POLISH POLAR RESEARCH	10	3	379—384	1989

Mieczysław BORÓWKA

Quaternary Research Institute
Adam Mickiewicz University
Fredry 10
61-701 Poznań, POLAND

The development and relief of the Petuniabukta tidal flat. central Spitsbergen

ABSTRACT. Observations of the surface of the Petuniabukta tidal flat showed the occurrence of dead forms indicating a relative lowering of the sea level. Under the silt deposits of the tidal flat a gravel-clay series was found to occur. Connecting this series with the glacial till covering the lowest marine terrace and with the erosion pavement in the lowest part of the outwash plain gave rise to the hypothesis that there might be a record of glacier oscillation. By dating a sample taken from the gravel series substrate, the age of the oscillation was estimated at less than 6370±120 years BP.

Key words: Arctic, Spitsbergen, Petuniabukta, tidal flat, fossil glacial and fluvio--glacial deposits.

Introduction

The foreland of the outwash plain being formed by waters of the Swenbreen, Hörbyebreen and Ragnarbreen is an extensive tidal zone (Fig. 1, plate 1). This was the study area in 1986. The field research included, geomorphological mapping, a series of 15 exposures extedding down into the top of permafrost, measurements of changes in the bay water level, and a series of reproducible photographs of the tidal flat.

Variation in the Petuniabukta water level

Measurement of changes in the water level were carried out at random, at a water gauge installed near Skottehytta on the eastern coast of the bay. They showed that the tidal range did not exceed 2 metres. The water may

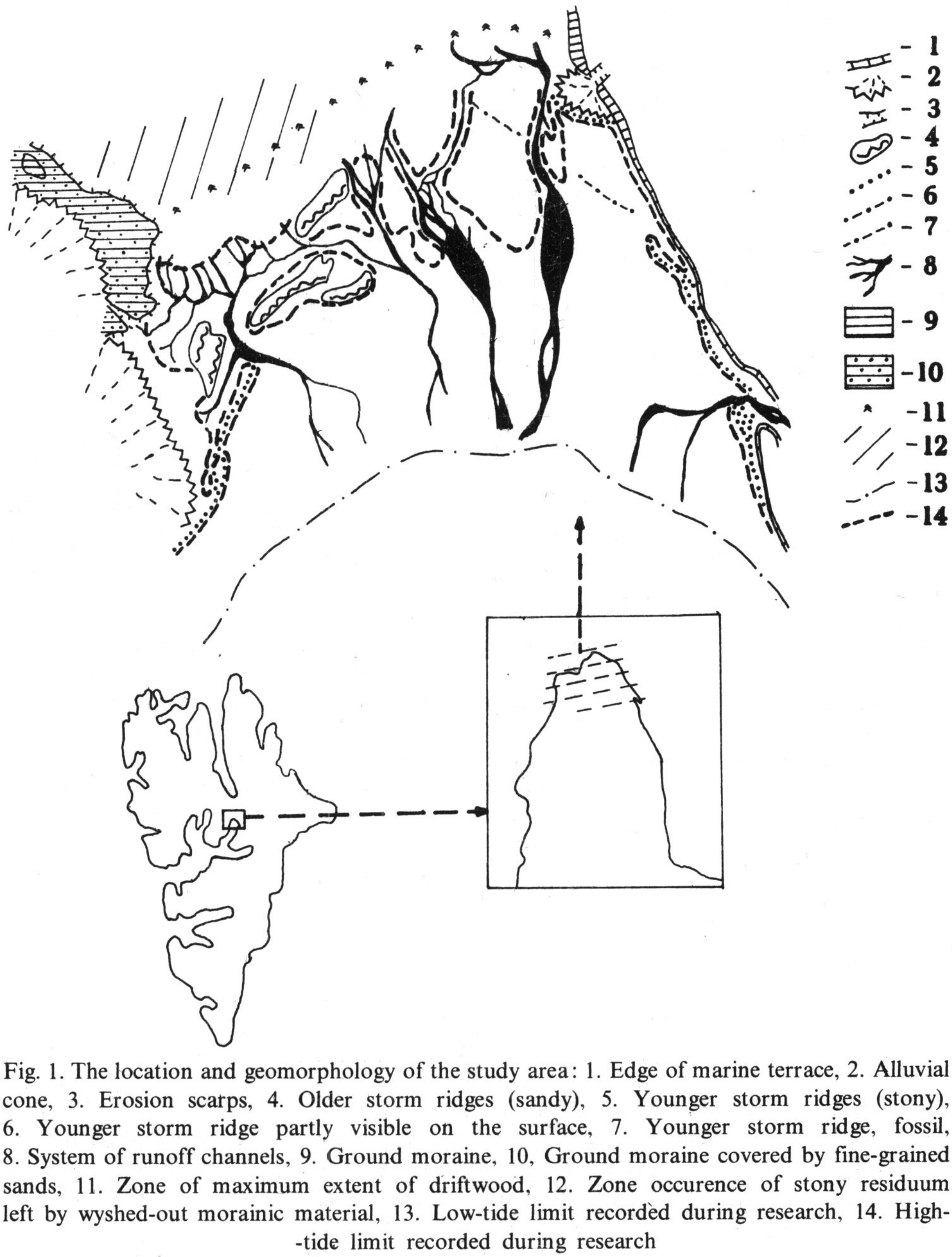
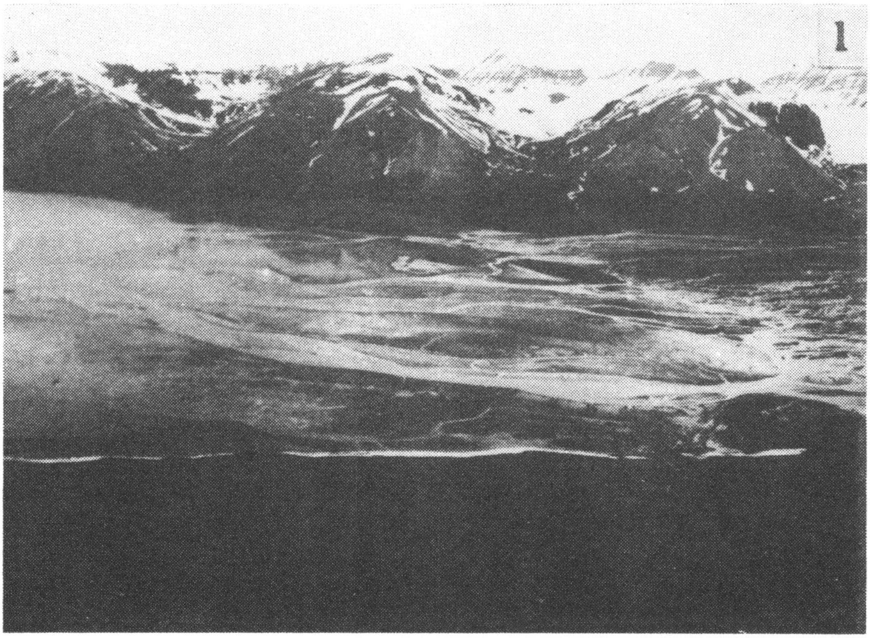


Fig. 1. The location and geomorphology of the study area: 1. Edge of marine terrace, 2. Alluvial cone, 3. Erosion scarps, 4. Older storm ridges (sandy), 5. Younger storm ridges (stony), 6. Younger storm ridge partly visible on the surface, 7. Younger storm ridge, fossil, 8. System of runoff channels, 9. Ground moraine, 10, Ground moraine covered by fine-grained sands, 11. Zone of maximum extent of driftwood, 12. Zone occurence of stony residuum left by wyshed-out morainic material, 13. Low-tide limit recorded during research, 14. High--tide limit recorded during research

reach higher when wind tides coincide with astronomical tides. Indeed in the lower part of the outwash plain one can observe drift-wood defining the maximum limit of the bay waters.

The reading of the water level at the gauge during selected tidal cycles was combined with taking a series of photos of the tidal flat from the slopes



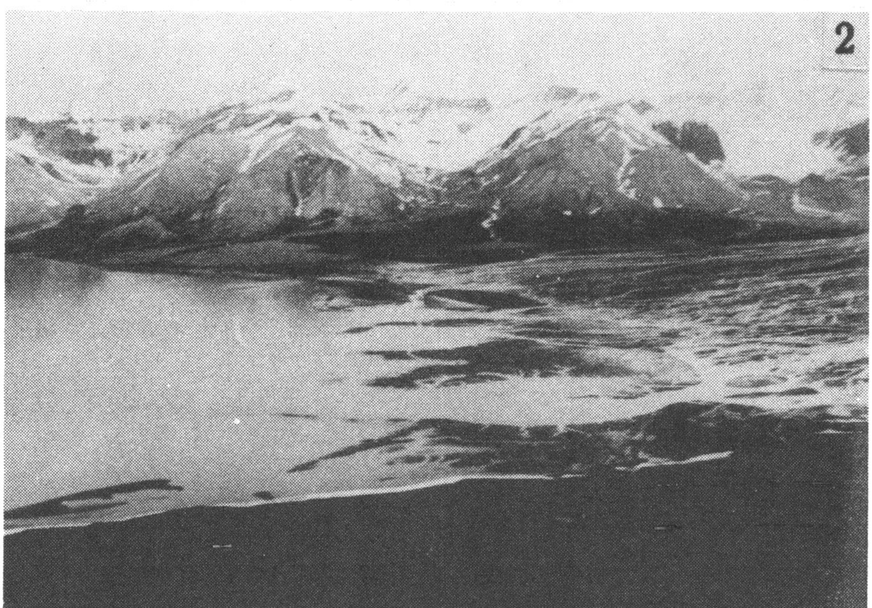


PLATE 1

1. The surfaces of the tidal flat during low (1) and high (2) tides

of Løvehovden. a peak situated east of the bay (Plate 1). In this way. without geodesic measurements, it was possible to estimete the heights of various surfaces and forms.

The relief of the tidal flat

The tidal zone in the central part of Petuniabukta. reaches a width of 2 kilometres. The lower limit is a marked break of the bottom of the fiord, uncovered at extremely low water stages. The upper limit lies 2 metres higher and beyond the line separating the area involved from the outwash plain. The upper part of the tidal flat is a clear morphological barrier for outwash plain waters. In the tidal zone the raimified system of outwash plain channels concetrates into three parallel runoff routes carrying water out to the bay. Henceforth they will be called western, middle (bipartite) and eastern.

Two morphological lewels can be distinguished on the extensive, mostly silt surface of the watt. In the northern part there are isolated patches of the higher level, currently not inundated. It is also 20—30 cm higher than the lowest part of the outwash plain. The beds of the runoff routes and the southern part of the flat constitute the lower level completely inundated during tides.

Above the flat watt surfaces of the tidal flat rise storm ridgesforming a system blocking the outlet from the outwash plain to the bay. An exception is the area between the middle and eastern runoff routes.

The storm ridges are not the limit of the tides. Behind them are a number of smaller internal watts. In the western parst these watts are a transit area for outwash plain water. The ridges attain a height of 50—100 cm above the maximum water level. Their width at the base series. The forms on the western and eastern coasts of the bay, adjoining uplifted marine terraces in a wing-like fashion, are narrow and their widt ranges from 2 to 5 m, while ridges in the central part of the bay have bases extending even to 20—80 m.

The lithology of surface forms

The surface of the tidal flat is diversified lithologically. The fragments of the higher level between the middle and eastern runoff routes are made of silt. At this level between the western and middle routes there are extensive sandy surfaces of storm ridges. Those lying at the lower tidal level are different, made of gravel and stones. They occur on the western and

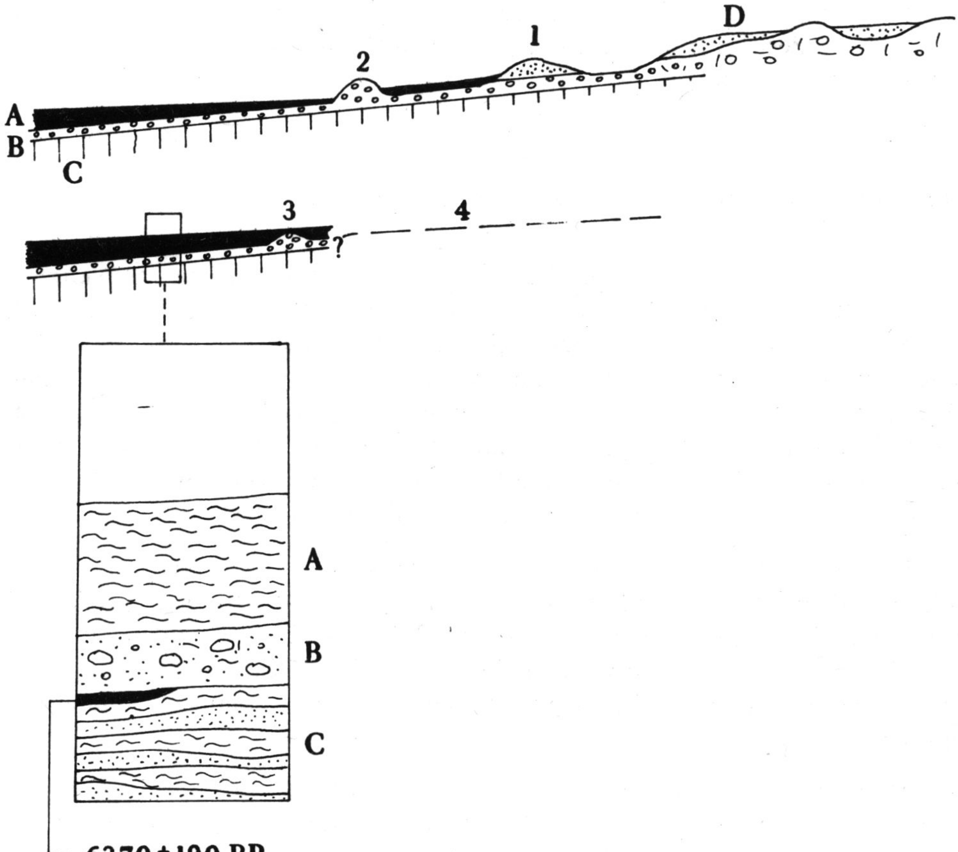


Fig. 2. A synthetic geological profile of the tidal flat deposits. Upper profile — western part of the flat. Lower profile — eastern part of the flat: A — silt series, B — gravel-clay series, C — sand-silt series, D — sand series, 1 — old storm ridge, 2 — younger storm ridge, 3 — younger storm ridge, fossil, 4 — outwash plain

eastern coasts of the bay. The small internal watts behind the storm ridges in the eastern part of the flat are silty, while those in the western part are silty and sandy-gravely. This follows from their role as a transit area for outwash plain water. The alluvial cones rooted in dissections in the escarpments of uplifted marine terraces are built of gravel and stones. In the western part of the study area fine-grained sands cover the surfaces between the alluvial cones. In some places stop bulges clusters of stones and boulders appear. There is glacial till lying in their vinicity.

The lowest level of the tidal flat is silty, like the higher level. It is only in the beds of the runoff channels that fine-grained sands can be found.

The geological structure of the tidal flat deposits

Throughout the area of the flat 15 exposures were made of 100 to 180 cm in depth and extedding to the top section of permafrost. Only exposures at the higher tidal level were feasible technically.

A synthetic profile of deposits is presented in Fig. 2. Under a silt cover a sand-gravel series was found. Farther below there occurs a rhytmically stratified sand-silt series. In the bottom of the silts and in the top of deposits underlying the gravel series there are fine, several-millimetre layers of algae. The gravel substrate was sampled for radiocarbon dating.

The silt series of the higher tidal level has a thickness of 80—120 cm. There are slight, several-millimetre sandy interbeddings, in its profile. The silt series is less thick in the northern part of the higher tidal level between the middle and eastern runoff routes. Here the gravel series comes up to the surface. In the silt substrate there is a gravel elevation. It may be a partly fossil storm ridge.

An interesting geological structure is displayed by deposits on a lower marine terrace whose fragments lie between alluvial cones closing the study ares from the west. In the erosion undercutting of this terrace a gradual transition of the gravel series from rewashed gravels through clayey gravels to typical glacial till can be observed. In the top of the till there are irregularities differing in relative altitude by up to 2 m. As has already been mentioned, in some places this till comes up to the surface. This fossil relief is masked by fine-grained sands.

An extension of the till outcrop in the erosion scarp mentioned is a zone of stones and boulders occupying the surface of the lowest part of the outwash plain. Most probably it is a residuum left by washed-out till.

An attempt at a reconstruction of events in the study area

The results of observations presented above do not allow a full reconstruction of the development of the tidal flat. However, they can help to trace the main stages in the formation of this area.

The sequence of events described below is limited by the age of the marginal line on the one hand and by the age of the outwash plain surface developing at present on the other hand. The rhytmically stratified sand-silt deposit occurring in the substrate of the gravel series is the oldest deposit found. The formation of the deposits of the contemporary outwash plain is suggestive rather of a littoral origin of this series. An analysis of the conductivity of the solution coming from rewashing of a sample of this series reveals a very high content of salts (2.700 μS). The marginal line may have developed in contact with the fiord water, at least during the tides.

In the western par of the study area the gravel series and the till are covered by fine-grained sand. Another analysis of the conductivity of the solution from a sample taken from this series indicates its land origin. The conductivity ranges from 90 to 100 μS. More precise geodesic measurements may supply different information, but field observations indicate that this surface runs aslant to the marine terrace which it adjoins.

Another lowering of the sea level initiated the sedimentation of the silt series of the higher tidal level and the planting of stony ridges in this series.

Today the upper part of the tidal flat is dissected and drained by a system of channels draining outwash plain waters. The area of the flat is a transit zone for fluvio-glacial deposits. Only suspended silt material is redirected from the fiord by the flood-tide and redeposited on lower surfaces of the flat.

The above interpretation of the sequence of deposits and their relation to the relief is only an attempt to reconstruct selected episodes from the palaeography of this area. It is the opinion of the author that the Petuniabukta tidal flat is a potentially rich source of information on glatiation and variation in the sea level in the Holocene. That the described traces of forms and glacial marginal deposits in the zone of the tidal flat are Holocene in age is proved by the absolute age of the organic material from the top of the deposit underlying the gravel-series (6370± 120 BP).

Received December 15, 1988
Revised and accepted May 24, 1989

Streszczenie

Badania równi pływowej Petuniabukta, prowadzone latem 1986 roku, obejmowały kartowanie geomorfologiczne oraz analizę budowy geologicznej warstwy czynnej oraz stropu wieloletniej zmarzliny. Na powierzchni sandru wyróżniono dwa poziomy morfologiczne (fig. 1). Wyróżniono także dwie generacje wałów burzowych. Stwierdzono występowanie w podłożu równi pływowej osadów genetycznie obcych (fig. 2). Pod pokrywą mułkową równi występuje osad piaszczysto-żwirowy z kamieniami. W miarę oddalania się od fiordu jest on bardziej gliniasty i przechodzi w glinę zwałową. Glina ta w zachodniej części zatoki przykryta jest piaskiem drobnoziarnistym.

Kolejne generacje wałów burzowych oraz poziomy morfologiczne równi pływowej stanowią zapis stałego, względnego obniżania poziomu morza. Seria gliniasto-żwirowa to natomiast efekt oscylacji lodowca i postoju jego czoła w strefie pływów. Na podstawie wieku materiału organicznego z podłoża serii żwirowej można powiedzieć, że oscylacja ta jest młodsza od 6370± 120 lat BP (fig. 2).