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Ryszard SZCZĘSNY

Institute of Geology
Warsaw University
Żwirki i Wigury 93
02-089 Warszawa, POLAND

Late Quaternary evolution of the Tjörn Valley, Wedel Jarlsberg Land, Spitsbergen

ABSTRACT: Preliminary results of field investigations and analysis of air photos of the Tjörn Valley region (Wedel Jarlsberg Land, Spitsbergen) are presented. The youngest, Quaternary deposits and landforms were mapped. Reconstruction of the last advance and retreat of the Tjörndals Glacier is also described.

Key words: Arctic, Spitsbergen, Quaternary glaciations.

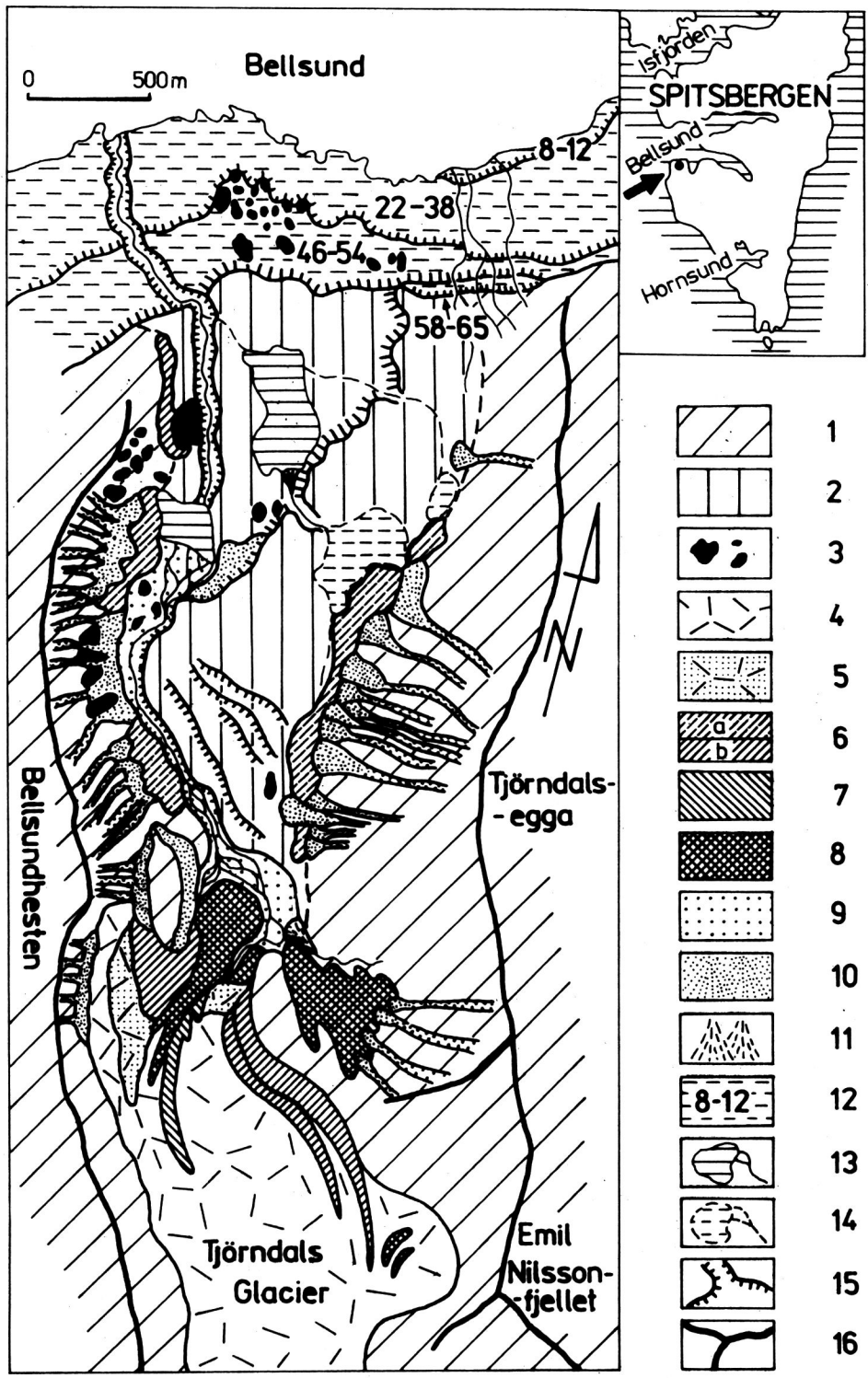
Introduction

Fieldworks in the northwestern Wedel Jarlsberg Land were carried out in summer 1986 during the expedition of the Maria Curie-Skłodowska University (Lublin, Poland). Research works were concentrated at the southern coast of Bellsund in the Tjörn Valley (Tjörndalen) and its forefield (Fig. 1). Collected data allowed to reconstruct the Late Quaternary geomorphologic and geologic processes there. An exact interpretation of Quaternary history of Tjörn Valley and its forefield is difficult because of lack of absolute datings of deposits.

Photogeological analysis of Norwegian air photos of 1961 (scale 1:50,000) completed the field investigations. Air photos formed the basis for preparing a geological sketch of Quaternary deposits (Fig. 1), in account of lack of large-scale maps of this region.

The Tjörn Valley is a small valley located in the northwestern Wedel Jarlsberg Land (Pl. 1, Fig. 1). It is delimited by narrow ranges of Tjörndalsegga in the east and Bellsundhesten in the west.

The Tjörn Valley is about 4.5 km long and 1 km wide. Its floor is rugged and falls in several thresholds to a seashore plain of Lyellstranda.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-fjellet
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Valley bedrock and surrounding mountain massifs are composed of tillites of varying lithology of clasts, partly interbedded with quartzites and phyllites. These beds belong to the upper part of the Hecla Hoek Formation (*cf.* Flood, Nagy and Winsnes 1971). Strata dip gently (approx. 30°) to the north, their strike is 60—70°. The upper part of the valley, above 250 m a.s.l. is filled up by the Tjörndals Glacier (Tjörndalsbreen). A firn field of the glacier is connected with the Renard Glacier (Renardbreen) through the pass between the Kjerulffjellet (747 m a.s.l.) and Emil Nilssonfjellet (788 m a.s.l.).

Landforms and deposits of the Tjörn Valley

The Tjörndals Glacier was a main factor which modelled a morphology of the valley. In a longitudinal profile of the valley there are several glacier-scoured thresholds. They are located in places where strata more resistant to glacial erosion occurred within the tillites. Thresholds run parallel to the strike of strata. A rocky floor of the valley is free of glacial deposits due to their removal by streams. Deposits of sandur fans and of permanent and periodic lakes are preserved in depressions only (Figs 1—2). Glacial deposits are located in nearest forefield of the glacier and at foot of mountain slopes. Two outstanding ice-cored moraines occur there, defined as rock glaciers by Dzierżek and Nitychoruk (1987). One of them is located at the Tjörndals Glacier snout (Pl. 1, Fig. 2) and the other runs eastwards on a floor of a small glacial cirque on a slope of Tjörndalsegga (Pl. 2, Fig. 1). A glacier ice is buried there by large irregular, sharp-edged blocks forming a compact, several meters thick cover (Pl. 2, Fig. 2).

The Tjörndals Glacier in the upstream part of the valley has been pushed to the west by a bedrock hummock. There are no crevasses in the glacier surface what suggest a lack of large irregularities in a glacier bedrock, and olny slide planes are visible. A thin ablation moraine occurs in the frontal part of the glacier. Narrow median and lateral moraines run at its eastern margin (Pl. 3, Fig. 1).

Fig. 1. Geological sketch of the Quaternary deposits in the Tjörn Valley 1 — mountains with a weathering waste, 2 — rocky floor of the valley, 3 — rock outcrops (klippen), 4 — compact glacier ice, 5 — ablation moraine on glacier ice, 6 — *a* nival moraines on lateral moraines, *b* lateral moraines; 7 — median moraines, 8 — ice-cored moraines (rock glaciers), 9 — sandur fans, 10 — talus, 11 — alluvial fans, 12 — raised marine terrace (altitude in meters a.s.l.), 13 — lakes and streams, 14 — periodic lakes and streams, 15 — edges, 16 — mountain crests

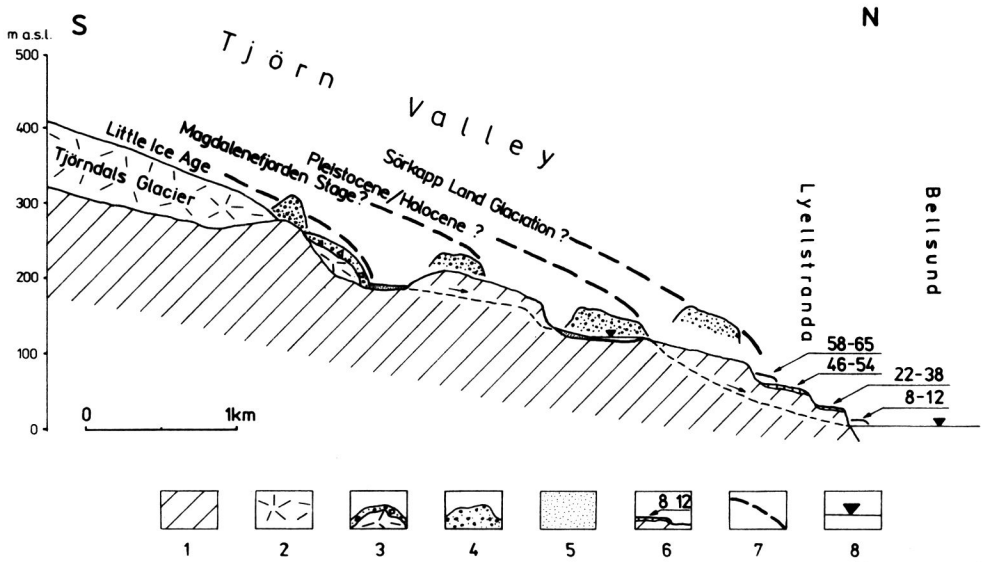


Fig. 2. Schematic geologie section of the Tjörn Valley and its forefield: 1 — bedrock, 2 — compact glacier ice, 3 — ice-cored moraines (rock glaciers), 4 — lateral and terminal moraines, 5 — sandur fans, 6 — raised marine terraces (altitude in meters a.s.l.), 7 — glacier extent, 8 — sea or lake level

In the middle part of the valley at the foot of Tjörndalsegga 1300 meters long nival moraine rampart is preserved (Pl. 1, Fig. 2). Surely it has been piled up over a lateral moraine. Similar forms are visible in the western side of the valley and its outlet (Pl. 3, Fig. 2; Pl. 4, Fig. 1). These moraines are strongly modified by rock debris which mantled them by scree and talus fans. There is no vegetation cover there.

Valley forefield

Four marine terraces (8—12, 22—38, 46—54 and 58—65 m a.s.l.) have developed in rocky bedrock of the seashore plain (Fig. 1). In other parts of Spitsbergen such terraces were dated. The highest two ones are dated for 33—25000 years BP (Feyling-Hanssen and Olsson 1959—60, Grosswald 1963, Szupryczyński 1968, Troitsky *et al.* 1975, Salvigsen 1979, 1981; Salvigsen and Nydal 1981, Kłysz and Lindner 1981) and the middle terrace for 12590 years BP (Salvigsen 1977), and for 8150 years BP in the Renardodden section of Bellsund (Troitsky, Punning and Surova 1985). The lowest terrace is referred to 2500—2400 years BP *i.e.* the Magdalenefjorden Stage (Szupryczyński 1968). Such a hypsometric correlation could be deceptive (Lindner, Marks and Szczęsny 1986) but the preliminary character of this elaboration and lack of absolute datings of deposits make it still useful.

A lot of klippen occurred on terraces among remains of ancient storm ridges.

Terraces are cut through by a canyon, 15 meters deep, formed by a glacial river running from the Tjörndals Glacier (Pl. 4, Fig. 2). Such deep dissection of a hard bedrock suggests a very intensive uplift of this area and a shift of the glacial stream into a fault zone.

Evolution of the Tjörn Valley

During the Late Quaternary there were at least four glacial stages (Fig. 2). The first one occurred when the Tjörndals Glacier filled up the whole valley and floated out over the present seashore plain into the Bellsund (Fig. 3a).

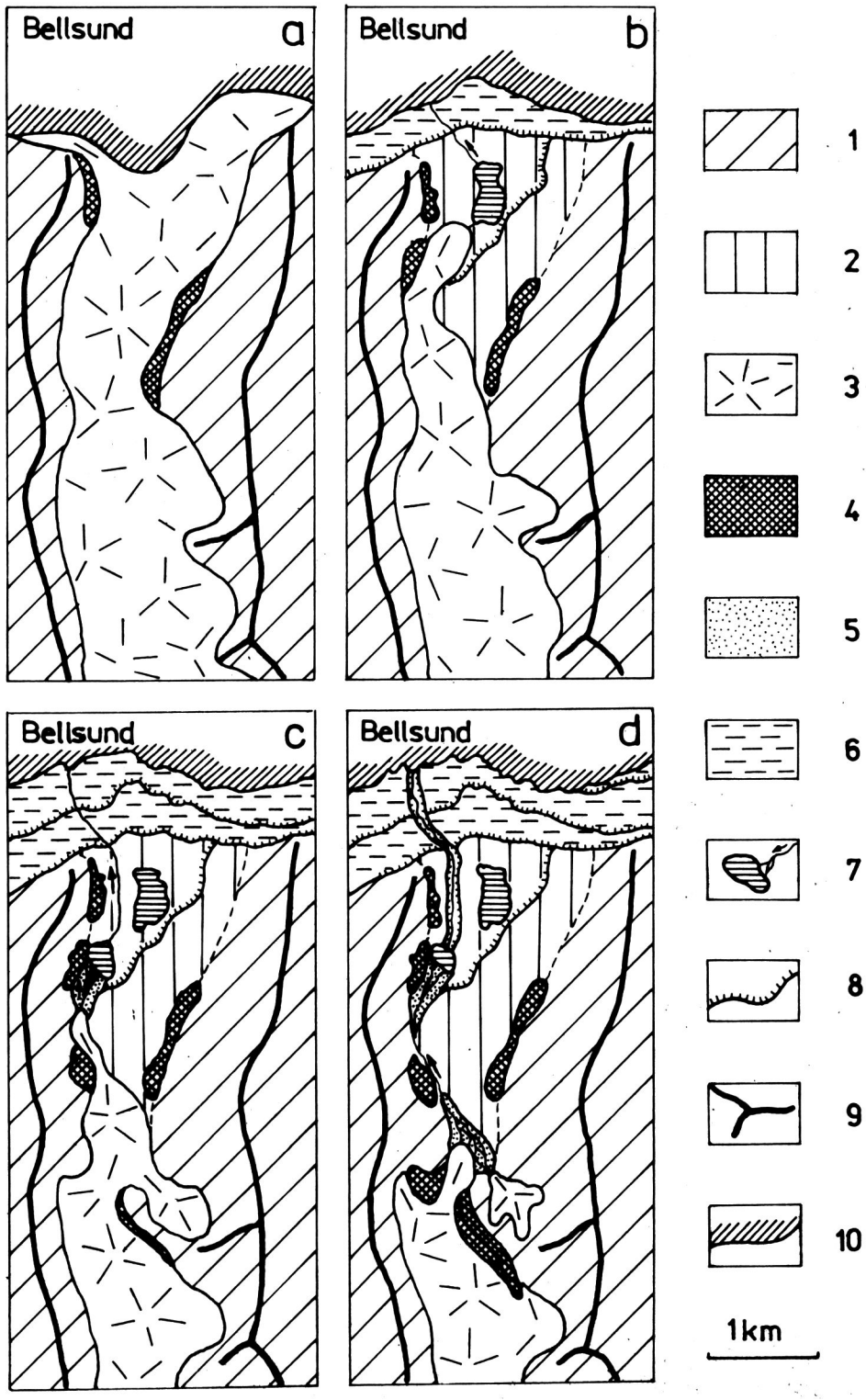
The Tjörn Valley is hanging now 20 meters over the seashore plain what seems to be an effect of insignificant erosion of the floating glacier ice (Szczęsny 1986). During the glacier retreat the highest marine terraces (58—65 and 46—54 m a.s.l.) have been formed. Lateral moraines over the threshold and in the mouth of the valley have been also formed during this retreat (Fig. 3a).

In the second stage the glacier did not fill the whole valley. The glacier slid down from an oblique threshold in the western side of the valley. Its snout reached the present lower sandur fan as delimited by a lateral moraine there (Fig. 3b). This time a depression in the forefield of the glacier was filled up by meltwater and than the Daltjörna Lake has been formed. Several parallel trimlines in a rocky threshold confirm a presence of the following retreat of the glacier from this place (Pl. 1, Fig. 2).

In the third stage (Fig. 3c) the glacier moved over the rocky threshold and formed the other lateral moraine. Another lake has developed below, being filled up by sandur fan at the same time. A river has changed a direction of its flow as it passed through the Daltjörna Lake: a river channel has been put into a fault zone. A small glacier on a slope of Tjörndalsegga has been isolated.

During the last stage (Fig. 3d) a front of the Tjörndals Glacier has retreated over another threshold, leaving succesive terminal and lateral moraines. Only short, narrow glacial snout has flowed through the slack in a rocky threshold. The next, upper sandur fan was formed by streams running from both glaciers: the Tjörndals Glacier and the small glacieret to the east.

The first stage corresponds in the author's opinion with the maximum extent of the last Pleistocene glaciation defined in South Spitsbergen as the Sörkapp Land Glaciation (Lindner, Marks and Pękala 1984). The second stage seems to refer to the turn of Pleistocene to Holocene. The last two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stages certainly occurred during the Holocene and corresponded with the Magdalenfjorden Stage (*cf.* Szupryczyński 1968) and the Little Ice Age (*cf.* Baranowski 1977, Pękala 1980).

Conclusions

Field investigations and analysis of air photos enabled to reconstruct a glacial evolution of the Tjörn Valley during the Late Quaternary. During the Sörkapp Land Glaciation the Tjörndals Glacier floated out the valley into the Bellsund and marked its extent by lateral moraines. At least 3 younger glacier stages occurred, delimited by moraine ramparts, sandur fans and trimlines on mountain slopes.

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Fig. 3. Extents of the Tjörndals Glacier: a — during the Pleistocene (33—25000 years BP), b — at the turn of the Pleistocene and Holocene, c — during the Magdalenefjorden Stage (2500—2400 years BP), d — during the Little Ice Age (600—100 years BP); 1 — mountain massifs, 2 — valley floor, 3 — glacier, 4 — lateral and terminal moraines, 5 — sandur fans, 6 — raised marine terraces, 7 — lakes and streams, 8 — edges, 9 — mountain crests, 10 — sea

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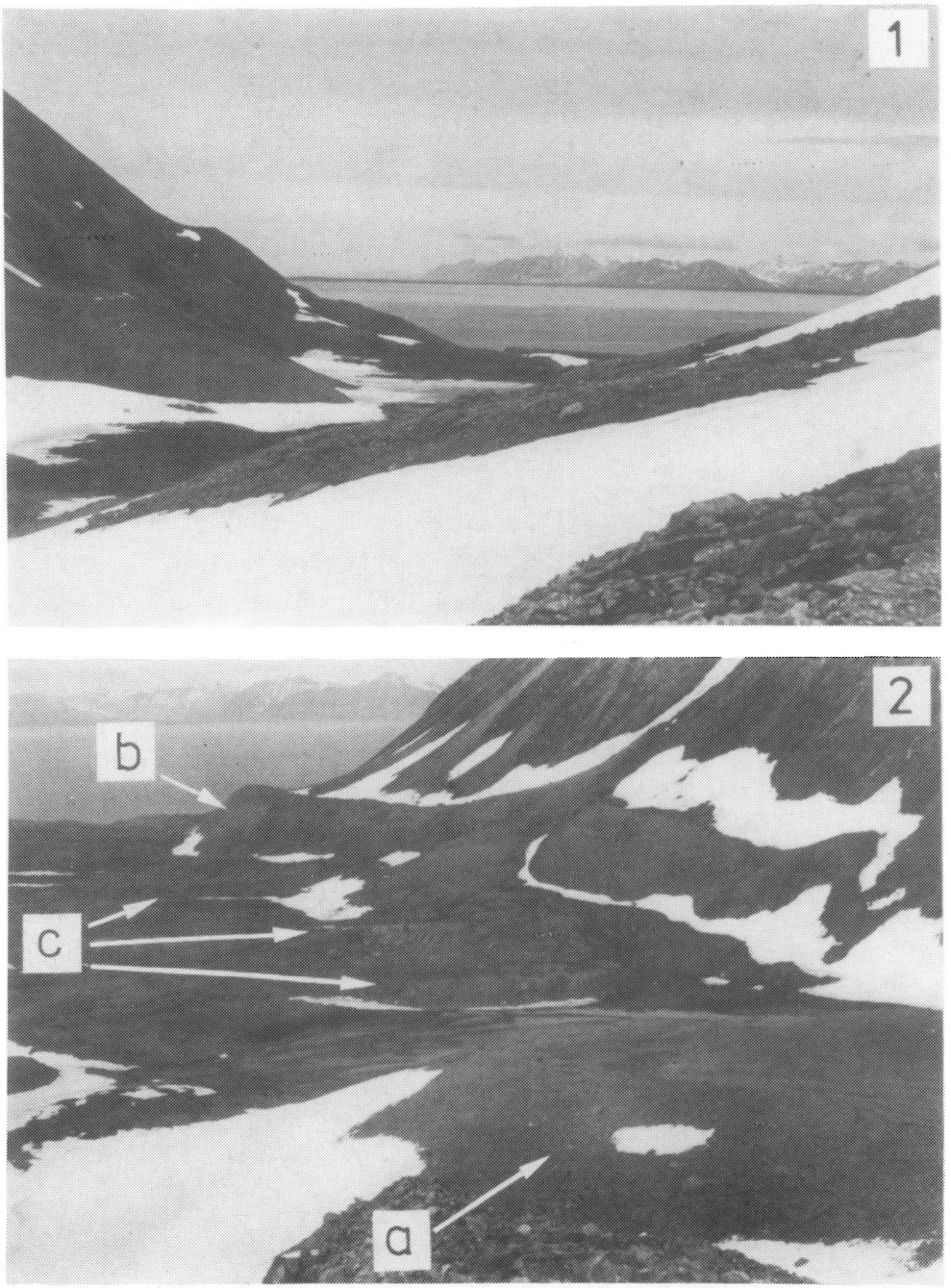
Streszczenie

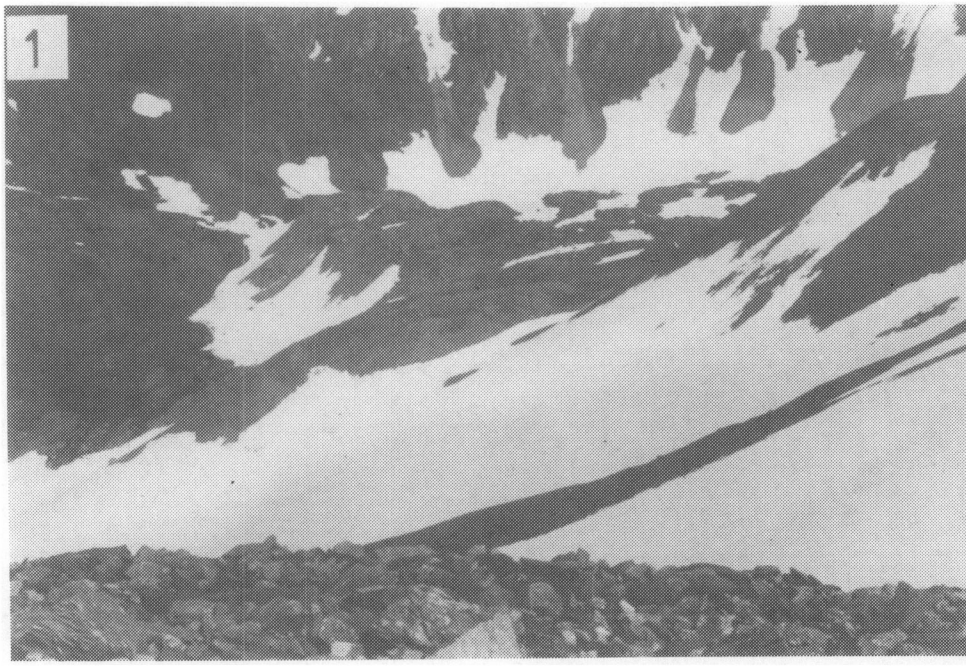
Prace terenowe w północno-zachodniej części Ziemi Wedel Jarlsberga na Spitsbergenie prowadzone były w lecie 1986 roku w ramach wyprawy polarnej Uniwersytetu im. Marii Curie-Skłodowskiej z Lublina. Badania osadów i rzeźby polodowcowej skoncentrowano na obszarze niewielkiej, uchodzącej do Bellsundu doliny Tjörn (pl. 1). Rozpoznanie terenowe uzupełniono fotogeologiczną analizą norweskich zdjęć lotniczyc z 1961 roku w skali 1:50000, co pozwoliło sporządzić szkic rozprzestrzeniania osadów czwartorzędowych (fig. 1).

Głównym czynnikiem kształtującym rzeźbę doliny był lodowiec Tjörndals zajmujący obecnie jej górną część. Przeprowadzone badania pozwalają stwierdzić ślady co najmniej czterech etapów postoju czoła lodowca (fig. 2—3). Pierwszy z nich miał miejsce, gdy lodowiec wypełniał całkowicie dolinę i spływał na jej przedpole do Bellsundu. W tym czasie utworzone zostały wały moren bocznych u stóp Tjörndalseggi (przykryte później moreną niewalną) i przy ujściu doliny (pl. 3). Działo się to podczas zlodowacenia Sörkapp Land — ostatniego zlodowacenia plejstoceńskiego. Kolejne generacje wałów morenowych, stożków sandrowych jak również charakterystyczne podcięcia na zboczach doliny świadczą (pl. 2, 4), iż rozwój i zanik lodowca Tjörndals w holocenie przebiegał w co najmniej trzech etapach. Miały one miejsce na przełomie plejstocenu i holocenu, podczas stadium Magdalenefjorden i Małej Epoki Lodowej. Bardziej szczegółowe rekonstrukcje deglacjacji tego obszaru staną się możliwe po opracowaniu obserwacji z sąsiednich dolin oraz wyników datowań bezwzględnych próbek osadów.

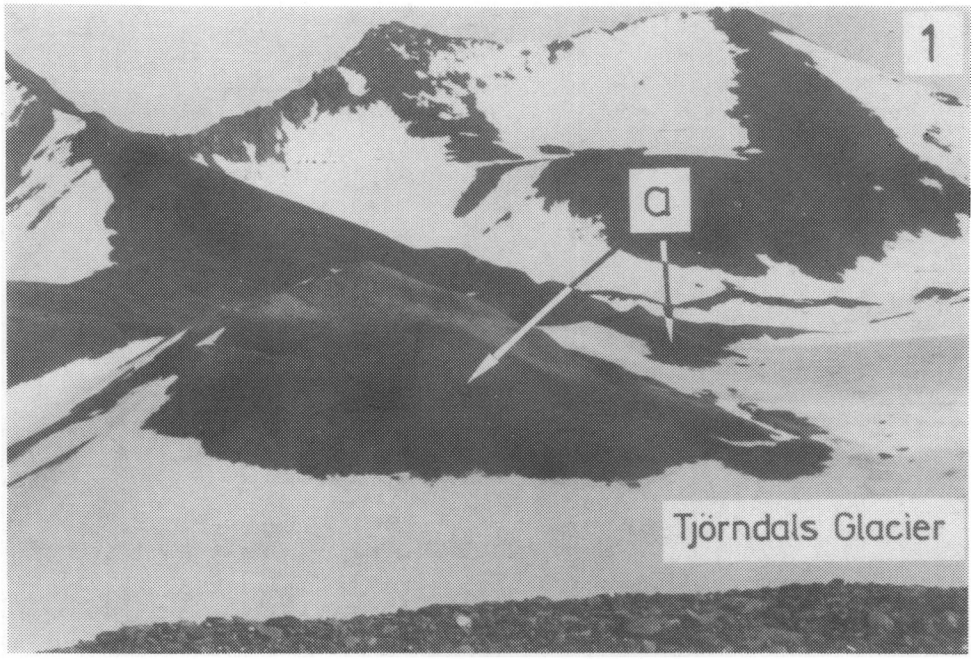
Praca została wykonana w ramach CPBP 03.03. B.7.

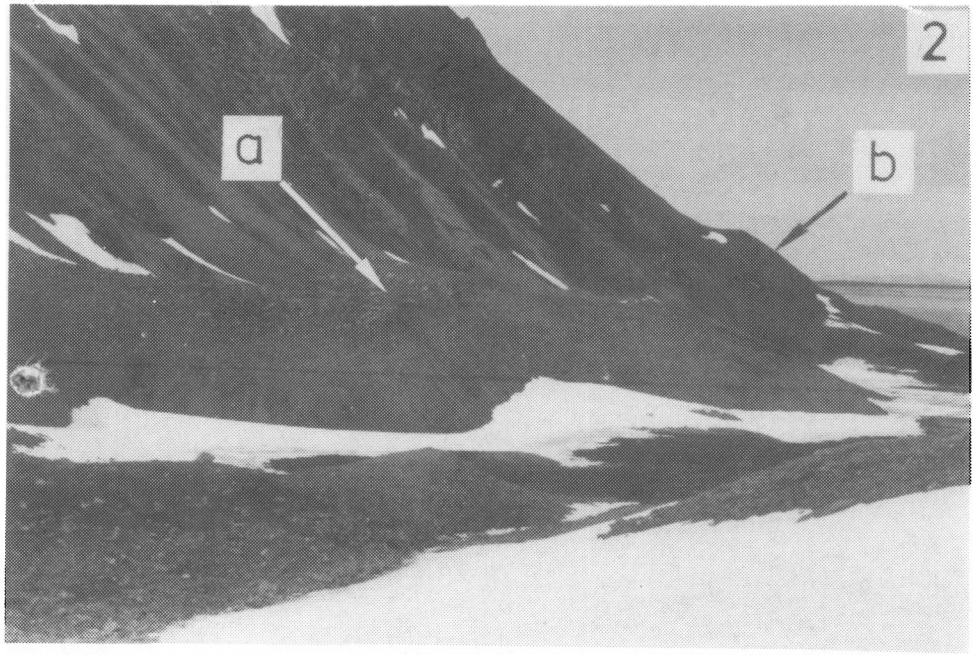


1. General view of the Tjörn Valley, July 1986
2. Upper part of the Tjörn Valley, July 1986: *a* — ice-cored moraine (rock glacier) at the Tjörndals Glacier snout, *b* — nival moraine on a lateral moraine, *c* — trimlines

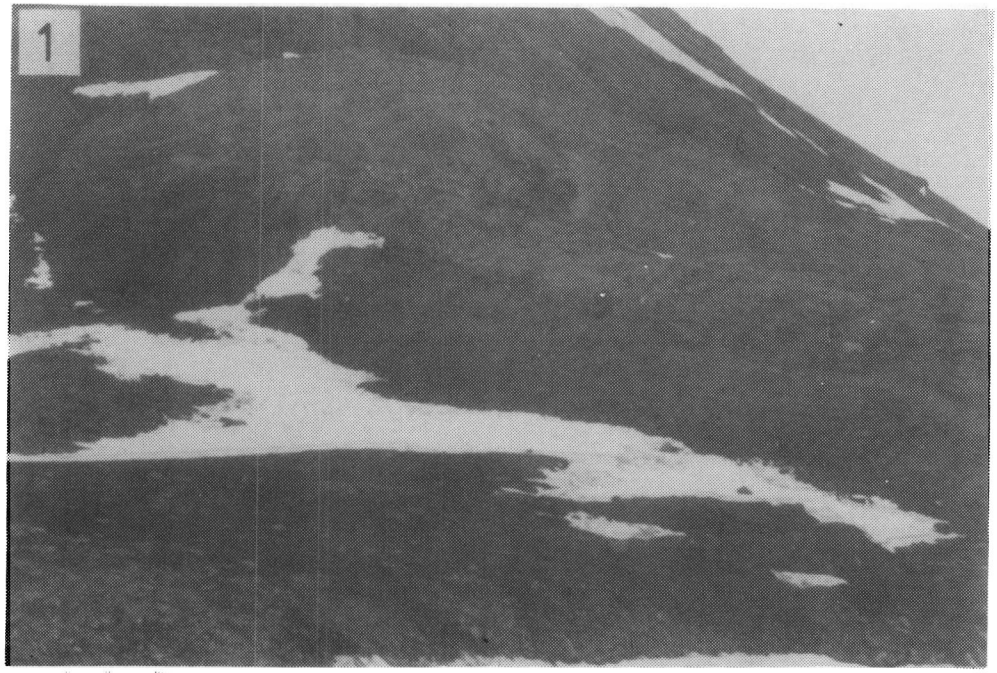


1. Ice-cored moraine (rock glacier) on a slope of Tjörndalsegga, July 1986
2. Surface of ice-cored moraine (rock glacier), July 1986





1. The Tjörndals Glacier, July 1986 *a* — lateral moraines
2. Moraines in the western side of the Tjörn Valley, July 1986: *a* — nival moraine on a lateral moraine, *b* — lateral moraine



1. Lateral moraine in the outlet of the Tjörn Valley, July 1986
2. Canyon of a glacial river, July 1986