POLISH POLAR RESEARCH	10	3	401—409	1989

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The profile of glacial deposits in the Hörbyedalen and an attempt at their chronostratigraphy central Spitsbergen

ABSTRACT: At the outlet of the Hörbyedalen, at the footslope of Gizehfjellet, lies a fragment of a raised marine terrace of an altitude of 45 m above sea-level. It is undercut by a proglacial river constituting an exposure with a series of marine, fluvio-glacial and moraine deposits. A lithological characterisation of the deposits was carried out, and radiocarbon dating and TL analysis were used in an attempt to present the chronostratigraphy and development of glacial and marine events in the Hörbyebreen during the Vistulian and the Holocene.

Key words: Arctic, Spitsbergen, Petuniabukta, litho-chronostratigraphy.

Introduction

On the eastern side of the outlet of the Hörbyedalen, which is the northern end of Petuniabukta, an arm of Billefjorden, at the footslope of Gizehfjellet, lies the base of an raised marine terrace of an altitude of 45 m above sea-level (Figs 1—2). The terrace is undercut by an eastern proglacial stream draining the Hörbyebreen and forming an exposure several hundred metres long with a height of some 18 m above the river water level (Karczewski *et al.* 1987).

There is a complete series of horizontally situated moraine, fluvio-glacial and marine deposits lying on a rock substrate which constitutes outcrops of anhydrites and gypsums (Fig. 3). They are a part of a complex of series of Carboniferous-Permian neritic and continental sedimentary rocks. Crystalline rocks of the Hecla Hoek formation appear in the Hörbyedalen only in its central part, near a dislocation oblique to the valley axis.

Unfortunately, the wall of the exposure proved inaccessible enough to render any detailed lithofacial and structural-textural studies of the deposits impossible.

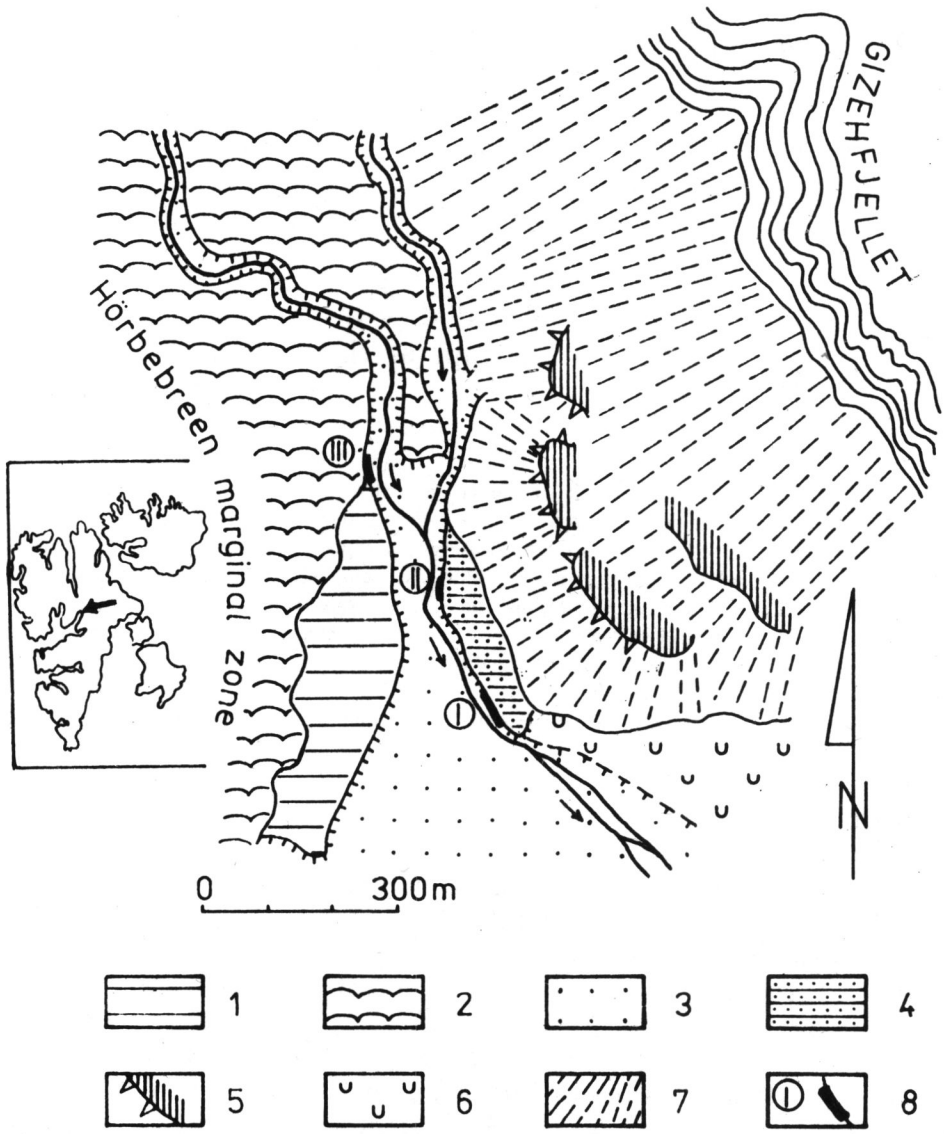

Fig. 1. The geomorphological situation of the geological profils. 1 — flat ground moraine, 2 — undulating and hilly ground moraine (relict glacier ice under deposits), 3 — outwash plain, 4 — base of raised marine terrace 45 m above sea-level, 5 — structural flattenings, 6 — solifluction slope, 7 — talus slope, 8 — analysed fragments of the exposure (I, II, III — *see* Fig. 3)

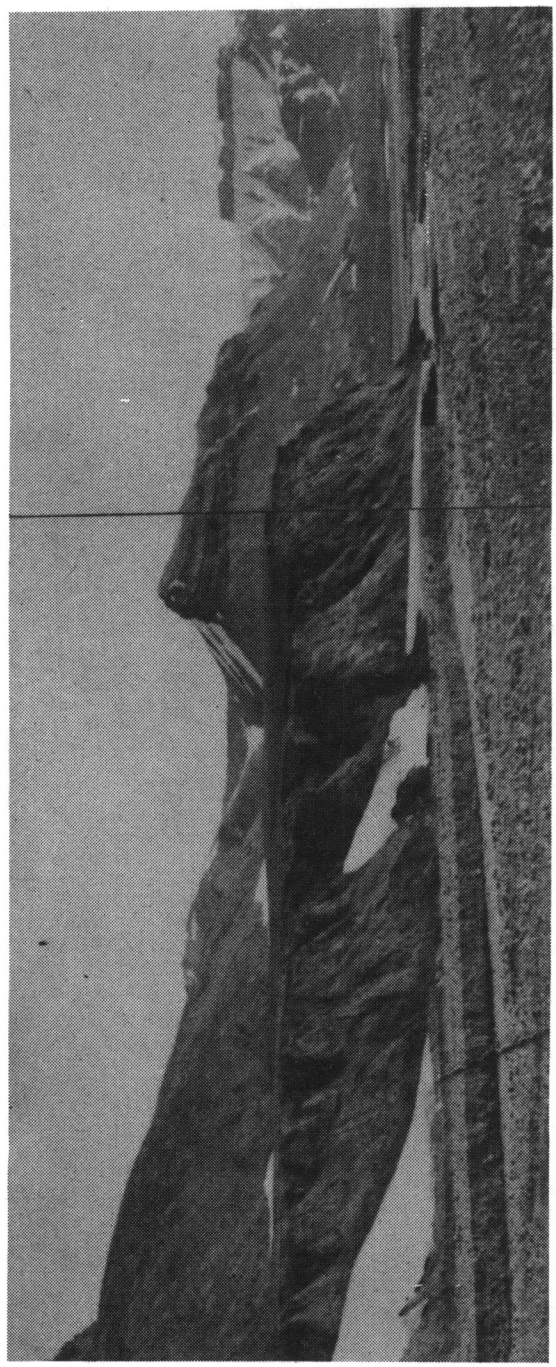

Fig. 2. A general view of the erosional undercut at the base of the raised marine terrace near Gizehfjellet

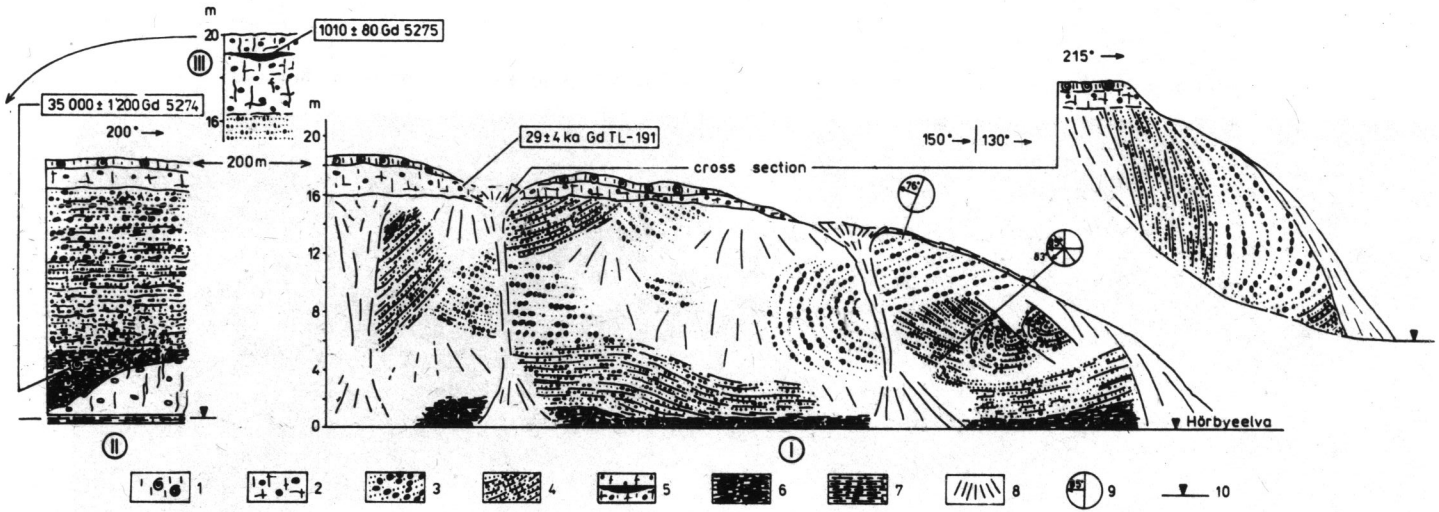

Fig. 3. The exposure in the base of the marine terrace

1 — clay reworked by sea activity — marine deposits (segment E_1 — Fig. 4), 2 — glacial till (segments A and E), 3 — sand-gravel-stone series (segment D), 4 — silt-sand-gravel series (segment C), 5 — lens of peat-silt deposits (segment F), 6 — silt-clay series (segment B), 7 — substrate rocks — anhydrites, 8 — taluses, 9 — direction and values of the dip of layers, 10 — level of the proglacial river, I, II, III — particular segments of the exposure

The lithology of the profile

The bottom of the deposit series situated on massive, anhydrite rocks (Fig. 4, segment O) is made of glacial till alternating with a clay-silt series. These are the oldest deposits of the profile. In some sections glacial till is visible (Fig. 4, segment A), very tough and with a large number of clasts of up to 100 cm in diameter. Among the clasts crystalline rocks can be found indicative of longitudinal transport down the valley. The till has a maximum thickness of 2 m above the river level. Its occurrence at points does not justify any statement as to its spatial range within the valley, but the diversification of its surface is evident.

In some places a clay-silt series lies on anhydrites (Fig. 4, segment B). It is massive, sometimes fairly distinctly laminated, but not of the varved type. The thickness of these deposits can reach 2.3 m. There are shells in the series which grow in number towards the bottom. The sand content, in turn, increases towards the top, to pass in a quiet sedimentary contact to a silt-sand-gravel series with a distinct horizontal or oblique stratification (Fig. 4, segment C).

This series attains a thickness of some 6 m. It consists of alternating thin layers of silts, sands and gravels, and its internal structure is marked by the

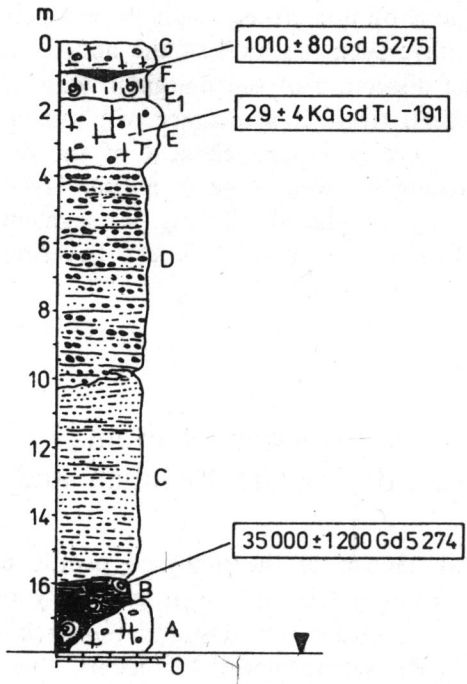

Fig. 4. A synthetic lithofacial profile (for particular lithotypes, *see* Fig. 3)

occurrence of fine erosion structures or deformations in the form of load casts or convolute disturbances. In some layers there are isolated shells and stones. Two places were found in which this series alternates with a gravel--stone complex with a trough cross-bedding and with a clearly marked grain-size distribution. The material found in channel slopes is fine and in their beds the coarsest, stony.

The discussed silt-sand-gravel series passes smoothly to the uppermost glacio-fluvial complex composed of layers of gravels, gravels and stones, or sands and stones (Fig. 4, segment D), usually cemented with matrix, which makes the deposit compact. This complex attains a thickness of some 7 m.

In the final, southern part of the exposure-forming erosion undercut there are disturbances in the primary structure of the series in the form of folds, shear folds and dislocated folds. Their amplitude amounts to a few metres. The azimuth of the wall ranges from 130° to 150°. Structural measurements taken in several places revealed dips of the layers towards the valley, that is, in the SW and W directions, with the dip as big as 76° to 85° (Fig. 3).

The character of the structures, the coarse-grained nature of the deposits, the direct discordant contact with the overlying glacial till, make them fit to be classified as glacio-tectonic structures.

The top of the terrace bench is built of the mentioned upper glacial till of 0.7 to 2 m in thickness (Fig. 4, segment E) with pebbles among which there are a few crystalline rocks. Its top to a depth of 40—80 cm is reworked by the sea, as evidenced by numerous sea-shells and pebbles (Fig. 4, segment E_1). Hence, it must have been the level of the activity of the sea bay water.

Farther down the dissection of the marginal zone of the Hörbye glacier by the eastern proglacial river, at a distance of about 450 m from the main wall under analysis, there is a third element of the exposure (Fig. 1 (III), 2) displaying two youngest levels. One is a thin layer of peats and silts, under 1 m thick, lying on glacial till (Fig. 4, segment E) and the other, a layer of glacial till of up to 1 m in thickness, covering the surface (Fig. 4, segment G).

An attempt at a reconstruction of events in the Hörbyedalen during the Vistulian and the Holocene

The oldest glacial deposit of the analysed profile at the outlet of the Hörbyebreen is the lower glacial till of fragmentary occurrence (A) lying directly on a massive substrate (O). Usually the rock substrate is covered with a silt-clay series (B). Where glacial till occurs, this series covers it with a thin layer.

In the silt-clay series shells of clams and snails can be found (e.g. *Macoma calcarea. Astarte eliptica, Mya truncala Linne. Petricola pholadifomis Lamark Lepeta caeca)* [1].

An analysis has shown that the composition of the mollusc fauna corresponds with the habitat of a body of sea water or an open sea bay of little depth and an oozy or sandy-oozy bottom. These are conditions that occur in the area of the Petunia Bay tidal flat at present.

The age of the shells was estimated by radiocarbon dating at 35.000—36.000 years BP [2]. Hence, the glacial till lying below (A) is an older deposit. It is probably connected with the glacier advance of the older part of Billefjorden Stage. This glacial episode is mentioned by e.g. Boulton (1979).

This glacial period is followed by a deep retreat and the dominance of marine morphogenesis. The silt-clay series (B) develops in the open sea bay. Starting with the silt-sand-gravel series (C) and then the gravel-stone one (D), there is a marked gradation of deposits indicating the shallowing of the bay and the expansion of the huge glacio-fluvial series connected with another glacial advance.

The advancing glacier caused dynamic deformation in the diamictite type of deposits (segment D) and the deposition of the discordantly situated upper glacial till — the lower (E).

Its age has been determined by TL analysis at 29.000±4.000 years. The dates obtained using this method are often controversial (they usually make a deposit older). Therefore, the age of the upper glacial till, and hence the retreat of the Hörbyebreen, can be established alternatively at about 30.000 years — stage, or the younger phase of the Billefjorden Stage can be assumed to be 11.000 years. Mangerud and Salvigsen (1984) define the age of the upper glacial till on Kapp Ekholm similarly, using radiocarbon dating and TL analysis.

In the sequence of the profile under analysis there is no glacial level from the middle-Holocene glaciation of 6.500 years BP recorded from the Petuniabukta area by Stankowski (1988), because, he states, the glacier did not cover marine terraces of an altitude of 40 m above sea-level.

On the immediate foreland of the Hörbyebreen, in the erosion dissection (profile III, Fig. 3), on the upper glacial till — the lower level (E), there is a lens of peats and silts (segment F) whose absolute age has been established at 1010±80 years BP. On organic deposits a layer of glacial till was deposited which is less than a thousand years old. Such a period of late-Holocene

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[1] The analysis was made by M. Ciszewska, M. Sc., The Department of Paleontology and Stratigraphy of A. Mickiewicz University, Poznań.

[2] The C-14 and TL analyses were made in the C-14 Laboratory of the Institute of Physics, Silesian Technical University, Gliwice.

recession is mentioned by e.g. Boulton and Rhodes (1974) Boulton (1979) or Baranowski and Karlén (1976).

The last glacial episode connected with the Little Ice Age (600—100 years BP) can be traced not in the analysed exposure, but on the immediate foreland of the Hörbyebreen with its complex of forms. The spatial pattern of disturbed debris bands on the glacier and their continuation in the form of ice-core morainic hills on the foreland and the high content of ice under the series of moraine (supra-glacial) deposits must be attributed to the activity of ice via the process of surge. The glacier today presents the type of areal decay.

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

Streszczenie

Po wschodniej stronie wylotu Hörbyedalen, północnego zakończenia Petuniabukta — odnogi Billefjorden, u podstawy zbocza Gizehfjellet położony jest cokół podniesionej terasy morskiej o wysokości 45 m npm. Podcięty jest on przez rzekę proglacjalną tworząc odkrywkę, która była przedmiotem analizy litofacjalnej i chronostratygraficznej (na trzech wycinkach — fig. 1—3). Odkrywka prezentuje serię osadów morenowych, wodnolodowcowych i morskich będących zapisem zmian paleogeograficznych jakie zachodziły w obrębie Hörbyedalen. Najstarszym osadem jest dolna glina morenowa, której wiek określono na środkowy vistulian

(35—45 tys. lat BP — starsza część Billefjorden Stage). Po tym epizodzie glacjalnym następuje morfogeneza morska, która reprezentuje seria mułkowo-ilasta z muszelkami złożona w zatoce morskiej. Następne serie mułkowo-piaszczysto-żwirowe i żwirowo-kamieniste wskazują na wypłycanie zatoki, rozrastanie się potężnej serii glacifluwialnej w związku z ponownym awansem Hörbyebreen. Transgredujący lodowiec spowodował zaburzenia w górnym segmencie serii, a następnie złożył pokład gliny morenowej, której wiek określono metodą TL na około 30 tys. lat. Sekwencja przestrzenna górnej gliny morenowej z innymi znanymi punktami wskazywałaby wiek młodszej części Billefjorden Stage, czyli około 11 tys. lat. Natomiast na bezpośrednim przedpolu lodowca (wycinek III) stwierdzono jeszcze jeden pokład gliny morenowej, pokrywającej osady organogeniczne o wieku 1 tys. lat. Wiązał by się z trzecim epizodem glacjalnym. Układ przestrzenny form strefy marginalnej lodowca należy wiązać z najmłodszym, czwartym awansem lodowca z okresu Małej Epoki Lodowej.