

PIOTR KŁYSZ & LESZEK LINDNER

## Development of glaciers on the southern coast of Hornsund in Spitsbergen during the Würm (Vistulian) Glaciation

**ABSTRACT:** Geologic and geomorphologic research in the Lisbet Valley (Lisbetdalen) and Kulmstranda proved a glaciation of the southern coast of Hornsund during the Würm (Vistulian) Glaciation. Maximum of this glaciation, expressed by an advance of glaciers in Hornsund, occurred about 45—40 000 years BP. An early retreat stage of the glaciers, marked among others by the highest marine terrace (80—100 m a.s.l.) took place about 25—20 000 years BP.

### INTRODUCTION

During fieldworks performed in Spitsbergen in summer 1980 by the expedition of the Institute of Geophysics, Polish Academy of Sciences, the authors participated in a preparation of a geomorphologic map of north-western Sörkapp<sup>1</sup> in the scale of 1:25 000. The map was prepared with a use of Norwegian air photos in the scale of 1:50 000. The studies over the sediments in which the marine terraces of Kulmstranda have developed and a genesis of Quaternary sediments of the Lisbet Valley were the most important problem that arose during the fieldworks.

The Lisbet Valley (Lisbetdalen) is open to the north towards Hornsund, from which it is separated by marine terraces of Kulmstranda (Text-fig. 1). In the east its lower part is surrounded by the mountain range of Savitsjoppen and in the west — by the massif Hohenlohefjellet. From the south the Lisbet Valley is bordered by the massifs of Kova-

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<sup>1</sup> This map was made by L. Andrzejewski M. Sc., Dr. P. Kłysz, Docent L. Lindner and Docent W. Stankowski as a research problem MR.II.16B "Investigation and protection of a polar environment".

levskifjellet, Gavrilovfjellet, Lidfjellet and Sergeijevfjellet. The valley is 7 km long and is no wider than 3 km in its lower part.

There are no detailed data about genesis of the Lisbet Valley, its age and sediments. Inadequate information relevant to geologic and geomorphologic problems in this part of Spitsbergen was limited to general information about Late Pleistocene glacial sediments in this valley (Birkenmajer 1964, Szupryczyński 1968), periglacial phenomena

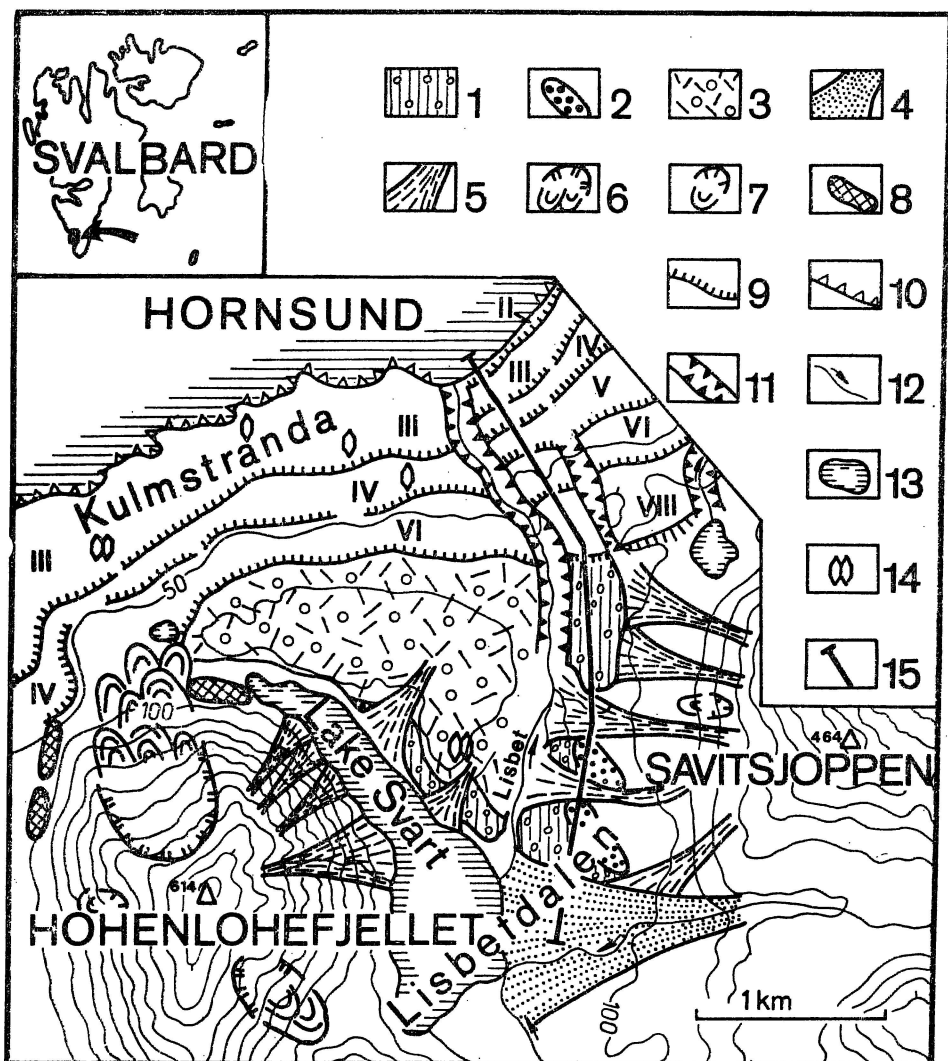


Fig. 1. Geomorphologic sketch-map of the southern Hornsund shore, near Kulmstranda (region arrowed in the inset), to show the lower part of the Lisbet Valley (Lisbetdalen)

1 ground moraine, 2 lateral moraines, 3 ground moraine with marine pebbles over its surface, 4 outwash, 5 talus fans, 6 nival lobes and niches, 7 solifluction lobes and niches, 8 nival moraines, 9 raised marine terraces II—VIII, 10 marine cliff, 11 valley gorges, 12 rivers, 13 sea and lakes, 14 structural soils, 15 line of cross-section presented in Text-fig. 2

(Dutkiewicz 1967) as well as lithology, stratigraphy and tectonics of the surrounding massifs (Birkenmajer 1964); general morphogenetic processes were studied by Czeppe (1966).

#### RELIEF AND GLACIAL DEPOSITS OF THE LOWER LISBET VALLEY

The fieldworks prove that in the lower Lisbet Valley (Text-fig. 1) ground moraines, lateral moraines, outwash fans and a vast basin of the Svart Lake (Pl. 1, Fig. 1) predominate.

The ground moraine occupies the axial part of the valley and the areas to the north of the Svart Lake. The moraine is composed of rubbly and muddy material, a few metres thick. Superficial observations and analysis of exposures in a gorge of the Lisbet Valley (Pl. 1, Fig. 1 and Pl. 2, Figs 1—2) prove that this sediment is typical for a chaotic bedding and blocks, up to 1 m diameter. In the exposures (Pl. 2, Fig. 2) the ground moraine is noted to overlie a slightly loose and eroded bedrock (Carboniferous sandstones). The ground moraine of the northern bank of the Svart Lake covers a more elevated gritty threshold and in the superficial part it is enriched in a small admixture of pebbles of marine origin (Text-fig. 2). In this case, the surface of the ground moraine shows a level change of about 5—10 m (Pl. 3, Fig. 1) testifying

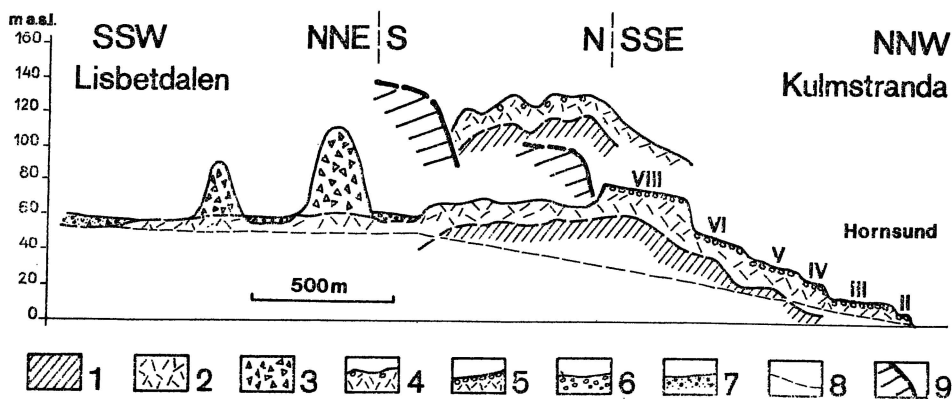


Fig. 2. Geologic cross-section through the marine terraces of Kulmstranda, and the glacial deposits of the lower Lisbet Valley (Lisbetdalen, cf. Text-fig. 1)

1 Carboniferous sandstones, 2 ground moraine, 3 lateral moraines, 4 ground moraine with marine pebbles over its surface, 5 marine pebbles distributed over the ground moraine, 6 talus fans, 7 outwash gravels and sands, 8 water level of the Lisbet river, 9 probable extent of younger retreat stages of the Late Pleistocene glacier

unequal supply of material from the glacier. Two ground moraines exist in the eastern part of the Lisbet Valley (Text-figs 1—2). The northern one is 40 m high and occurs at about 100 m a.s.l. it is composed of muddy and rubbly material, among which the blocks of the Hecla-Hoek Formation shales dominate. The lateral moraine, lower and localized farther

to the south, is slightly above 20 m high and occurs at 80—90 m a.s.l. It is mainly composed of macroclastic rubbly material with dominating Carboniferous sandstones. The western slopes of these moraines (proximal to the glacier that previously existed in this area) are very steep. A morphologic situation and a sediment of these features suggest them to be the nival moraines.

The outwash fan in the south-easterly part of the Svart Lake should be included to the features of the glacial origin, undoubtedly younger than the ground and lateral moraines. The fan was produced by meltwaters flowing from the glacial cirques, at present devoid of glaciers. The glaciers still exist on slopes of Kovalevskifjellet in the most south-easterly part of the Lisbet Valley. The Svart Lake is also a younger postglacial feature, interpreted as a terminal basin formed in a marginal part of the glacier which filled previously the Lisbet Valley.

Deposits and features of a glacial origin have been subjected to younger slope, nival and periglacial processes (cf. Dutkiewicz 1967).

#### MARINE TERRACES OF KULMSTRANDA

In Kulmstranda and in the western part of the Lisbet Valley there are raised marine terraces (Text-figs 1—2, and Pl. 1, Fig. 2, Pl. 3, Figs 1—2). These terraces resulted from abrasion of the Carboniferous sandstones and cover a ground moraine; their sediments are well exposed in the present-day sea cliff. There similarly as in the gorge of the Lisbet Valley, the ground morainic deposits overlie the folded Carboniferous sandstones (Pl. 4, Figs 1—2). They have a similar composition as the deposits exposed in the marginal zone of the Hans Glacier and called the exarational moraines after the ones, described by Różycki (1976) from Central Poland.

The highest marine terrace (VIII), localized at 80—100 m a.s.l., still occurs only to the east of a gorge in the Lisbet Valley (cf. Text-fig. 1). Its surface part, composed of a few centimetres thick bed of marine gravels, was transformed by meltwaters flowing northwards from the glacier previously existing in the Lisbet Valley. A distinct edge that surrounds the southern side of the terrace VIII, is a result of a localisation of an ice cliff there in that time.

In this part of the Hornsund coast the terrace VII, of 56—75 m a.s.l., was not noted; instead, it occurs along the western coast of Sörkapp Land. There are all the middle terraces: VI at 42—54 m a.s.l., V at 30—38 m a.s.l., IV at 20—28 m a.s.l., and the low terraces: III at 10—18 m a.s.l. and II at 6—8 m a.s.l. A relatively thin series of marine deposits (pebbles of the Carboniferous sandstones mainly) that compose all the storm ridges, is typical for every terrace. The storm ridges are separated in many places by outcrops of the Carboniferous sandstones

featuring cliffs that are typical for a skerry coast. Considerable parts of the terraces are covered with structural soils formed by local periglacial processes. In the analyzed coast fragment the lowest marine terrace (3—4 m a.s.l.) was not noted, but it occurs farther to the west.

AN ATTEMPT TO STRATIGRAPHY

In the investigated area neither organic deposits nor faunal remains have been found so, the age of deposits and features could not be unmistakably defined. Geologic and geomorphologic data allow however to qualify mutual relations in time between processes needed for a deposition of glacial sediments and features but also, of raised marine terraces. The ground moraine that forms the bedrock of the marine terraces in Kulmstranda and similar glacial deposits and features in the lower Lisbet Valley owe their origin to the same glacier which previously advanced into Hornsund but then, it gradually disintegrated

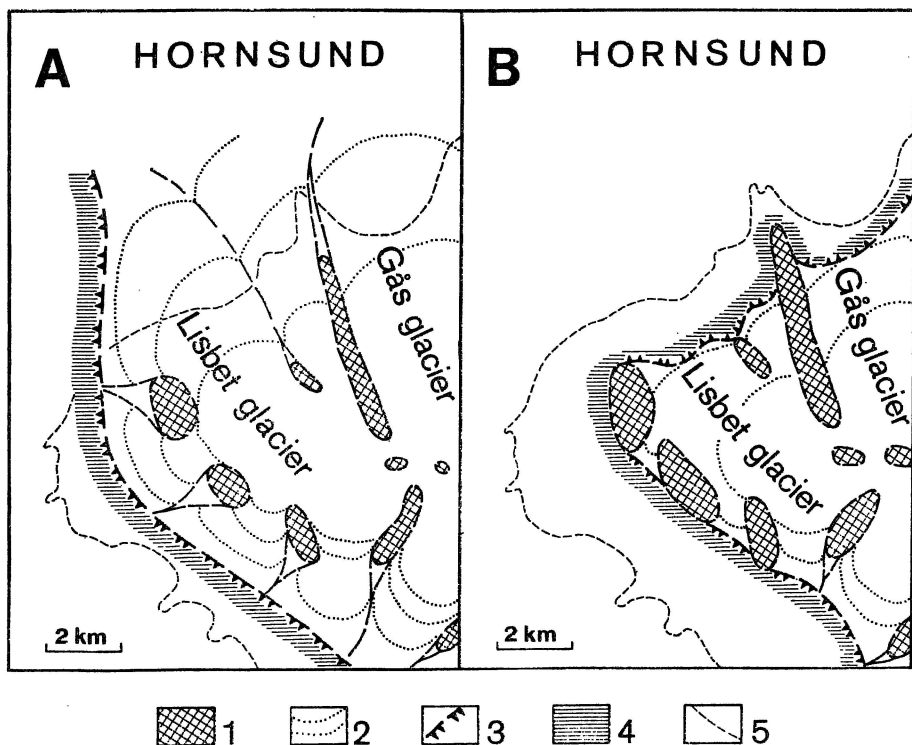


Fig. 3. Probable extents of the glaciers and of the shoreline in the north-western Sörkapp area

A — maximum extent of the Würm (Vistulian) Glaciation, ca 45—40,000 years BP;  
 B — older stage of decline of the Würm (Vistulian) Glaciation, ca 25—20,000 years BP

1 nunataks, 2 surface of glaciers, 3 ice cliff, 4 extent of the sea, 5 present-day extent of the shoreline

(Text-fig. 3). An attempt to define the age of this glacier stage when the glacier front occurred along the edge that surrounds now the terrace VIII in the south (Text-fig. 2), can be resolved if qualifying a chronostratigraphic position of low marine terraces in the Hornsund area.

The observations of Jahn (1959), Birkenmajer (1960), Szupryczyński (1968) and Karczewski & *al.* (1981) suggest, as well as an absolute datings of these terraces (II and III), that they are of Holocene age. The lower terrace (II) should be correlated with the terraces  $2a_1$ - $a_2$  of Birkenmajer (1960) which were dated by a radiocarbon method for  $7010 \pm 90$  years BP to  $9440 \pm 230$  BP (Birkenmajer & Olsson 1970). This terrace corresponds with the *Mya* terrace in Billefjorden (cf. Feyling-Hanssen 1965).

The higher marine terraces of Hornsund can be correlated with the features well dated in other parts of Spitsbergen. Marine gravels that occur in Prins Karl Forland at 20 m a.s.l. are dated by radiocarbon method for 21 000 years BP (Feyling-Hanssen 1965). Keeping this in mind, as well as results of many datings and conclusions in relation to the Würm Glaciation and Holocene Glaciation in Spitsbergen (Boulton 1979, Salvigsen 1977), the terrace VIII seems to have been formed about 25—20 000 years BP so, during a retreat stage of the Middle Würm Glaciation glaciers in Spitsbergen (cf. Text-fig. 3B), the maximum of which was about 45—40 000 years BP (Boulton 1979, Salvigsen 1977). This maximum does not seem to be synchronous with the maximum extent of the Würm (= Vistulian) icesheet in central Europe (cf. Mörner 1977). The accumulation of the ground moraine which forms the bedrock of Kulmstranda marine terraces is probably related to the same period. An extent of these deposits farther to the north proves a contemporary connection between the Lisbet Glacier and any other glaciers which flowed to Hornsund (Text-fig. 3A). Independently from a defining of the age of glacial deposits and processes, a connection of the maximum glaciation of the Hornsund region and a period of the Late Würm (18 000 years BP) should be taken into consideration when a considerable development of the Barents Shelf ice sheet took place (Grosswald 1980). The interpretation of this kind seems to be certified by studies of palaeotemperatures of the North Atlantic during the last 120 000 years (Kellogg 1980).

#### CONCLUSIONS

The maximum development of the glacier which filled the low Lisbet Valley and flowed to Hornsund, took part 45—40 000 years BP. A gradual disappearance of this glacier occurred about 25—20 000 years BP, as it is expressed by the formation of the ice cliff which was cut at the base by waters of Hornsund at a marine terrace VIII. The Late

Würm development of the glaciers, registered in Spitsbergen about 11—10 000 years BP, was marked in the Lisbet Valley by repeated advances of the glaciers that formed the lateral moraines. The Little Ice Age, corresponding with a period 600—100 years BP (Pękala 1980) was probably expressed in the investigated area by an accumulation of the outwash fan in the Svart Lake, formed by waters flowing from the glaciers of the northern slope of Kovalevskifjellet.

*Institute of Geography  
of the Adam Mickiewicz University,  
ul. Fredry 10,  
61-701 Poznań, Poland  
(P. Kłysz)*

*Institute of Geology  
of the Warsaw University,  
Al. Żwirki i Wigury 93,  
02-089 Warszawa, Poland  
(L. Lindner)*

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P. KŁYŚZ i L. LINDNER

### **ROZWÓJ LODOWCÓW NA POŁUDNIOWYCH WYBRZEŻACH HORNSUNDU (SPITSBERGEN) W CZASIE ZŁODOWACENIA WÜRM (VISTULIAN)**

(Streszczenie)

Badania geologiczne i geomorfologiczne doliny Lisbet (Lisbetdalen) i rejonu Kulmstranda na Spitsbergenie (patrz fig. 1—2 oraz pl. 1—4) wskazują na fakt objęcia południowych wybrzeży Hornsundu zlodowaceniem Würm (Vistulian). Maksimum tego zlodowacenia zaznaczone moreną denną sięgającą południowych wybrzeży Hornsundu przypadało na około 45—40 000 lat BP, jeden zaś ze starszych etapów zaniku lodowców, zaznaczony utworzeniem najwyższego tarasu morskiego (VIII), można datować na około 25—20 000 lat BP (patrz fig. 3). Późnowürmski rozwój lodowców (około 11—10 000 lat BP) zaznaczył się w dolinie Lisbet postojem lodowca na linii zachowanych tu moren bocznych.

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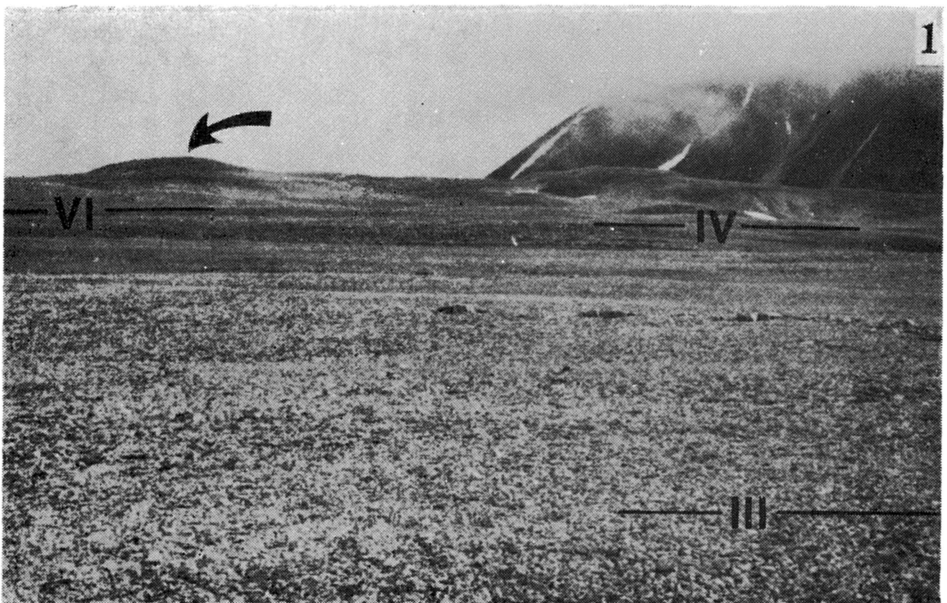
1 — Southern part of the Lake Svart; August 1980

2 — Marine terrace III; higher terraces (IV—VIII) and the Lisbet gorge visible at the background; August 1980



1 — Lisbet gorge in the ground moraine; August 1980

2 — Exposures of Carboniferous sandstones (a) and overlying ground moraine (b) in the Lisbet gorge; August 1980



1 — Marine terraces (III—VI) as seen from Hornsund; at the background a bedrock with overlying ground moraine (arrowed) is visible; August 1980  
 2 — Lisbet gorge in the marine terraces (III—IV); August 1980



- 1 — Exposures of the ground moraine along the Kulmstranda cliffs; August 1980  
 2 — Exposures of Carboniferous sandstones (*a*) and overlying ground moraine (*b*) along the Kulmstranda cliffs; August 1980