, when analysed from the view--point of local bases of denudation, shows several major horizons. These are either larger fragments of terraces and marine beaches with storm ridges ranging in respective height from 4 to 45 m above sea level (Birkenmajer 1958; Jahn 1959; Jahn & Szczepankiewicz 1958). Among these coastal horizons, the system of terraces from 4 to 17 m merits special attention. Extensive spatial spread constitutes the major topographic feature of this system and presence of animal fossils — its chief stratigraphic characteristic. According to Birkenmajer (1958) terraces above 8,8 m do not contain any fauna. However, the present writer established the presence of animal fossils within the sediments of the entire system i.e. up to 17—18 m above sea level. This is characteristic of the sedimentary environment of present-day raised beaches. A large proportion of the current sedimentation by running waters corresponds to horizons 4 to 17 m above sea level. Also terraces and beaches up to 45 m above sea level are accessible to youthful sedimentation. Old cliffs and abrasional shelves rising from 65 to 275 m above sea level (Jahn 1959; Jahn & Szczepankiewicz 1958) are now subjected to vigorous denudation as are also the slopes of the adjacent mountains.

TALUS CONES, CONES DUE TO DEPOSITION BY WATER AND SLUMPING, OUTWASH PLAINS

Along the north coast of Hornsund there areas differing in landscape features may be distinguished. Within the narrow coastal zone extending between the Horn and the Hans glaciers talus cones are predominant. Abrupt mountains sides descend here alomost directly into the sea. The bases of talus cones rest on narrow rock benches terminating by a precipitous cliff. Longer rivers, that would be apt to create alluvial cones are lacking in this part of the coast.

The next part of the coast, characterized by different development of accumulational forms, extends between the glaciers Hans and Werenskiold. Apart from talus cones, it exhibits water-laid and slump-cones. Talus cones are developed on the steep slopes of the Fugleberget, Ariekammen, Skoddyfjellet, Tornbjernsenfjellet and Gulliksenfjellet while water-laid and slump cones are spread at the valley exits of rivers that abandon these mountain ridges. Talus cones are resting on abrasional terraces situated above 32, 37 and 45 m. The zone of water-laid and slump cones extends on surfaces situated at lower altitudes, descending to the level of terraces raised 8 m.

Along the sea-shore, between the glaciers Werenskiold and Torell there is a third stretch characterized by the presence of outwash plains. The gravel-sandy sediments of outwash plains extend from the front moraines of the glaciers Werenskiold, Nann and the east part of the Torell down to the present-day storm-ridge.

The segment of the coast between the glaciers Hans and the Torell was chosen for a more detailed study of these deposits. In contrast to the east part where gravitative and solifluction processes are predominant the landscape under consideration displays effects of downwash and fluvial accumulation.

WATER-LAID AND SLUMP-CONES OF THE ARIEELVA AND STEINVIKELVA IN THE LIGHT OF FORMATIVE PROCESSES

Two cones differing in topographic character will be taken as examples. One of them is situated in proximity of the base of the Polish expedition, at the point where the Arie river abandons the incised valley at the edge of the Ariekammen. The second is situated at the opening of the Steinvikdalen near the Trulsenfjellet. The Arie river whose upper course flows through a hanging valley represents a typical example of a river fed by glacial meltwaters. Streamlets draining the relict glacier preserved in the upper part of the Ariedalen form its beginning. At the margin of the Ariekammen below the rocky exit, the river has, on its way into the plain, formed a large fan extending from the gorge over a distance of about 700 m down to the fragments of a terrace 8 m above the Hornsund. The fan is composed of various elements. Below the gorge,

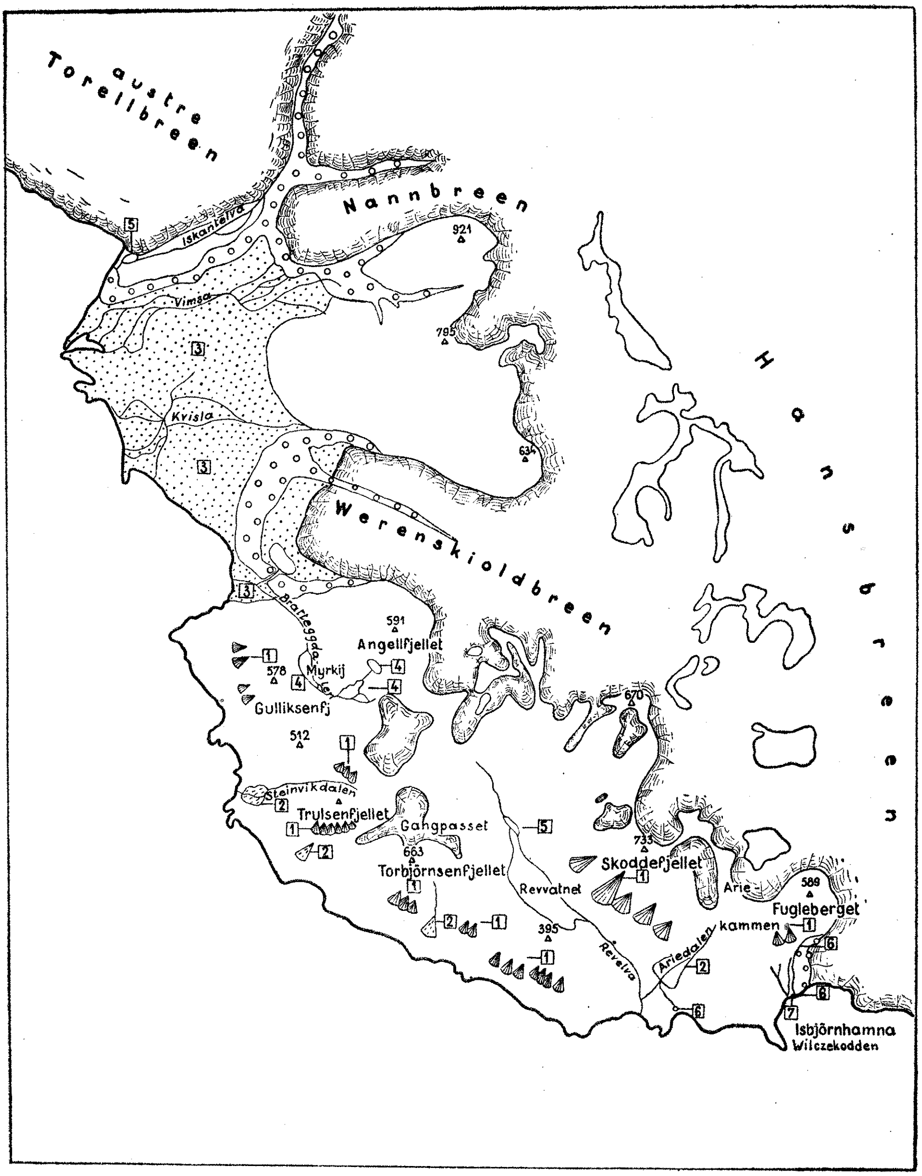

Fig. 1. Distribution of the main centers of sedimentation in the area of Hornsund
1. talus cones; 2. water-laid and slump cones; 3. outwash plains; 4. lacustrine deposits; 5. dammed-lake deposits; 6. glaciofluvial drift; 7. fluvio-nival drift

there is a small, steep cone consisting of both water-laid and slump material. The actual Arieelva cone is inset into the V-shaped cut of this cone (Troll 1954). The blocks at its head have up to 1 m in diameter. Below, the material becomes increasingly finer down to pebbles and gravels ca 2 cm in diameter. From the middle of the cone block material reappears. Thus, this part of the deposit does not actually pertain to what is *sensu stricto* the form itself.

Below the erosional cut in the edge of the Ariekammen, several sedimenty units may be distinguished. First among them is the steep and small cone, cut through by erosion that represents the accumulational equivalent of the upper part of the gully. The structure of the younger actual cone shows three further units overlapping one another. The oldest part composed of poorly rounded blocks and gravels appears in the lateral undercuttings. This material is overlain by a series of pebbles and gravels. A sandy-silty cover, the thickness of which varies from 0,5 to 0,3 m represents the youngest element. The dense moss cover overgrowing its surface is locally overlain by a contemporary deposit of the same type. Waters flowing over these deposits, disappear amid the blocks and pebbles of the lower part of the cone.

Both the profile obtained in the field (fig. 2) and the bedrock composition indicate that the base of the actual Arieelva cone lies within the

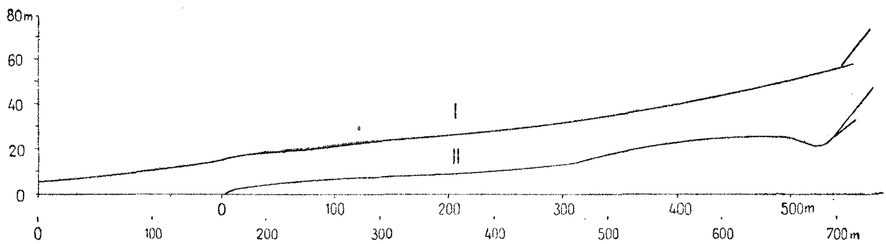

Fig. 2. Morphologic profiles of cones: I — Arieelva, II — Steinvikelva

horizon of an abrasional terrace of about 12 m. A block-field and congelifluction material spread down the rocky edge of the 12 m level constitute an apparent prolongation of the Arieelva cone. Isolated fragments of approximately 8 m high terrace covered by marine gravels emerge here and there from under the rubble. The rock material of this terrace, destroyed by periglacial processes, is also included in the prolongation of the Arieelva cone. It extends down to the floor of the Rev river. Fines, washed out of both cone and rubble have accumulated on the floor of the river-bed, thus contributing to the swampy character of the lower part of the Revelva valley.

The steep cone, near the opening of the valley is younger than the ca 45 m terrace on which its base is resting. The pedestal of the large actual cone originated on 17 and 12 m terraces. Its lowest element rests on a 12 m terrace. The intermediate cover may have arisen during the same time as the 8 m horizon. The youngest sandy-silty cover is still increasing in thickness after each of the seasonal floods, especially the spring floods. Grain-size gradation from coarse to fine towards the top of the formation is probably an expression of the reduced transportive capacity of the waters due to changes in climatic conditions. The large blocks occurring within the covers of the cone and on its surface are attributable to the catastrophic overflow of melt-waters. The rubbly prolongation of the cone is relatively youthful. The blocks are principally derived from the 12 m abrasional terrace.

Dissection of the cone was not caused by a periodical lowering of the absolute level of erosion base resultant from isostatic movements, since the younger sediments are here not inset but gradually superimposed upon each other. The development of the formation was controlled by climate and the former relief. The mode of development of this compound formation was determined at first by the older denudational relief and later, according to the further development of the landscape, by each of the particular surfaces of accumulation.

In contrast to the typical Arieeleva cone, the other cone chosen for comparison, that occurs at the opening of the Steinvik valley looks at present like a flat hillock. In the plan, it is elliptic in outline and its longer axis is parallel to the direction of the valley. It has about 20 m in relative height. The longitudinal profile of the form (fig. 2) reveals the presence of a considerable depression between the upper part of the cone and the opening of the valley. Both cones also differ in composition. It has been established, on the basis of excavations and observations, that the upper sedimentary layer of the Steinvik cone consists of fluvial sands and gravels including rock rubble and blocks. The blocks either occur in loose material or are scattered over the surface of the mound. Petrographic analysis showed that both blocks and gravels are derived from the adjacent slopes of the Trulsenfjellet. The blocks have rolled down onto the cone, at the time when it was closely connected with the valley exit or perhaps somewhat later when the depression between the exit and the cone had become filled with snow.

During its initial phase, the development of the Steinvik cone was similar to that of the Arieelva cone. Its steep element due to deposition by water and to slumping was formed when the edge exposed by deglaciation became dissected. Rapid melting of the ice-sheet within the abrasional horizon situated above 200 m exposed the ancient hanging valley of Steinvik. Owing to the increased activity of erosive processes, the older cone and also partly its rocky base became dissected. In the course of subsequent development, the rock material at the head of the newly forming cone penetrated into the dissected older form. After the large, younger cone had been formed, its further development progressed in a different manner than that of the Arieelva cone since its head below the valley exit became dissected by a breach, several meters in amplitude, that cut off its connection with the valley exit. Therefore, the younger deposits are here not superimposed upon the older ones but inset into the laterally dissected actual cone. At present, a new flat cone is forming, mainly composed of sandy deposits. Its base extends far beyond the remnants of the older cone.

Differences in the conditions under which deglaciation progressed seem to be the only conceivable reason of the dissimilarity in the development of these two formations, in spite of their equal relationship to the absolute Level of erosion base. These differences were caused by both older relief and local climate. The Arie river abundantly fed by waters from the ice-sheet preserved in the Ariedalen, continuously contributes to the growth of its cone. The Steinvikdalen ice-sheet having already disappeared and the river being nourished only by melting snow and partly by rain, its water have considerably decreased in quantity and consequently the head of the cone from which the fines had been outwashed became dissected by erosion. At the same time the course of the stream became diverted along the edge of the strongly convex form.

Considering these two examples it does not seem possible to attribute the dissection of the Steinvik cone to erosion resulting from lowering of the level of erosion base. The dissection of the Steinvik cone being still in progress, it is most probably due to the decreasing water supply in this river, in contrast with that of the Arieelva.

SOME GEOMORPHIC PROCESSES IN THE OUTWASH-PLAIN AREA

Wide-spread outwash plains are characteristic features of the Hornsund coast between the glaciers Werenskiold and Torell. Their sediments are either derived from water-destroyed terminal moraines or represent typical outwash cones formed by glacial rivers and streams. They are scattered over a surface of about 50 km^2. In their lower portions they overlap with the marine sediments of youthful storm ridges. They rest on glacial drift or solid bedrock, truncated by abrasion. Isolated residual rocks, that are being vigorously destroyed by disintegration, emerge among the outwash-plains. Rubble visibly encroaches upon the sands and gravels of the outwash-plains. The residual rocks are frequently destroyed down to the accumulational surface.

During the summer season 1959, preliminary observations regarding the outwash-plains and glacial rivers occurring in this area were made in order to evaluate the increase of erosive and accumulative processes. A striking fact which is undoubtedly responsible for the formation of outwash--plains is the varying amount of water-supply in glacial rivers. This is best exemplified by the glacial rivers that drain the Werenskiold glacier. In 1957 the Kvisla river that drains the right-side margin of the Werenskiold glacier could not be crossed afoot, while the present left-side river was almost inexistant. In 1959, the hydrographic situation changed altogether. The Kvisla river became an insignificant streamlet while the left--side stream had become a large river, abundantly fed by waters from the interior dammed lake. A considerable amount of the waters that nourished the Kvisla river must have apparently been diverted into the dammed lake between the glacier front and its front moraine and thence farther on, into the left-side river. This is likely to have resulted from some change in the circulatory system of waters within the glacier and the dead ice on its foreground. Reduction of water supply caused the Kvisla river to cut deeper into the bedrock, while in 1959 the abundantly fed left-side river accumulated effectively. The horizontal distribution and stratigraphy of the outwash-plain deposits are not only indicative of climatic changes but also reflect modifications of the circulatory system within the marginal zones of glaciers.

PROGRESS OF ACCUMULATION IN LAKES AND DAMMED POOLS

Several sites were chosen in different parts of the area with a view to investigate the progress and the mechanical composition of deposits in deltas, lakes and ice-dammed pools. In order to obtain comparative data quantitative measurements were made of the downwash processes operating on slopes, wherefrom the sedimentary material is derived. Investigations by A. Jahn showed that on a bedrock composed of limestone and shists of the Hecla Hoek formation, the amount of material removed is up to 1 mm over a period of 150—170 years. A similar order of value characterizes the material removed, that was largely (without reckoning the one that was carried off into the sea) deposited in the collection tanks, included in the courses of the glacial and snow-melt streams. A certain quantity of material remains also on slope planations in the form of colluvial deposits. Especialy deltaic, lacustrine and dammed-lake deposits were investigated in greater detail.

ACCUMULATION BY RIVERS NEAR THE FUGLEBERGET

These are a „glacial" stream, that drains the right-side margin of the Hans glacier, a „nival" one, emerging from under the snow-patches of the Ariekammen moutain-sides and two small lakes included in the „glacial" stream. Sedimentologic data concerning this system are based on investigations made in both the field and in the laboratory. The origin of the lower lake is due to marine accumulation, the contemporary storm-ridge having obstructed the outlets of both the „glacial" and „nival" river into the Hornsund. This ridge is about 4,5 m in height. The level of the lake is at ca 3,4 m above sea level. It is connected with the Isbjörnhamna by a short stream. The banks of the lake basin are polygenetic. The lake is bounded to the east by the lateral moraine of the Hans glacier and by small residual rocks. To the west the lake is bordered by the fragment of 5 m terrace and to the north, lies the flat delta of the „glacial" river and an old dissected storm-ridge. Dependant on the shore components on which it borders, the basin-floor is coated with material coming from the destruction of these forms. Silty and sandy deposits of both the „glacial" and the „nival" streams are spread round their mouths, situated close-by each other.

Samples of these deposits have been tested in the laboratory of the Geographical Institute in Wrocław. Thus, a comparison could be established between their mechanical composition (fig. 3). It was found that

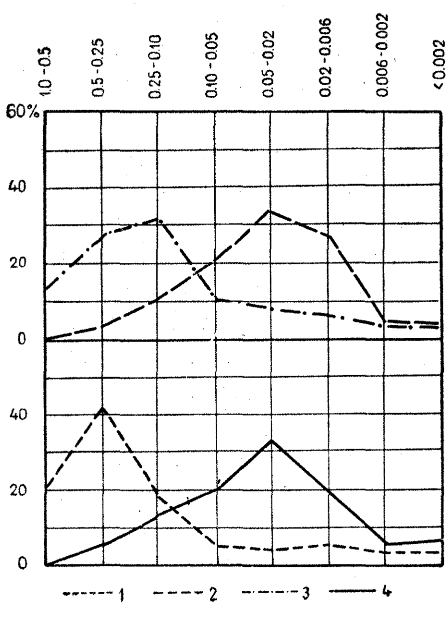

Fig. 3. Diagram of grain-size gradation in deposits near the Fugleberget

1. water-deposited material derived from below snow-patch; 2. accumulation by „nival" river; 3. glaciofluvial accumulation in upper lake; 4. accumulation in lower lake deposited by „glacial" river

these are drift deposits. A comparison of the diagrams of grain-size gradation in the material deposited by either the „glacial" or the „nival" river revealed certain relationships. There is a great similarity between the materials deposited by the „glacial" river in both the lower and the upper lake. A fact worth noting is that the upper lake lies directly below the moraine of the Hans glacier, at the point where the river, emerging from the lateral moraine, deposits the materials washed out of both glacier and moraine.

Likewise, there is a similarity between the drift deposited by the „nival" river and the material intersepted by the collection tanks that had been installed on the slope of the Ariekammen (Jahn & Szczepankiewicz 1958). Material transported and deposited by the „nival" river shows a grain-size gradation approaching the one found in the slope and under snow-patches on the slope. In contrast, the deposits of a „glacial" and those of a „nival" type that are accumulated by both these rivers widely differ from each other. The „glacial" river carries and deposits predominantly fines eluviated from both glacier and moraine, whereas the „nival" river supplies the lower lake with coarser particles (fig. 3). This indicates that near-by transportation fails to induce sorting of material.

OBSERVATIONS IN THE LAKE AT THE MOUTH OF THE ARIEELVA

The lake-basin at the outlet of the Arieelva into the Hornsund is bounded: to the south, by an old ca 8 m high storm ridge, through which the Arie river forces its way to the sea; to the east and west — by fragments of abrasional terraces including rocks of a residual character; to the north — by the vast, swampy Arieelva valley. Three motometers have been installed in the dry portions of the lake-basin, on sorted circles that were the best-developed of all those occurring in the area north of Hornsund (Jahn & Szczepankiewicz 1958) Samples of material were taken for investigation from: the lake-floor, the centers of the sorted circles and the near-by abrasional terrace. Samples derived from the lake-floor were found to contain ca 40% of sandy, and 60% of clayey and silty particles. Some of the samples from the centers of sorted circles also contained an approximately similar percentage of fine sands, clay and silts. Thus, there is likeness in mechanical composition between the lacustrine deposits and the material composing the center of sorted circles. Samples from the third and highest altitude i.e. from the surface of the adjacent abrasional terrace contained ca 50% of sandy and 50% of silty-clayey grains, whereby they differ from the former. Some of the stone circles are likely to have developed within a cover, the detritus of which was supplied by the near-by edge of the terraces and by the slopes of residual rocks. Coarse, debris material encroached upon the fluvial drift that accumulated within the shallow lake beyond the ridge. Frost-caused processes by inducing surfaceward migration of fines contributed to the formation of sorted circles. Such a possibility, together with the preparatory sorting due to upfreezing of stones, should be also taken into account.

DAMMED LAKE ON THE UPPER REVVATNET

The Rev lake probably owes its origin to the eroding action of a glacier, the only traces of which are found at present in the lateral moraines occurring on the valley sides of the Revelva. The lake consists of two parts separated by a rock-bar lying across the valley axis. A flat accumulational plain extends on the left-hand side of its smaller, upper portion. It consists of drift transported by the upper Rev river that originates at the Gangpasset glacier. Lake and adjacent plain occupy the whole width of the flat valley-floor. In order to investigate the composition of the bedrock, a cross-section was made in the water-free part of the basin, together with soundings, spaced 8 m apart and reaching down to the permafrost table (fig. 4). The profile shows variations in height up to 0,6 m

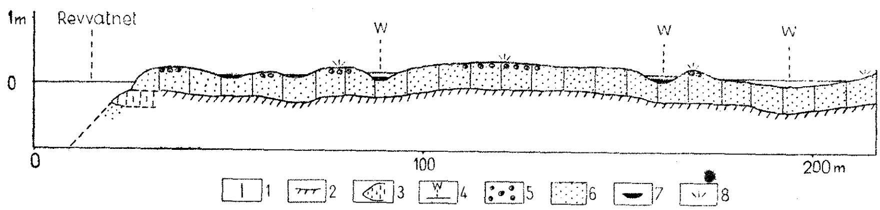

Fig. 4. Geologic cross-section through the Rev dammed-lake
1. points of soundings; 2. permafrost table; 3. lake-ice; 4. water table; 5. patches of gravel; 6. sands; 7. loams including organic remnants; 8. lichens and mosses

which also characterize the whole surface of the plain. The plain displays several enclosed depressions containing water at the bottom. Loamy material containing vegetal remnants, particularly *Salix polaris* leaves, mosses and lichen has settled within these depressions. Higher upward surfaces are composed of fine gravels overlying sands and silts. Flat protuberances are locally overgrown with lichens and mosses.

The depth of occurrence of the permafrost table was measured in the profile on August 13-th 1959. It varied from the 0,4 to 0,65 m from the surface, and was nearest the surface in the proximity of the water-basin.

Lake-ice burried under the drift deposits (fig. 4) must have largely contributed to the formation of this dammed lake *in statu nascendi*. A small excavation made in the lake-bank argues in favour of this assumption. Clean ice was found at a depth of 0,4 m from the surface, beneath fluvial deposits. Under the lake-water, the ice was tapering. Below, there is a sediment of sandy-fluvial drift. If this ice were to melt away, the present-day flat plain that corresponds to a surface of composite accumulation would be likely to assume an undulatory, concave shape. Some of the samples show a predominance of coarse-grained sandy material, testifying thereby to the considerable transportive capacity of the upper Rev river.

ACCUMULATION IN THE BASIN OF THE BRATTEGG RIVER

The Myrktj lake that is included in the course Brattegg river collects a large quantity of material derived from the upper part of the valley. The lake lies at an altitude of about 75 m above sea level, beyond the rock-bar at the edge of the level of abrasion. This edge is being vigorously

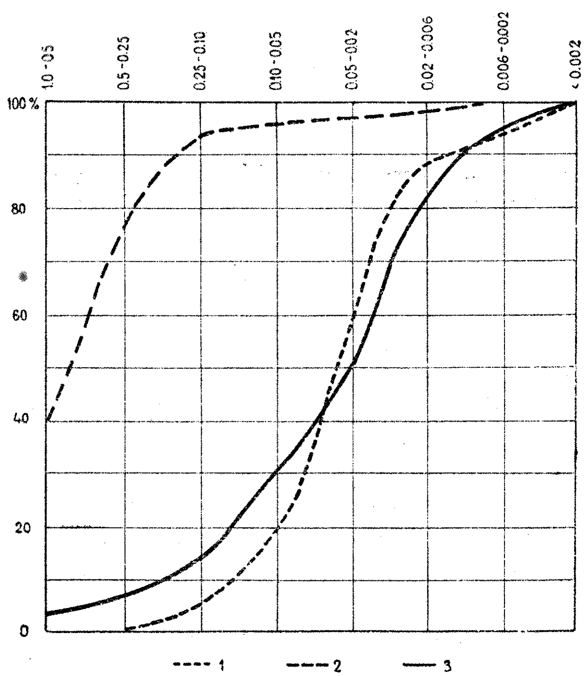

Fig. 5. Cumulative curves of lacustrine deposits in the basin of the Brattegg river
1. deposits in „upper" lake; 2. deposits in „central" lake; 3. deposits in Myrktj lake

breached by the Brattegg river. Above the Myrktj lake, the basin of the upper Brattegg contains two further lakes that are not marked in the Norwegian map from 1953. One of them lies far at the head of the valley, the other on the right-side of the valley within the rocky abrasional horizon at ca 200 m in elevation. The Brattegg river is principally fed by ice- and snow-meltwaters. The „central" Brattegg lake is connected with one of the springs-rivers that is nourished by glacial waters, while the „upper" shallow lake that is almost extinct as a result of accumulation, drains snow-meltwaters into the Brattegg valley. Samples for comparisons between the natures of these deposits were taken from the places where rivers and streams discharge into the three lakes (fig. 5). At the mouth the of the river that falls abruptly into the central lake, coarse material has accumulated although the river is fed by glacial waters. Samples of coarse material were taken from the declivity, entrenched by the river-bed. Material containing predominantly fines has settled within the upper and the lower lake, that are situated in flattened surfaces. The rivers conveying the material have lost much of their transportive capacity over the abrasional terraces surrounding these lakes.

DAMMED LAKE NEAR THE TORELL GLACIER

The left-side margin of the Torell glacier is drained by a large „glacial" river, the Ikantelva. At its mouth, waters spill over forming a lake, that lies almost at the level of the near-by sea. It is bounded: on the sea-

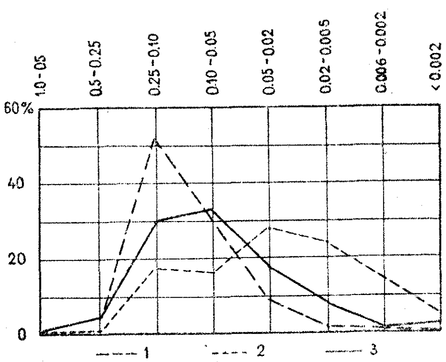

Fig. 6. Diagrams of grain-size gradation in accumulational horizons of the dammed lakes Torell and Revvatnet

1. lower sedimentary horizon of the Torell dammed lake; 2. higher sedimentary horizon of the Torell dammed lake; 3. sediments in Rev dammed lake

coast side by a high storm ridge that has been breached in one place (west) by the short terminal part of the Ikantelva; to the south and south-east by a (once more extensive) lateral moraine of the Torell glacier; to the north-east by the glacier itself. The plain of accumulation consists of two horizons. The lower one lies almost at water-table level and corresponds to accumulation under normal conditions. The second horizon raised about 0,8 m is most probably due to the spread of flood-waters. Samples taken from both these horizons show well-marked differences (fig. 6). The fines of the higher horizon are being deposited by the extensively spread overflow of the Ikantelva during spring floods. Fig. 6 illustrates the widely divergent nature of the „dammed" deposits of the Revelva and those of the Ikantelva, the latter showing a much greater similarity in grain-size to Pleistocene „dammed" deposits, as they contain a much percentage of fines.

It should be pointed out that the western barrier of the dammed lake i. e. the storm ridge is relatively high. Apart from the action of the open sea, that of the vigorous waves due to the calving of the Torell glacier into the sea in proximity of the ridge may also have largely contributed to its formation. This is a case of marine accumulation under specific conditions. In general, many lakes have come into being as a result of contemporary marine accumulation, principally because of the formation of storm ridges. These lakes collect a large amount of the materials carried by the rivers draining the ice-free northern coast of Hornsund.

TYPES AND MECHANICAL COMPOSITION OF SEDIMENTS

In the periglacial zone of the northern Hornsund coast, weathering and denudation of slopes induce vigorous accumulative processes, principally at the slope bases and on the surfaces of raised beaches and abrasional terraces. These deposits are either colluvial, alluvial, glaciofluvial or lacustrine in origin. Glacial and marine accumulation form separate groups.

Alluvial, glaciofluvial and lacustrine accumulation were studied in greater detail. Analyses of grain-size gradation in a large number of samples permitted to distinguish the predominant characteristics of each of the sedimentary types. Both areometric and sieve-method were applied. Grain-size fraction was classified as shown in tabl. I.

Table I

Grain-size gradation of deposits

Pebbles and coarse gravels mm	Gravels			Sands		silt and clay	
	medium mm	fine mm	coarse mm	medium mm	fine mm	coarse silt mm	fine silt and clay mm
5,0	5,0—2,0	2,0—1,0	1,0—0,5	0,5—0,25	0,25—0,10	0,10—0,05	0,05

The medium sizes of drift deposits were calculated on the basis of the percentage of each fraction in the samples, according to the formula:

$$d_m = \frac{\Sigma d_j p_i}{100}$$

where d_i represents the arithmetic mean value of grain-size, and p_i its percentage (by weight) (Shamov 1959). For drift deposits in a general sense d_m data were obtained. Using the index of what is drift material in the strict sense i. e. the percentage of grain-size below 0,05 mm, it was established that the deposits belong to three different categories. These data are listed in table II.

Table II

Medium sizes of fraction and categories of deposits

Origin of accumulational material	d_m	categories
Colluvial material in the slope of the Ariekammen	0,36	—
Material from under the snow-patch on the slope of the Ariekammen	0,27	—
Deposits of glacial river in the upper lake near the Hans glacier	0,061	II
Delta of „nival" river near the Hans glacier	0,33	III
Delta of glacial river near the Hans glacier	0,060	II
Dammed lake by the Torell glacier, lower level	0,12	III
Dammed lake by the Torell glacier, higher level	0,054	I
Rev dammed lake	0,47	III
Lacustrine deposit, lower Bratteggdalen	0,057	I
Lacustrine deposit, Bratteggdalen, central lake	0,47	III
Lacustrine deposit, Bratteggdalen, upper lake	0,057	I

Application of the d_m index permits to distinguish two different groups, one of which is characterized by a medium grain-size of the order of decimals of a mm, while that of the other is expressed in 100-th of a mm. Nival, fluvio-nival and slope deposits belong to the first group. The dammed deposits of large glacial rivers from a kind of sub-group. Deltaic, glaciofluvial and dammed deposits compose the second group.

It has been established by applying the index of drift material in the strict sense, i. e. that of the percentage of grain-size below 0,05 mm that the sediments may be classified into 3 categories based on differences in fraction: I — including 90—75% of material below 0,05 mm in diameter, II — including 75—50% and III — including below 50% of that range of grain-size fraction.

Thus these indexes may be, among others, applied in the genetic classification of the Pleistocene sediments of the periglacial zone.

GENERAL CONCLUSIONS

As established by observations in the area of Hornsund and by laboratory investigations, the composition of drift deposits due to near-by transportation shows a certain uniformity.

Development and distribution of accumulational land-forms is largely controlled by the older relief. Abrasional terraces and raised beaches are important local bases of denudation collecting large masses of accumulated material.

As demostrated by such examples as the Arieelva and the Steinvikelva cones, the development of land-forms situated near-by each other, showing an equal relationship to the absolute denudational base level and formed under the same climatic conditions, may proceed along entirely different lines, this development being controlled by the totality of local conditions.

Outwash plains are, as indicated by the drainage system of the Werenskiold glacier, not only the reflection of climatic changes but also that of changes in the circulatory system within the marginal zone of glaciers.

The bi-partition of formations, that is a condition requisite for the formation of sorted circles is likely to result from the conditions under which sedimentation progressed. Instead of being due to frost-caused sorting, its initial phase may have been induced by debris material from the slope encroaching upon fluvial deposits of deltaic or dammed type.

Within the periglacial zone of Spitsbergen, there is a periodical increase of processes due to water-action owing to which sedimentation progresses rapidly and new accumulational land-forms are being created.

Translation by T. Dmochowska

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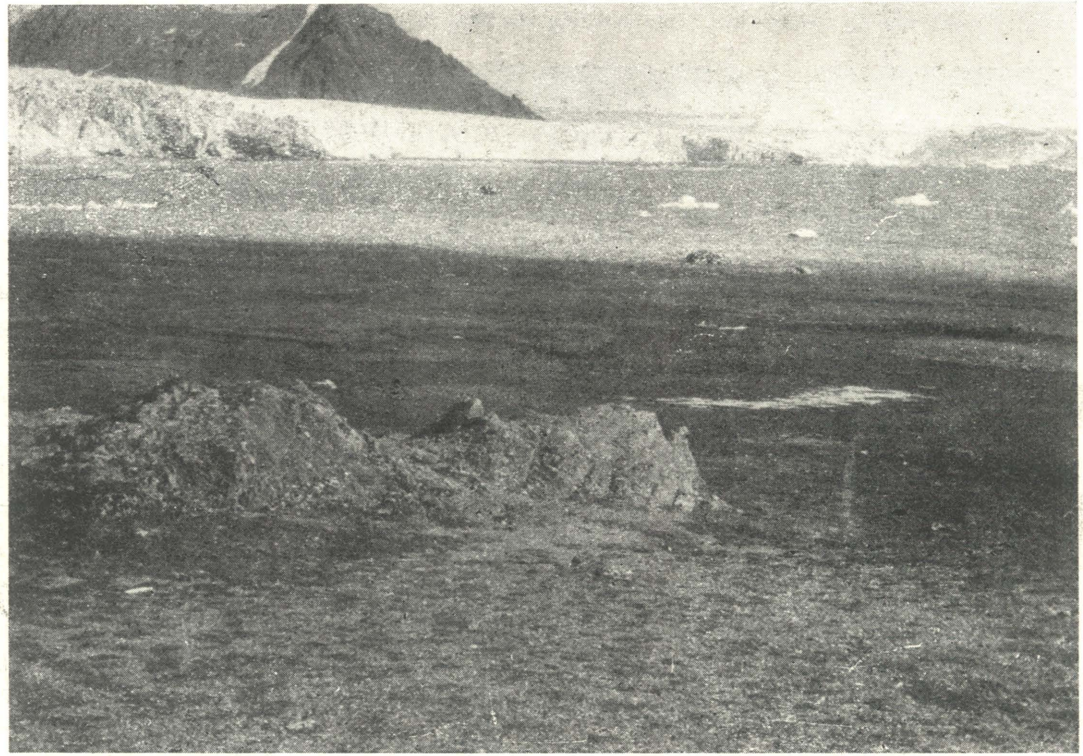
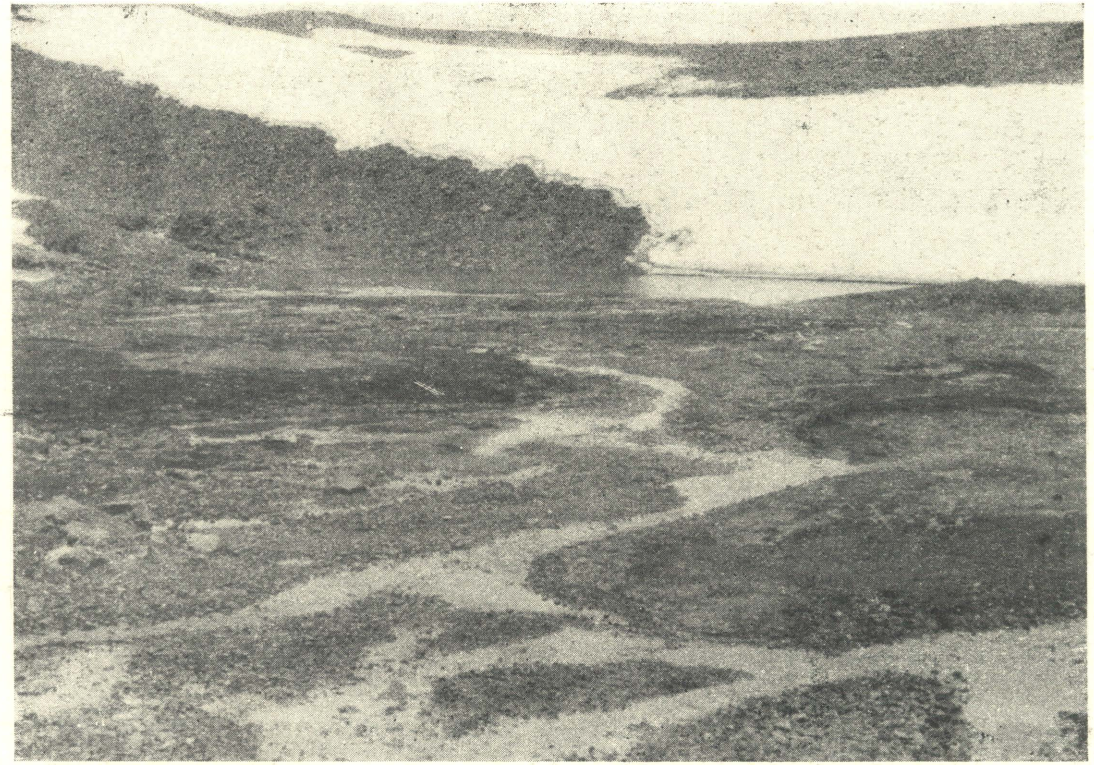
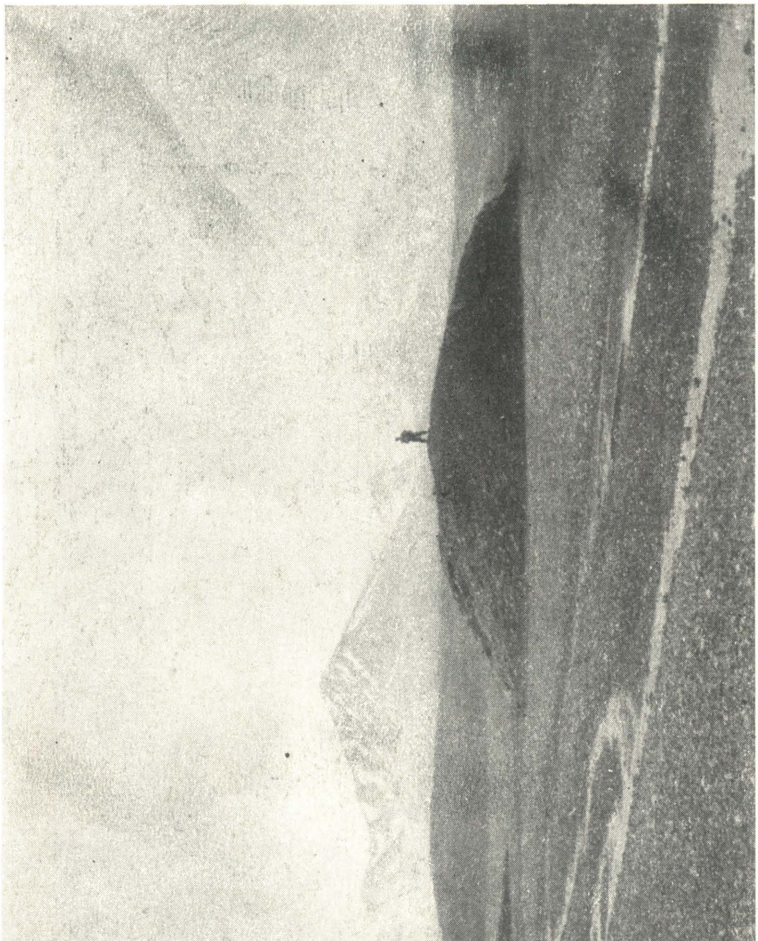


Pl. 1. Abrasional terraces and raised beaches in proximity of the base of the Polish expedition over the years 1957—1959, as local levels of denudation

Pl. 2. Congelifluction lobe near the Fugleberget, cut through by erosion



Pl. 3. „Upper" lake as accumulational basin near-by moraine of Hans glacier



Pl. 4. Outwash plain of Werenskiold glacier with residual rock