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LESZEK MARKS

Late Holocene evolution of the Treskelen Peninsula (Hornsund, Spitsbergen)

ABSTRACT: The studies over sediments and landforms of the Treskelen Peninsula found them to occupy a considerably larger area and to be more varying than considered previously. A mutual relation of these features enabled to fix the successive phases of their formation, dependent on a rate of the Hyrne Glacier retreat. A critical approach to Heintz's (1953) and Birkenmajer's (1964) glacier extents and the occurrence of a glint lake at the peninsula during the Little Ice Age is also presented.

INTRODUCTION

The Treskelen Peninsula (*Treskelodden*) is located inside the Hornsund fiord, southern Spitsbergen, over 20 km to the east from the open sea. The peninsula is about 3.5 km long and thus it leaves a narrow pass only in the southern part of the fiord.

Glacial features of the Treskelen Peninsula have been studied occasionally (Vasiliev 1925; Pillewizer 1939; Birkenmajer 1958, 1959, 1960; Jahn 1959), and only two papers (Heintz 1953, Birkenmajer 1964) are of a complex character.

The Author's investigations were carried through at the turn of July and August 1979, during the expedition organized by the Institute of Geophysics, Polish Academy of Sciences. The collected data were then arranged with a use of Norwegian air photos taken in 1966 (*cf.* Text-fig. 1) but unfortunately, the latter did not cover the whole area and were in a small scale (about 1:50 000).

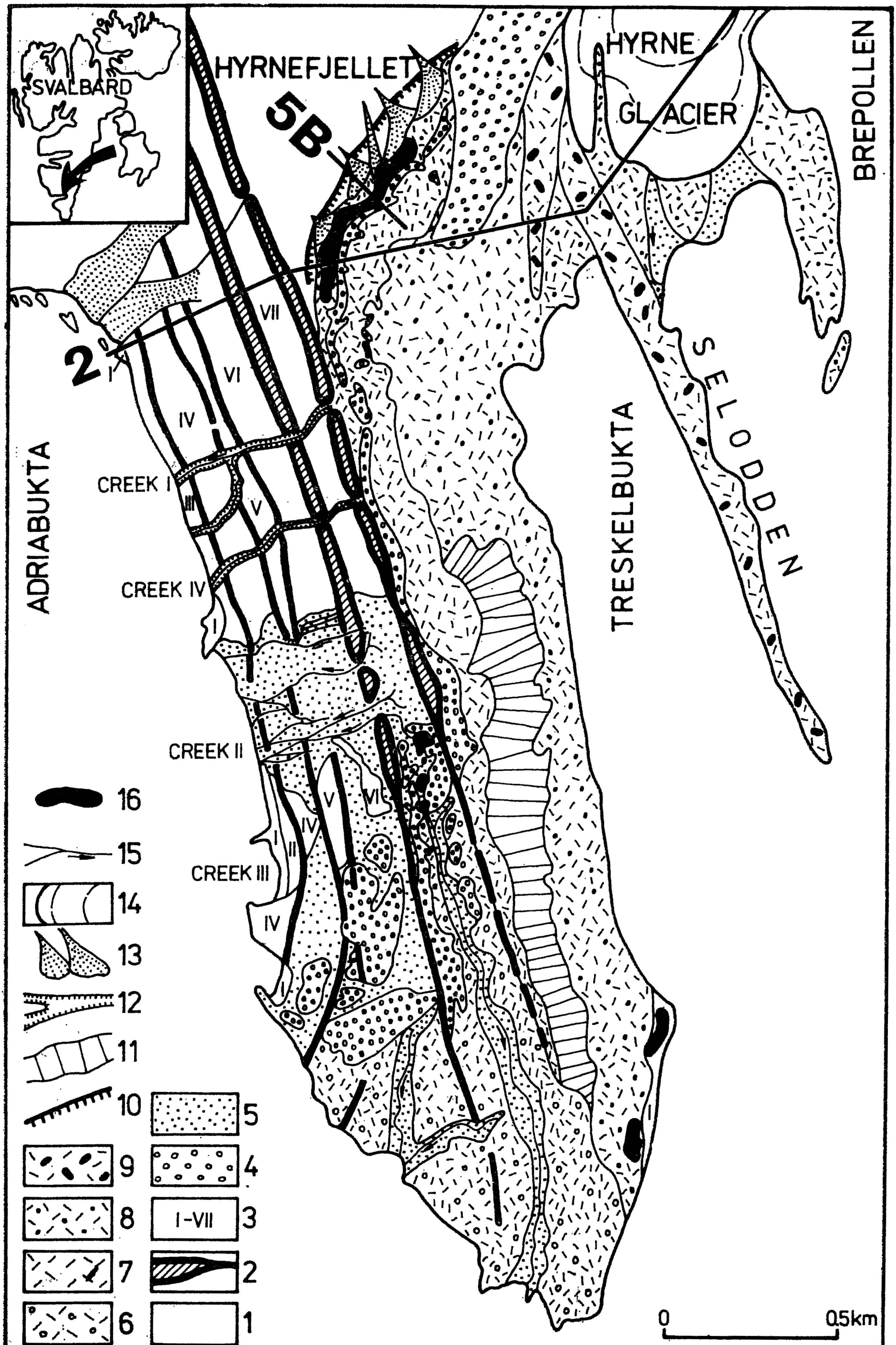

Fig. 1. Geomorphologic sketch of the Treskelen Peninsula and of the Hyrne Glacier forefield; indicated are the lines of cross-sections presented in Text-figs 2 and 5*B*

QUATERNARY SEDIMENTS AND GLACIAL FEATURES

Raised marine terraces are the dominant feature of the western shore of the Treskelen Peninsula (*cf.* Karczewski & *al.* 1981). Their arrangement is strictly related to the geological structure of the pre-Quaternary bedrock (*cf.* Birkenmajer 1964). Rounded pebbles of marine origin are usually mixed with soliflucted debris. Southern and eastern parts of the peninsula have been recently glaciated during the Little Ice Age; at that time the glacier overpassed the Treskelen crest and occupied the marine terraces in the south-west (*cf.* Heintz 1953; Birkenmajer 1960, 1964; Jahn 1959; Grosswald & *al.* 1967).

Glacial striae prove a glacier advance southwards and south-southeastwards at three-fourth of the peninsula and south-westwards or even locally west-southwestwards at its southern end and at the south-western shore. Thus, a distinct influence of ice masses moving along the fiord (from the east westwards) is noted. Such a glacial stream probably occurred not only during the Little Ice Age but possibly also during the previous glacier advances. At the southern slope of Hyrnefjellet (*cf.* Text-fig. 2) there is a glacier scour limit at about 180 m a.s.l. that can be correlated with similar features in the Rev Valley (*Revdalen*) and Fuglebergsletta (both further to the west, at the Hornsund entry) and considered as the limit of the last but one glacier advance, *i.e.* at 2000—3500 years BP (*cf.* Karczewski & *al.* 1981). The only problem is why no glacial sediments and landforms occur at the raised marine terraces of the north-western part of the Treskelen Peninsula (*cf.* Heintz 1953, Birkenmajer 1964) although the terrace 8—12 m a.s.l. has been formed about 9000 years BP (*cf.* Birkenmajer & Olsson 1970). The glacial features have been expected to occur there, because the crest of the Treskelen Peninsula is only slightly over 150 m high close to the Hyrnefjellet massif and must have been overridden by glaciers at least once during the Holocene before the Little Ice Age, and possibly also during the Late Würm. The absence of glacial sediments and landforms can result either from their destruction by slope processes after a glacier retreat or from being of the peninsula a significant obstacle for the moving glaciers. The slope processes have been undoubtedly highly intensive at a steep western slope of the peninsula, composed of rather

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1 — mountain slopes, usually with a weathering mantle; **2** — bedrock outcrops; **3** — raised marine terraces: *I* — 2 m, *II* — 4.5—6 m, *III* — 8—12 m, *IV* — 25—30 m, *V* — 40—42 m, *VI* — 69—75 m, *VII* — 112—113 m (all a.s.l.); **4** — lateral ice-cored moraines; **5** — outwash; **6** — shelly ground moraine; **7** — ablation moraine underlain by a buried ice; **8** — degraded ablation moraine; **9** — ablation moraine over structural crests of the bedrock; **10** — glacier scour limit formed at the maximum extent during the Little Ice Age; **11** — slope with intensive solifluction processes; **12** — gorges; **13** — talus fans; **14** — glacier; **15** — streams; **16** — lakes non-resistant or poorly resistant rocks (mainly shales and limestones) that are quite steeply dipping what favors the slope processes (*cf.* Text-fig. 2). On the other hand, a considerable fragment of the Treskelen crest could not be covered at all during the glacier advance of 2000—3500 years BP due to by-passing of the ice-masses. It seems probable that the glacier ice piled up at the eastern side of the peninsula and passed over its crest only in the south (similarly as during the Little Ice Age). In fact, the glacier of that time has not even reached Hyrneodden, Adriabukta (*i.e.* an area about 3 km to the west of the Treskelen Peninsula) as the marine terraces, noted there up to 32—35 m a.s.l., have no glacial cover.

SEDIMENTS AND LANDFORMS OF THE LAST GLACIER ADVANCE

Investigations of glacial landforms and sediments at the Treskelen Peninsula enabled to reconstruct the outwash evolution during the last deglaciation (Text-fig. 3).

Lateral moraines at the raised marine terraces in the south-west as well as cuttings at the peninsula crest (the so-called Creek *I* and *IV* of Heintz, 1953, and Birkenmajer, 1964) have probably originated during the maximum glacier advance of the Little Ice Age (named the Treskelen Stage by Grosswald & *al.*, 1967), *i.e.* in the 19*th* century (*cf.* Baranowski 1977) but not in 1910 or 1900 as suggested by Heintz (1953)

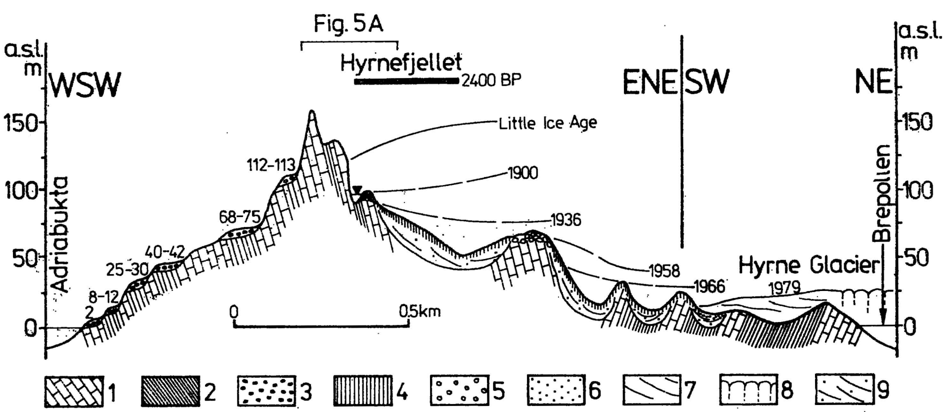

Fig. 2. Geological section across the Treskelen Peninsula (*cf.* Text-fig. 1) with marked positions of a glacier snout during its maximum extent and retreat phases of the Little Ice Age, as well as the glacier scour limit at about 2400 years BP (at the Hyrnefjellet slope)

1 — rocks more resistant to weathering, 2 — rocks less resistant to weathering, 3 — gravels of raised marine terraces (altitudes in metres a.s.l. indicated), 4 — ablation moraine, 5 — gravels and clays of lateral ice-cored moraines, 6 — outwash gravels and sands, 7 — active glacier ice, 8 — ice cliff, 9 — buried glacier ice

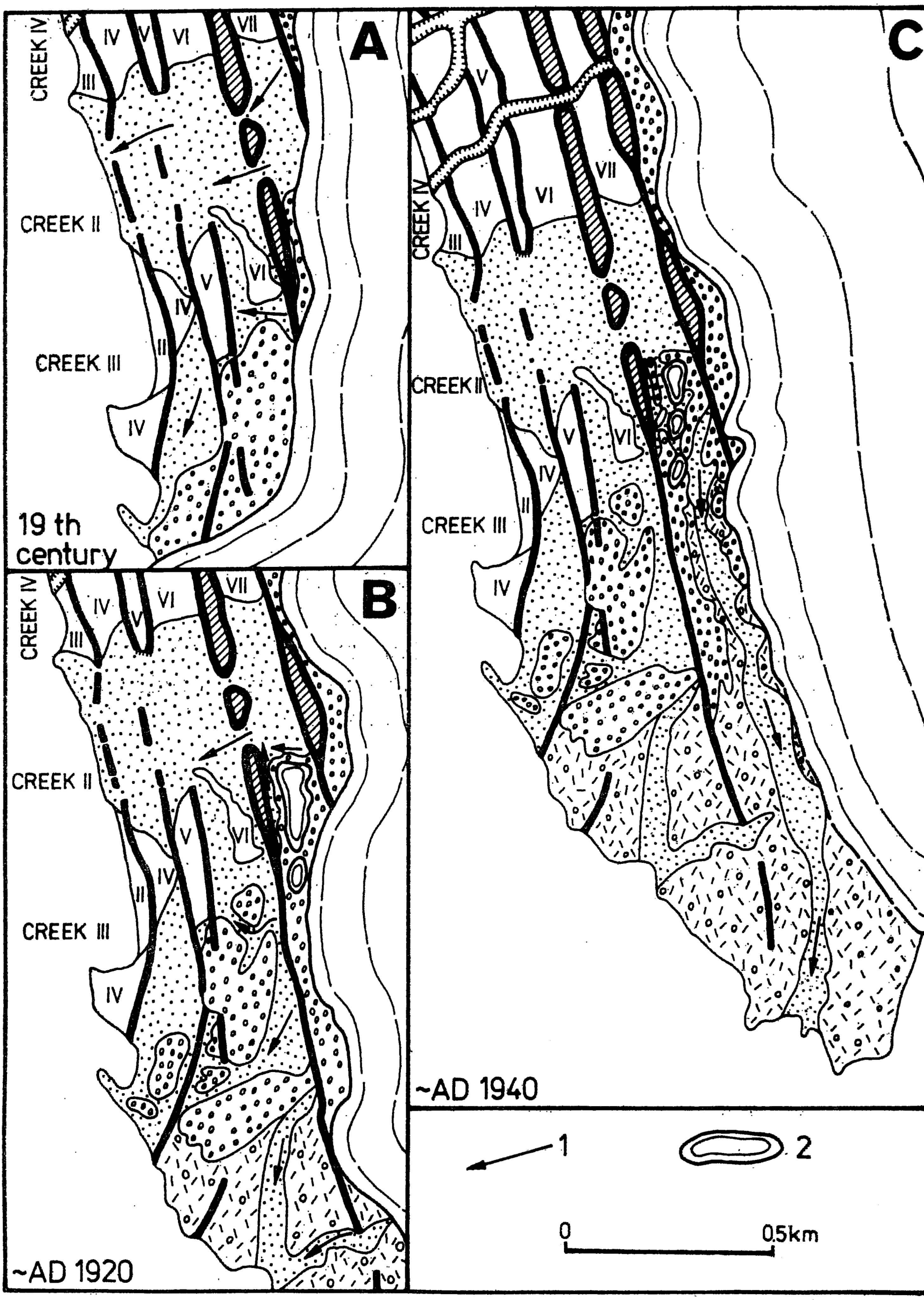

Fig. 3. Paleogeomorphologic sketches (*A*, *B*, *C*) showing the outwash evolution in the south-western part of the Treskelen Peninsula during the maximum glacier advance and the last deglaciation of the Little Ice Age

1 — directions of meltwaters flow, 2 — dead-ice blocks; for other explanations see Text-fig. 1

and Birkenmajer (1964). During its maximum extent the glacier passed over the peninsula crest close to the Creek *III* where numerous marginal hummocks, several metres high, occur up to 90—100 m a.s.l. (Text-figs 3 and 4).

The southern part of the peninsula is now covered with a ground moraine that includes shells of fiord molluscs; the latter came probably from the sediments of the marine terrace 8—12 m a.s.l. that had undoubtedly existed at the eastern side of the Treskelen Peninsula but were afterwards eroded and transported by the glacier during the Little Ice Age (*cf.* Heintz 1953, Birkenmajer 1959).

Further to the north, the glacier snout adhered the highest fragments of the Treskelen Peninsula (Text-figs 2 and 5*A*) where a gravel-loamy morainic ridge (several metres high) is noted (up to 116 m a.s.l.). The meltwaters of that time formed the creeks (Creek *I* and Creek *IV*) at the western side of the peninsula (Text-fig. 1). The area of the present lake at the foot of the Treskelen eastern slope (*cf.* Text-fig. 1) seems to have been entirely occupied by the glacier. At 120—122 m a.s.l. there is a distinct undercut with bright-yellowish weathering waste at the eastern slopes of Hyrnefjellet and Treskelen Peninsula (Text-fig. 5). It was previously considered for an ancient strandline and a terrace of a glint (ice-dam) lake, existing during the maximum glacier advance (Heintz 1953, Birkenmajer 1964). But the presence of such a lake there

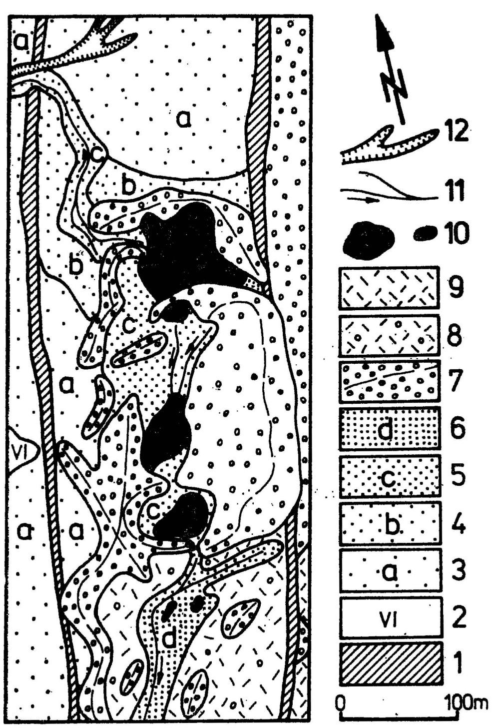

Fig. 4

Geomorphologic sketch of morainal features at the crest of the Treskelen Paninsula, formed by the glacier during its maximum advance of the Little Ice Age

1 — bedrock outcrops, 2 — VI*th* raised marine terrace (69—75 m a.s.l.), 3—6 — successive outwash tracks, 7 — lateral ice-cored moraine, 8 — shelly ground moraine, 9 — ablation moraine, 10 — lakes, 11 — streams, 12 — gorges

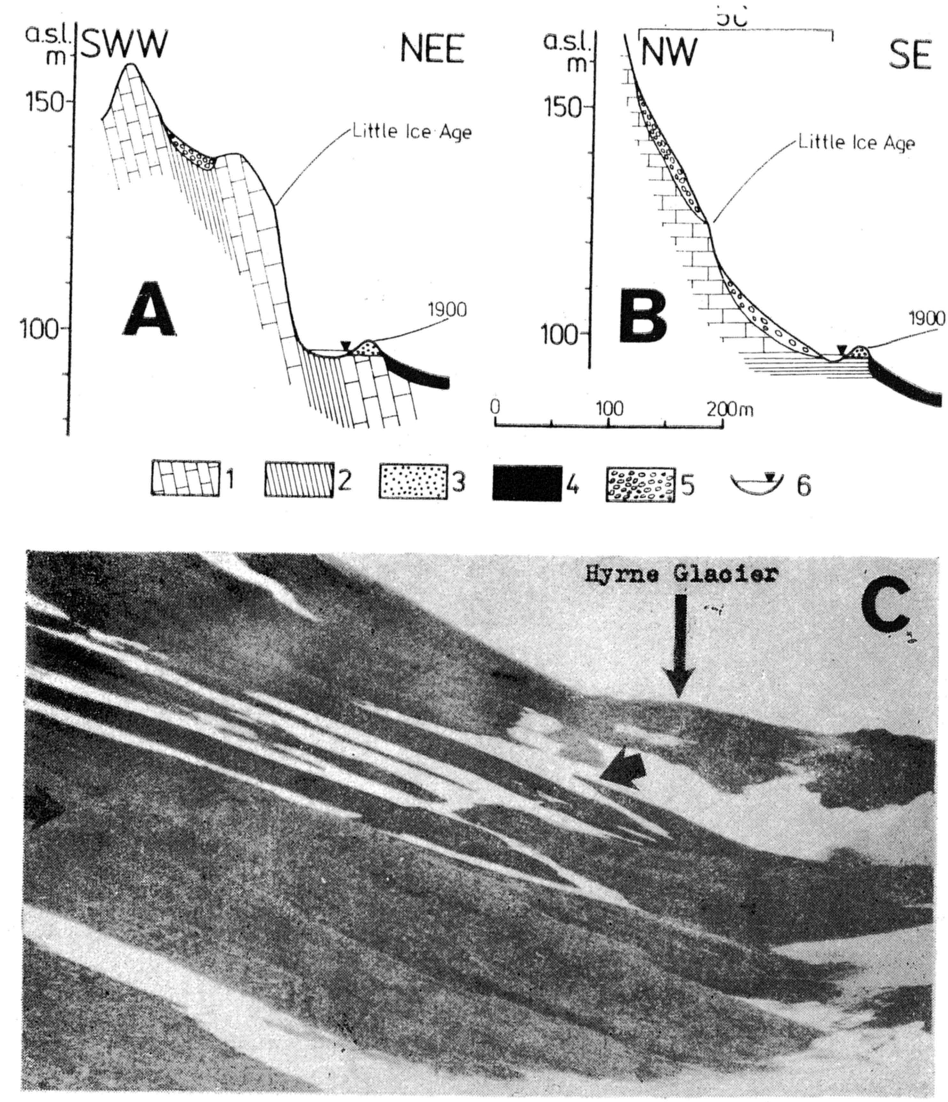

Fig. 5. Interpretation of the undercut, considered previously (Heintz 1953, Birkenmajer 1964) for a strandline: **A** — at the eastern slope of the Treskelen Peninsula; **B** — at the southern slope of the Hyrnefjellet massif (for location *see* Text-fig. 1); **C** — Hyrnefjellet slope with a distinct glacier scour limit (*arrowed*), formed at the maximum of the Little Ice Age and now slightly masked by slope deposits (August 1979)

1 — rocks more resistant to weathering, **2** — rocks less resistant to weathering, **3** — gravels of lateral ice-cored moraines, **4** — till, **5** — debris of talus fans, **6** — present lake water level; marked are glacier snout positions at the maximum of the Little Ice Age and AD 1900 seems improbable as it could not exist close to the glacier and at the easterly exposed Treskelen slope (in August 1979 a considerable part of the present lake was still covered with winter ice, although the glacier was already 700—800 m to the east).

Nevertheless, if an existence of the open lake at that time is there accepted then the water resorvoir would have been too small for a possible wave action to form lake cliffs and abraded terraces. No connection of the suggested ancient lake with the Creeks *I* and *II* (*cf*. Heintz 1953, Birkenmajer 1964) was noted. In fact, the undercut of the Hyrnefjellet and Treskelen slopes seems to be an effect of the glacial erosion during the maximum glacier advance in the 19*th* century (*cf*. Text-fig. 5). A lack of glacial sediments at the slopes of the Treskelen Peninsula and Hyrnefjellet results either from their possible covering by a weathering mantle or from a total sweeping off by meltwaters that flew through the Creeks *I* and *IV*.

It is consequently concluded that the morainic ridge along the southern and eastern shores of the present lake (being much smaller than the ridge further to the south) as well as small morainic hummocks to the east, have been formed during the following retreat phases of the glacier (Text-figs 1 and 2).

EVOLUTION OF OUTWASH DURING THE DEGLACIATION

During the maximum glacier advance at the Treskelen Peninsula in the 19*th* century, the meltwaters formed the Creeks *I* and *IV* whereas close to the Creeks *II* and *III* the outwash fans were deposited (Text--fig. 3*A*). The latter start at the Treskelen crest and gradually get down into the marine terraces. They are composed of fine pieces of bedrock shales and sandstones. The outwash cover is about 0.5 m thick at the peninsula crest but it is thicker westwards and blurs the outlines of the terraces and its edges.

During a glacier retreat the meltwaters gradually disappeared in the Creek *III*. Then, there were only short-lasting small outwash fans in the south-west, drained directly into the sea (Text-fig. 3*B*). Instead, the outwash still worked at the Creek *II* during the initial retreat phases. After a time when the meltwaters simply flew over the Treskelen crest, the outwash became concentrated. Amidst the morainic hills at the Treskelen crest there are two small outwash levels inclined northwards and running towards the Creek *II* (Text-fig. 4). Undoubtedly, they have been formed already during the melting of stagnant glacier fragments.

Behind the lateral moraines at the Treskelen crest, there is a meridional outwash track that enters the sea near the southern end of the Treskelen Peninsula (Text-fig. 3C and Pl. 1, Fig. 1). In fact, it is much greater than recognized by Birkenmajer (1964) as it is about 1.6 km long, 40—50 m wide and is downstream cut 20—25 m in a ground moraine and the bedrock marls. The valley tract was used by meltwaters running from the glacier, stagnating along the Treskelen crest and to a smaller degree, by waters from the melting dead-ice blocks located inside the marginal morainic hummocks at the Treskelen crest (Text-figs 3 and 4). A confrontation with successive phases of a glacier retreat (*cf.* Heintz 1953, Birkenmajer 1964) proves that the outwash valley originated and worked at the end of the thirties of this century. A longitudinal depression occurred there probably already much earlier and thus it favored the glacier advance (*cf.* Heintz 1953). During the deglaciation the stagnant ice masses occurred there for a longer time and supplied the outwash with meltwaters.

A further retreat of the Hyrne Glacier was very quick (*cf.* Text-fig. 2), and from 1958 to 1979 it values about 500 m (*i.e.* 24 m annually on the average). In result, the Sel Peninsula (*Selodden*) was devoid of ice as well as the next peninsula, located further to the east (Text-figs 1—2 and Pl. 1, Fig. 2). More eastwards there are also fragments of other peninsulas or island rows, exposed in fragments from under the Stor Glacier (Pl. 1, Fig. 2). All these features reflect the structural elements of the bedrock.

Since the end of the thirties, no other outwash has been formed in the forefield of the Hyrne Glacier (*cf.* Text-fig. 1). Most meltwaters got probably directly into the sea. A significant part was also played by a glacier calving as there was a long ice cliff at that time (in 1958 it was still 1.5 km long whereas in 1979 it was about 0.5 km).

In 1979 two small outwashes only occurred in the area between the Sel Peninsula and the peninsula located more eastwards (Text-figs 1 and 2). But the outwash was at an initial stage: numerous fine braided channels, filled with gravels and sands, migrated amidst clayey hummocks (several dozen centimetres high) of a fresh ablation moraine.

A significant influence has been exerted lately by a sea water on a melting rate of ice masses, buried inside the ablation moraine (Pl. 2, Fig. 1). The eastern seashore of the Treskelen Peninsula, built of an ablation moraine and about 0.5 km wide, is located several metres below the area closer to the Treskelen and Hyrnefjellet slopes (*cf.* Text-figs 1—2 and Pl. 2, Fig. 2). This lower position seems to result from a warming effect of the sea water on the dead ice contained under the ablation moraine.

Institute of Geology
of the Warsaw University,
Al. Żwirki i Wigury 93,
02-089 Warszawa, Poland

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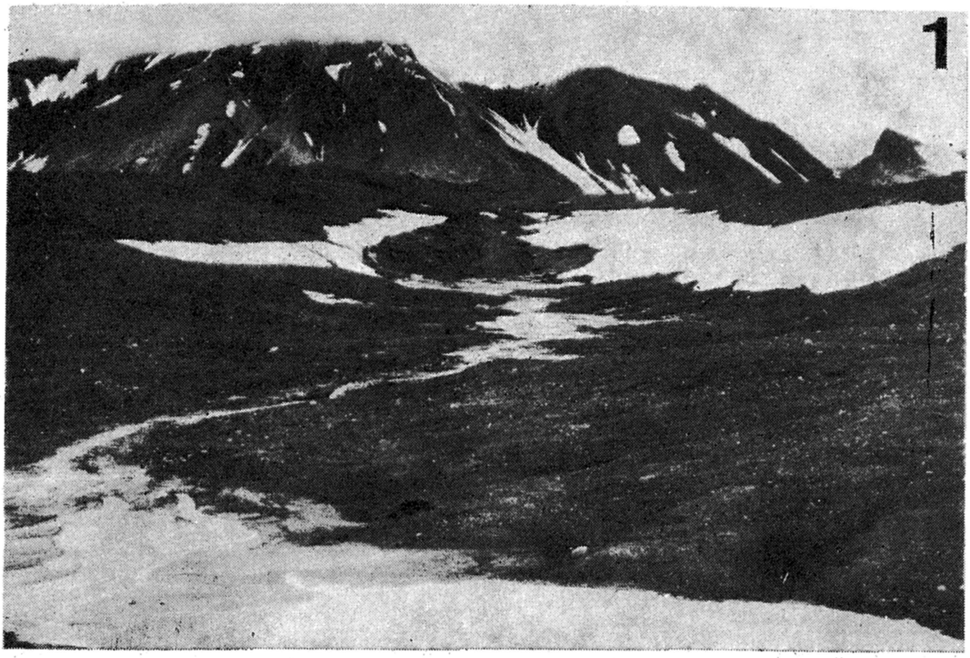
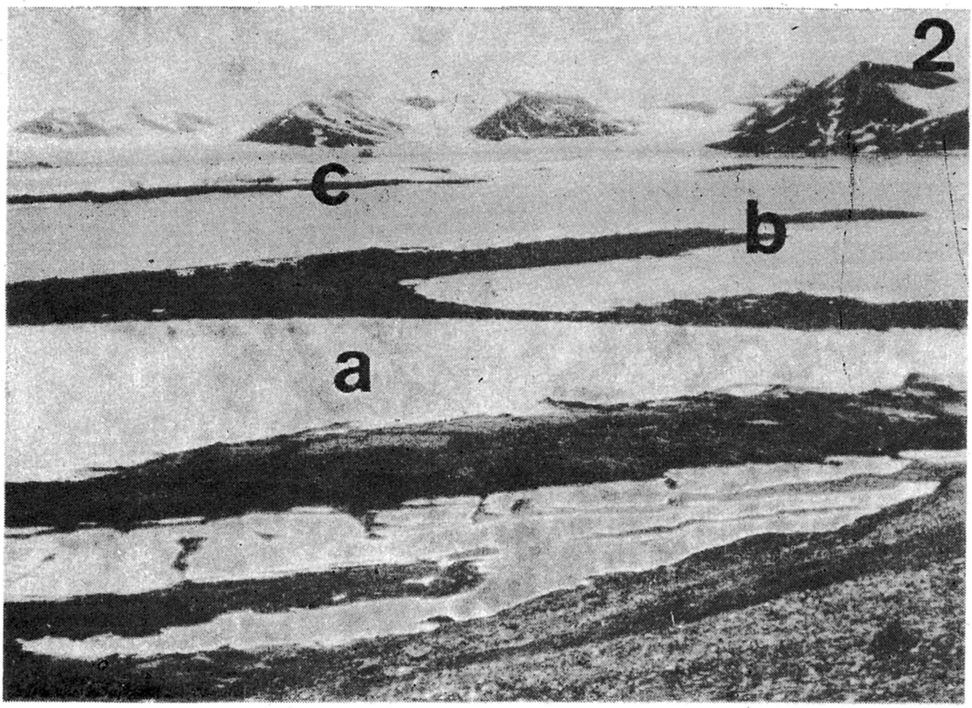
L. MARKS

ROZWÓJ PÓŁWYSPU TRESKELEN (HORNSUND, SPITSBERGEN) W MŁODSZYM HOLOCENIE

(Streszczenie)

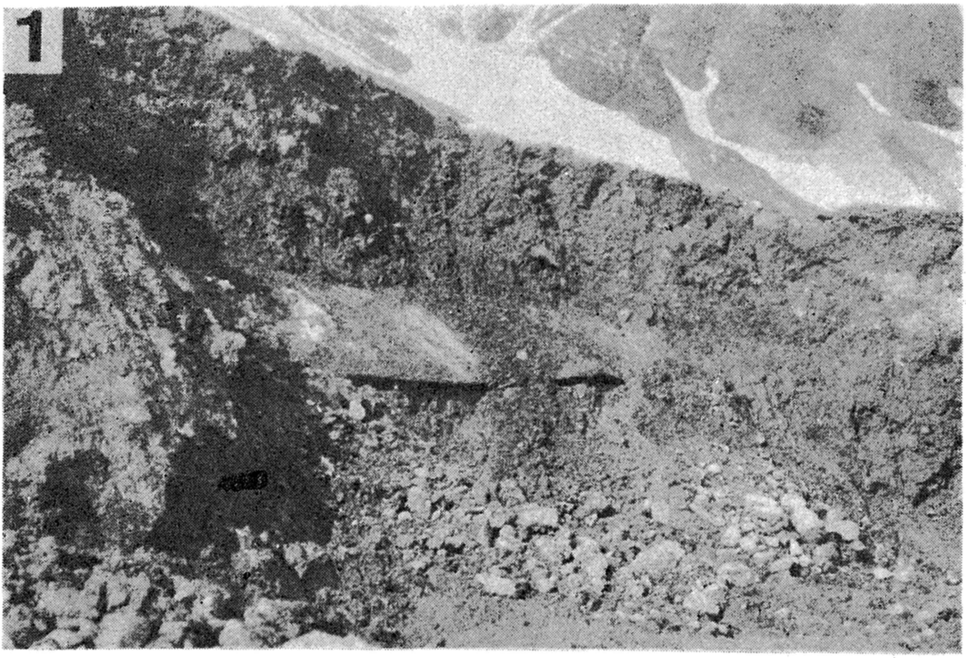
Badania terenowe przeprowadzone na półwyspie Treskelen (Hornsund, Spitsbergen) w lecie 1979 r. oraz fotointerpretacja zdjęć lotniczych (wykonanych w 1966 r.) pozwalają określić przebieg sedymentacji i rozwój rzeźby lodowcowej od maksimum Małej Epoki Lodowej do dziś (fig. 1). Na podstawie analizy zasięgu stref odpływu sandrowego (fig. 3 oraz pl. 1, fig. 1) oraz obszarów występowania wałów lodowo-morenowych (fig. 4) scharakteryzowano kolejne etapy ostatniej recesji lodowca Hyrne (fig. 2). Rozmieszczenie osadów lodowcowych oraz rzeźba badanego obszaru, jak również tempo recesji lodowca Hyrne i wytapiania zagrzebanego lodu lodowcowego (pl. 2, fig. 1—2) zależały w znacznym stopniu od ukształtowania podłoża podczwartorzędowego (pl. 1, fig. 2). Stwierdzono, że strefa określana poprzednio (Heintz 1953, Birkenmajer 1964) jako linia brzegowa jeziora zaporowego na wschodnim zboczu półwyspu Treskelen oraz na zboczu Hyrnefjellet, jest w rzeczywistości górną granicą podciosu lodowcowego pochodzącego z maksimum Małej Epoki Lodowej (fig. 5).

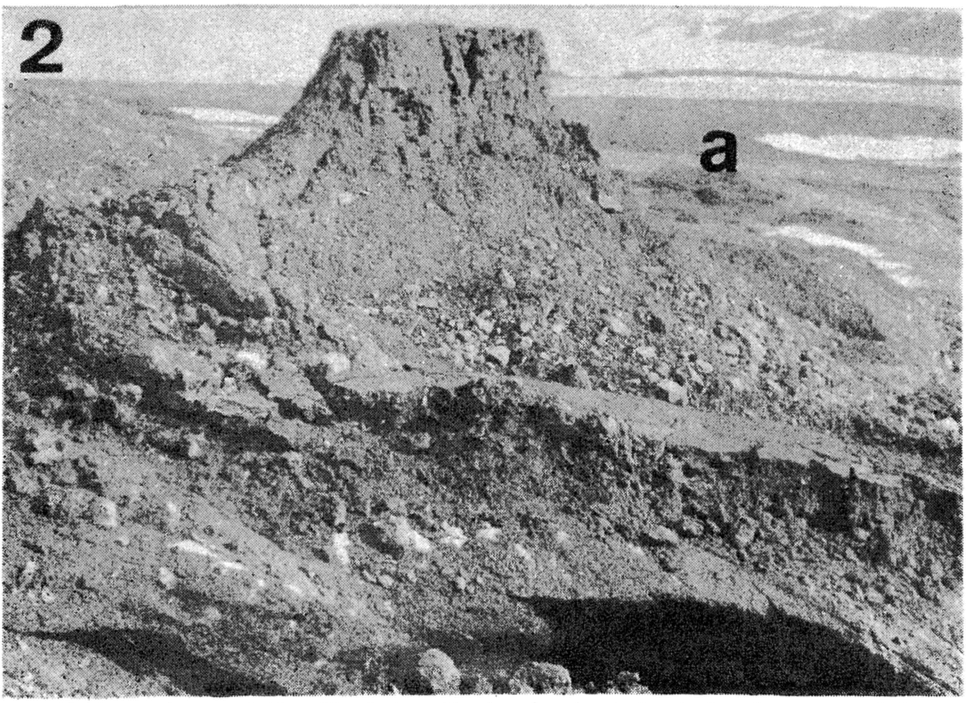




1 — Southern part of the Treskelen Peninsula: an outwash valley formed at the end of the thirties; August 1979

2 — Western fragment of the Hyrne Glacier snout (*a*); in the middle, a peninsula covered with a till mantle (*b*), deposited during the last twenty years of the glacier retreat; at the background — a bedrock crest, being exposed from under the Stor Glacier (*c*); August 1979





1 — Eastern slope of the Treskelen Peninsula: buried glacier ice covered by a till (about 1 m thick) in the actually degraded area; August 1979

2 — Eastern slope of the Treskelen Peninsula: a marginal fragment of an ablation moraine subjected to intensive destruction due to melting of the buried glacier ice; at the background, a strip of a degraded ablation moraine (*a*) along the seashore; August 1979