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Quaternary sediments of the southwestern Nordenskiöld Land, West Spitsbergen

ABSTRACT: Quaternary sediments in the southwestern Nordenskiöld Land are described with particular emphasis put on distribution of erratics against their basset matrices. Results confirm previous suppositions on directions of past glacial advances from east westwards. The latter separated by sea submergences, caused translocations of the rock material. This process was most intensive in upstreams of large mountain valleys.

Key words: Arctic, Spitsbergen, Quaternary, erratics.

Introduction

The paper presents results of studies of the third Academic Polar Expedition, undertaken by students and scholars from the Warsaw University in 1985 to the Nordenskiöld Land. Field mapping with application of oblique surface photographs, resulted in preparation of the map of Quaternary sediments in scale of 1:25,000, against a structure of the pre-Quaternary bedrock in the Ytterdalen area. Particular attention was paid to distribution and differentiation of erratics, constituting a record of past directions of glacier advances.

Location of the study area

The southwestern Nordenskiöld Land is a diversified area both in its geology and landscape. It has a vast seaside plain Lågnes bounded in the east by two parallel mountain ridges of Thuefjellet (607 m a.s.l.), Ytterdalsgubben (901 m a.s.l.) and Ytterdalssåta (593 m a.s.l.) on the one hand, and Haroldfjellet (664 m a.s.l.), Foldtinden (730 m a.s.l.) and Ingeborgfjellet (714 m a.s.l.) on the other. These ridges frame Ytterdalen, the upstream part of which is occupied by the Erdmann Glacier (Erdmannbreen). Eastern slope of the second ridge has the Fridtjov Glacier (Fridtjovbreen) which forms a glacial cliff in the Fridtjovbukta. Smaller Grånut and Saga glaciers are the western confluents of this vast Fridtjov Glacier. Sartosius and Jarn glaciers open into Ytterdalen together with a small glacier on the northern slope of Flynibba (Fig. 1).

The plain Lågnes is located at 25—50 m a.s.l. Its south eastern part is drained by Ytterdalselva, starting from the Erdmann Glacier (Erdmannbreen) and flowing into Van Muydenbukta. The downstream Ytterdalen has temporary summer flood and marginal waters as well as throughflow lakes, but they disappear in autumn. Lakes in Eunganeelva and Ytterelva mouths exist permanently.

Quaternary bedrock

The area considered is cut by the boundary of strongly metamorphosed Precambrian rocks (Hecla Hoek Formation) and of the Paleozoic sedimentary complex (Flood *et al.* 1971, Hjelle *et al.* 1986). Precambrian shales, tillites, locally metamorphosed limestones (pink, green, and grey) outcrop covered to the west of the line (Fig. 2) running from Millar cape to the western slopes of Ytterdalssåta, Skardkampen (615 m a.s.l.) and the eastern slopes of Salen (598 m a.s.l.). Generally, this line has the NW-SE direction and is followed by subsequent outcrops of Paleozoic rocks.

Rocks of the Hecla Hoek Formation are occasionally inconsistently overlain by lightgrey Carboniferous quartzite sandstones with Lepidodendron root and stocks and leaf imprints, containing thin inserts of hard coal. Such rocks form eastern slopes of the Thuefjellet-Ytterdalsgubben-Ytterdalssåta mountain ridge and also commonly outcrop in the Ytterdalen floor. Eastern slopes of Ytterdalen are composed of Paleozoic carbonate rocks. Outcrops of hard Carboniferous sandstones are also noted in the mountain ridge between Flynibba (745 m a.s.l.) and Ingeborgfjellet (714 m a.s.l.). On the narrow Bellsund seashore they form abrasive inselbergs; their contact with the Hecla Hoek sequence is exposed in the cliff to the east of Millar cape. Lightgrey Lower Carboniferous sandstones dip there easterly at an angle of 60—70°.

Middle and Upper Carboniferous is represented by cherry-red and red sandstones, darkgrey dolomites, gypsums and limestones with a rich coelenterate fauna. These rocks form a straight ridge of Ytterdalsegga. Outcropping dolomites, being more resistant than the neighbouring strata, form a sharp edge on the western transverse of Ytterdalsegga. Single outcrops of coarse

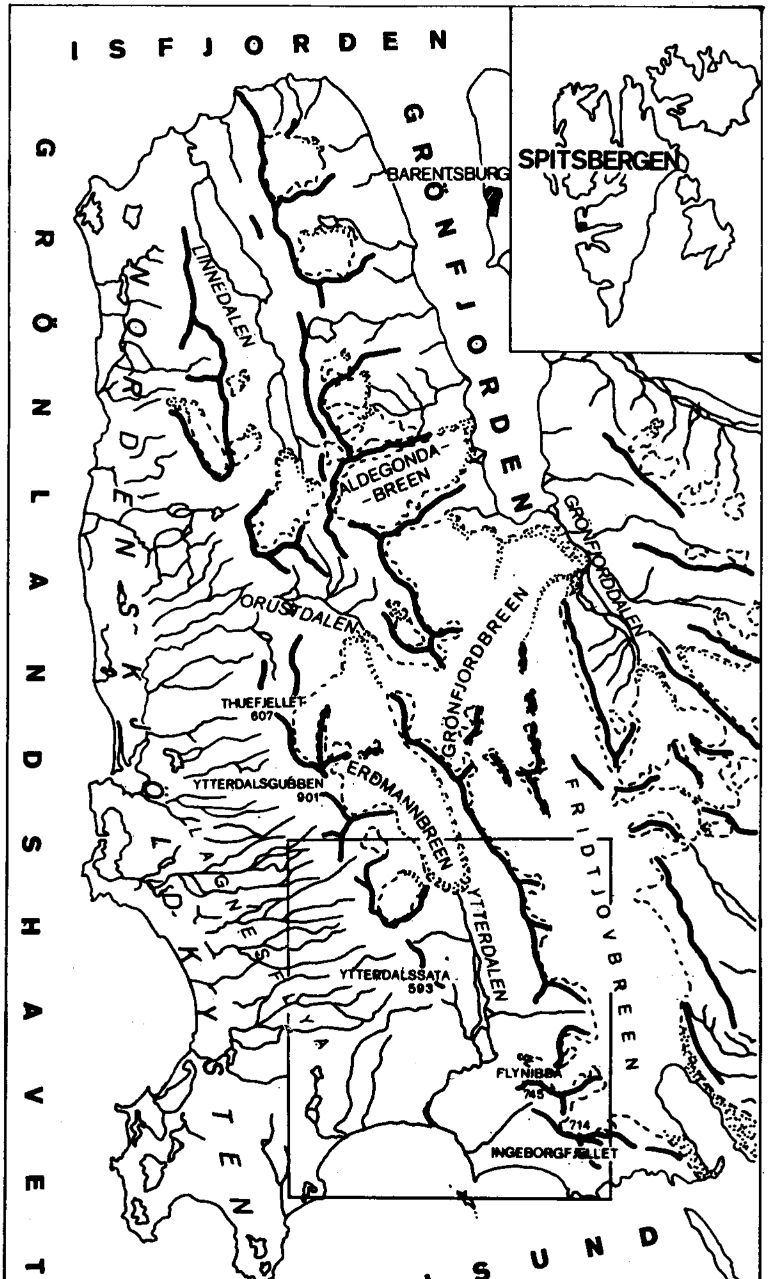

Fig. 1. Southwestern Nordenskiöld Land (marked is the studied area)
1 — main mountain ranges, 2 — glaciers

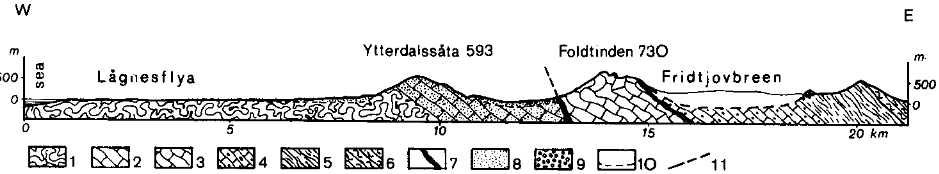

Fig. 2. Geologic section of the western Nordenskiöld Land
1 — slates, tillites and locally metamorphosed limestones (Hecla Hoek Formation), 2 — grey quartzite sandstones (Lower Carboniferous), cherry-red and red sandstones (Middle Carboniferous), darkgrey dolomites, gypsum and limestones rich in *Coelenterate* fauna (Upper Carboniferous), 3 — black limestones (Permian), 4 — fine-grained grey sandstones with darker stripes (Triassic), 5 — silty shales with siderite concretions (Jurasic), 6 — light sandstones and mudstones (Cretaceous), 7 — dolerites, 8 — glaciomarine sediments, 9 — ice-cored moraines, 10 — glacier, 11 — faults

crystalline gypsum occur there at about 250 m a.s.l. Peaks of the described ridge to the south of Folddalen, i.e. Eggtinden (730 m a.s.l.), Foldtinden (730 m a.s.l.), and Granutane (745 m a.s.l.), are formed of the Permian rocks, represented by black siliceous limestones rich in brachiopods, and by grey limestones. Triassic as fine-grained grey sandstones with dark bands outcrop in nunataks within the Fridtjov Glacier.

The presented geological background indicates a clear streaked structure, differing in lithology, age and resistance. Individual series are from 600 to 3000 m wide. The analysed area is located at the boundary of the old Caledonian structures and the younger sedimentary complex what suggests a tectonic instability. The western part of the Nordenskiöld Land is located on the outer border of the Tertiary graben (Flood *et al.* 1971; Hjelle *et al.* 1986). These areas were rejuvenated during the Neogene and the Quaternary due to strong neotectonic and glacioisostatic movements, which resulted in the development of young horst structures (Semevskyj 1967; Kvitkovic 1971; Salvigsen and Nydal 1981; Boulton 1979; Salvigsen 1984; Lindner, Marks and Szczęsny 1986). In this time numerous splits, breaks and shifts of rock layers appeared. Hence, many valleys within the considered area are formed along the faults which cut mountain ridges (e.g. Folddalen, Kleivdalen and Jarndalen).

Quaternary landforms and sediments

Mountains in the southwestern Nordenskiöld Land are almost entirely covered by block debris, locally by clayey ones (Fig. 3). They form compact covers dissected by rock avalanches and gullies, in which bare rock outcrops. Block debris covers are the thickest down carbonate slopes, hence displaying the bedrock structure (e.g. at Ytterdalsegga). Single rocks, ramparts, banks and towers protrude from the waste, commonly near the mountain peaks. There are also structural-denudational rock cliffs and inselbergs.

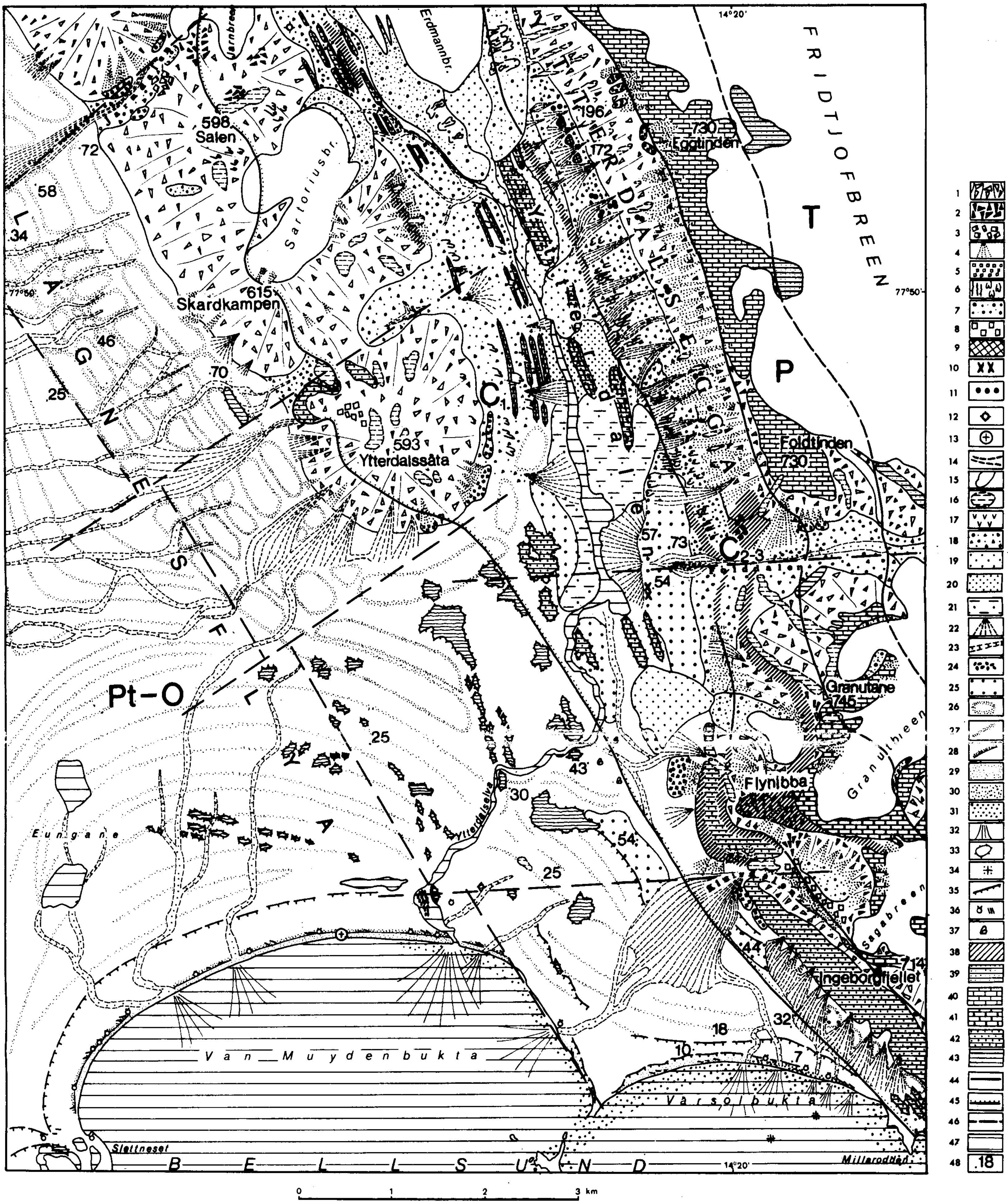

Fig. 3. Geologic map of the southwestern Nordenskiöld Land 1 — block-rubble and clayey slope matles, 2 — block fields, 3 — block fields of large rocks slides, 4 — rubble an blocks of talus cones, 5— rock blocks and rubble of nival moraines, 6 — stony stripes and solifluction tongues, 7 — boulders, rubble, sands, silts, slimes, clays of ice-core moraines, 8 — rock blocks and rubble of ground moraine, 9 — till, 10 — erratics of Hecla Hoek Formation, 11 — erratics of grey, cherry-red and red Carboniferous quartzit sandstones, 12 — erratics of Permian limestones, 13 — erratics of crystalline rocks (red granites), 14 — rock outcrops with rifts, fissures, grooves, splinters and glacier trimline, 1 — glaciers, 16 — multi-annual snow patches, 17 — ice cover, 18 — black-rubble-clayey glacial and marine sediments, 19 — boulders, rubble, pebbles and gravels of proxima parts of outwash cones, 20 — varigrained sands and slimes of distal parts of talus cones, 21 — vari-grained sands, slimes, locally silts of overflow lakes, 22 — rubble, gravel, sand and silts of outwash connes, 23 — pebbles, gravels and sands of river beds, 24 — stone fields, 25 — coarse gravels and small stones of sandy marine terraces, 26 — sands an gravels of high sea terraces, 27 — gravels and sands of ancient storm ridges, 28 — gravels and sands of present storm ridges, 29 — beach sands, 30 — beach gravels, 31 — gravel on abrasive platform, 32 — eastuary sands and gravels, 33 — skerries on high sea terraces, 34 — skerries still under water during low tides, 35 — distinct edges of sea terraces 36 — whale bones and driftwood, 37 — mollusc shells on sea terraces, 38 — dolerites (Jurrasic? Cretaceous?), 39 — fine-grained grey sandstones (Triassic), 40 — grey limestone and black siliceous limestones with rich brachiopods (Permian), 41 — darkgrey dolomites, cherry-red sandstones, dolomites, gypsum and limestones with rich *Coelenterate* fauna (Middle und Upper Carboniferous), 42 — light-grey quartzite sandstones with *Lepidodendron* root-stocks and leaf imprints (Lower Carboniferous), 43 — pink, green and grey shales, tillites, locally metamorphosed limestones (Cambrian and Ordovician), 44 — stratigraphic boundaries, 45 — stratigraphic discontinuities, 46 — tectonic lines, 47 — surface waters, 48 — elevation points

Similar features are also connected with mountain ridges composed of rocks of the Hecla Hoek Formation. On the other hand, elevations out of the Lower Carboniferous light quartzite sandstones possess a thinner and less compact mantle. In such places the outcropping bedrock frequently bears traces of glacial erosion. On resistant rocks there are block fields as on slope of Flynibba (formed of greygreen dolerites), in Jarndalen and on slopes of the elevation 576 m a.s.l. (where light Carboniferous quartzite sandstones occur). In Jarndalen a stone field composed of gigantic blocks of Carboniferous quartzite sandstones (dimensions up to $6 \times 5 \times 4$ m) occur.

At most gully mouths the talus cones developed, with their slopes to 35°. They are most numerous on the eastern Ytterdalsegga slope composed of carbonate rocks. Many talus cones overlap and overlie one another due to changeability of morphogenetic processes.

An essential role in modelling a landscape of the Svalbard archipelago has been played by glacial processes. This fact is expressed both in shaping of forms and in the very nature of sediments.

The area studied in detail enclosed the western part of the Fridtjov Glacier, a morainal zone of the Erdmann Glacier, upper parts of the Grånut and Saga glaciers, the Sartorius Glacier, a fragment of the Jarn Glacier as well as a cirque glacieret located on the northern slope of Flynibba. These glaciers have distinct shaped frontal and lateral ice-cored moraines as well as outwash trains. The most pronounced icecored moraines are located in front of the Erdmann Glacier which has undergone an abrupt retreat during the last fifty years (Pl. 1, Fig. 1). Its lateral part was in 1985 already more than 500 m away from the ice-cored moraine. The morainic material present in the morainal zone is composed of crushed rocks of the Hecla Hoek Formation (strongly metamorphosed shales, colourful marbles) and of lightgrey quartzite sandstones of the Lower Carboniferous age. Debris of the eastern ice-cored moraine contains a lot of Permian limestones and dolomites.

It is of special interest that marine shingle composed mainly of lightgrey Lower Carboniferous quartzite sandstones but also of single cherry-red Middle Carbiniferous sandstones, is noted in the frontal rampart on the eastern side of Ytterdalselva.

The described morainal features are intensively transformed by mass movements. These is a vast zone of landslides, mud streams, solifluction terraces and thaw lakes, the greatest development of which takes place at the end of the arctic summer. In consequence, a clear selection of the morainic material takes place, with drowning of larger rock fragments in morainic mud. In this way silt-clayey solifluction terraces develop on numerous ice-cored moraines.

The frontal ice-cored moraines of the Sartorius Glacier contain the rock fragments of the Lower Carboniferous and the Hecla Hoek Formation, as well as greygreen dolerites. A large number of immense rock blocks draws special attention.

Similar forms in front of the glacier on the northern side of Flynibba are covered with rock pieces of the Middle and Upper Carbonaceous, and of Permian age. The ice-cored moraine at the base of the slope with a southwestern exposition upstream Kleivelva has a similar structure. Smaller ice-cored moraines in Jarndalen, beneath a pass between Salen and Skardkampen contain dark rocks of the Hecla Hoek Formation. Rocky blocks of ground moraines blanket bottoms of the upstream Kleivdalen and of a small cirque at western Ytterdalssåta.

Quaternary sediments of the southwestern Nordenskiöld Land are frequently rich in erratics (Musiał 1983, 1984). Meridional setting of narrow outcrops of various rocks makes it easier to trace the transport routes of erratics.

The largest ones weigh over ten tons and have sharp edges, without traces of glacial erosion. The other ones are composed of well and very well rounded (marine) shingle. There are also quite common rock pieces of various dimensions, the edges of which have been subjected at most to a slight glacial erosion.

Most erratics form marine shingle and are composed of lightgrey quartzite sandstones of the Lower Carboniferous and occasionally of cherry-red and red sandstones of the Middle Carboniferous. High resistance of these rocks, light colour and typical oval or rounded shapes make them easily recognizable within the angular debris of dark carbonate Permian and Hecla Hoek Formation rocks.

Lightgrey and cherry-red quartzite sandstone pebbles with dimensions from 12 to 82 cm are noted in various morphological situations:

— within the sea terraces, i.e. up to 73 m a.s.l., in areas composed of the Hecla Hoek Formation rocks;

— on mountain slopes up to 247 m a.s.l., within the areas with outcrops of Permian carbonate rocks;

— in ice-cored moraines ramparts of the Erdmann Glacier (119 m a.s.l.);

— at the mouth of Folddalen that enters Ytterdalen, i.e. at some 160 m a.s.l.

Most erratics are noted at higher marine raised beaches where the alien material of gravels often attains 90%. Such a situation can be also observed on Lågnesflya where within the outcrops of strongly metamorphosed Hecla Hoek shales there are gravels of the Carboniferous quartzite sandstones. They attain rather small dimension, only occasionally reach 20 cm in diameter, but the smaller grain size (up to 10 cm) predominates there.

In other locations as on slopes of Ytterdalsegga, either single pebbles or their small clusters (up to several dozen of stones) have been found. They are considerably concentrated in front of the ice-cored moraine of the Erdmann Glacier where they locally form more than 50% of the morainic material.

An enormous erratic block (5×3×1 m) of the Permian limestone with a rich fauna of corals and brachiopods is located on the western side of Ytterdalen between the Erdmann and Jarn glaciers in a zone with Lower Carboniferous out crops. Its parent rock outcrops more than 3 km to the west.

Single erratics of the Hecla Hoek Formation rocks are found in Ytterdalen on the Lower Carboniferous rocks. They attain about 1 m in diameter while their edges are poorly rounded. They have been observed at the mouth of Folddalen and close to the ice patch in Ytterdalen.

Special attention should be paid to the erratic of a red granite found on a beach Van Muydenbukta to the west of Ytterdalselve mouth. The closest outcrops of such rocks have been identified some 100 km to the east (Y. Ohta *pers.comm.*).

Vast outwash plain occurs in Ytterdalen in front of the Erdmann Glacier. Closely to the frontal ice-cored moraine it is composed of boulders and gravel while in the outskirts a finer material predominates, sands and silts inclusive (Pl. 1, Fig. 2). There are fragments of the Hecla Hoek Formation rocks, quartzite sandstones of the Lower Carboniferous, limestones of the Middle and Upper Carboniferous, Permian dolomites, and siliceous Permian limestones. The outwash is transformed further into a limnoglacial plain with deposition of sands and silts. In the morainal zone of the Erdmann Glacier and internal outwash developed too, composed of angular gravels, vari-grained sands and silts.

The outwash on the northern side of Flynibba is formed of slightly rounded fragments of Permian and Carboniferous rocks, though white gypsum pebbles are also noted there.

A much smaller intramorainal outwash, composed mainly of gravels and sands, stretches in front of the Sartorius Glacier.

Nival phenomena resulted in a development of subslope nival moraines. They are composed of large angular blocks, coming from the closest vicinity. Subslope nival moraines occur on the eastern slope of Ytterdalssåta, to the north and to the south of the Kleivelva mouth and in Jarndalen.

At the foot of Foldtinden in Ytterdalen there is a vast ice cover which significantly melts during the polar summer. Due to significant water content in soils around the ice, larger rock fragments get drowned in silty material. Small elevations are being formed, with their centers composed of silty-sandy material.

Observations in summer 1985 indicated a presence of only few patches of multi-annual snow in the southwestern Nordenskiöld Land. They occurred in deep gullies, in nival niches, at feet of rocky cliffs and locally in glacier pots. Slope gradients do not seem essentially significant in distribution of these snow patches as they are equally encountered on eastern as on western slopes.

Periodical thaw-freeze of the upper soil layer is directly related to the development of periglacial forms and structures. They have developed both on flat and inclined surfaces. Consequently, there is a constant displacement and selection of loose rock material. Hence, solifluction forms could emerge as well as stony striae, tongues, etc.

Sediments of alluvial cones are relatively poorly smoothed. Petrographic composition of rocks appearing in these cones is varied and closely related to the rocks in the nearest neighbourhood. As the runoff becomes concentrated and a river valley attains a more or less definite shape, then rock debris displays an increased smoothing. River valleys which developed on the seashore Lågnes have sandy-stony bottoms incised into sea sediments. Locally, at bottoms of larger rivers (like Ytterdalselva and the stream in Folddalen), shingle fields emerge.

Cycles of exogenic landscape-creative processes, mainly of glacial and littoral nature, resulted in repeated redeposition. The largest area is occupied by raised marine terraces. They stretch at the food of the western slope of the Thuefjellet — Ytterdalsgubben — Ytterdalssåta mountain ridge and enter downstream Ytterdalen at a distance of 3—4 km (Pl. 2, Fig. 1). Raised terraces are also located at the feed of Flynibba and Ingeborgfjellet.

The highest raised marine terrace in the southwestern Nordenskiöld Land was noted at 72—73 m a.s.l. (altimeter measurements). The terrace surface is covered with compact mantle of marine pebbles composed of the Lower Carboniferous lightgrey quartzite sandstones, commonly over 25 cm in diameter. Under these pebbles there are grey vari-grained sands of marine origin. These highest terraces occur in the mouth of Folddalen and on Lågnesflya (Pl. 2, Fig. 2). Raised marine terraces at 57—58 and 54 m a.s.l. are similar if their shape and distribution is concerned, at the mouth of Folddalen. The marine terrace 50—54 m a.s.l. was composed at the depth of 5 m of yellow-grey stratified vari-grained but mainly fine-grained sands, underlain by grey-brown silty sands (60 cm thick) and a brown till (over 1 m thick). This marine terrace resembles the one described by Landvik and Salvigsen (1985) in Gangdalen (some 50 km to the northeast), and by Lavrushin (1969) in Linneelva gorge to the Isfiord.

It is typical that Glacial series in the Nordenskiöld Land (usually two tills) are generally noted from under the sea sediments. Individual raised terraces are not separated by abrupt edges, since they have been smoothed out due to solifluction.

Marine terraces at the open sea are usually formed of finer material. Lower Carboniferous lightgrey quartzite sandstones predominate in terrace composition but there also occur smoothed fragments of slates, limestones and vari-coloured marbles of the Hecla Hoek Formation. Single cherry-red and red sandstones of Middle Carboniferous age are quite frequently noted too. In the vicinity of the mouth of Jarndalen into Lagnesflya a piece of Permian spiriferous limestone was found. The raised marine terraces occur therefore at 72—73, 57—58, 54—58, 51 and 32—34 m a.s.l. At Van Muydenbukta and

Varsolbukta, shores in Bellsund there are raised marine terraces at 2, 7—8, 10, 15—18, 27, 30—32, 43—44, 54 and 57—59 m a.s.l.

Altitudes of the mentioned terraces correspond with the ones in other parts of Svalbard (*cf.* Feyling-Hansen 1959; Birkenmajer 958, 1960, 1964; Grosswald *et. al.* 1967; Szupryczyński 1968; Lewandowska 1981; Musiał 1981; Karczewski *et. al.* 1981; Kłysz and Lindner 1981; Marks 1983; Lindner *et al.* 1984; Lindner, Marks and Ostaficzuk 1986). Many terraces comprise ancient storm ridges that form parallel stripes, composed of pebbles, gravels and sands.

Distinct edges (6—8 m high) of marine terraces occur in Varsolbukta. Patches of winter snow persist frequently at the feet of these edges for a long time, making formation of nival lag concentrates possible.

Marine terraces at the mouth of Ytterdalen continue upvalley as narrow rock ledges lying at 196, 184, and 172 m a.s.l. These levels cannot however, be easily recognized due to thick solifluction and parly fluvial mantle.

A flat sandy beach runs along Van Muydenbukta from the Ytterelva estuary to Slettneskapp. Vari-grained beach sands contain also very well smoothed gravels. Piles of broken winter ice persist locally on these beaches during the whole summer, if buried in beach sediments.

Within these coastal plains there are common outcrops of the bedrock, remodelled by abrasion. They form smaller or larger skerries in the down- and mid-stream parts of Yttedalen.

Conclusions

Distribution of erratics in the southwestern Nordenskiöld Land against their parent areas fully confirmed the opinion of Büdel (1960, *see* Szupryczyński 1963) on the westward advance of glaciers in the past. Besides that, there are also traces of several glacier advances after sea retreat from this area (*cf.* Lindner, Marks and Ostaficzuk 1986) as well as in Scandinavia (Karlén 1976).

When considering the transportation of erratics one should first of all take the glacial factor into account. This conclusion is fully corroborated by geologic and geomorphologic studies based on air and terrestrial photographs (*cf.* Horodyski *et al.* 1987). Dimensions of erratics, their present altitudes and distances exclude the sea as the transporting agent (Musiał 1985).

Repeated glacier advances separated by sea transgressions resulted in such a displacement of rock material that is fully expressed in the formation and nature of Quaternary sediments in the Nordenskiöld Land.

Transformations of sediments have been most intensive in upstreams of large valleys where glaciers development several times. On the other hand, the greatest selection and smoothing of rock material took place on the platform abraded by the sea.

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Streszczenie

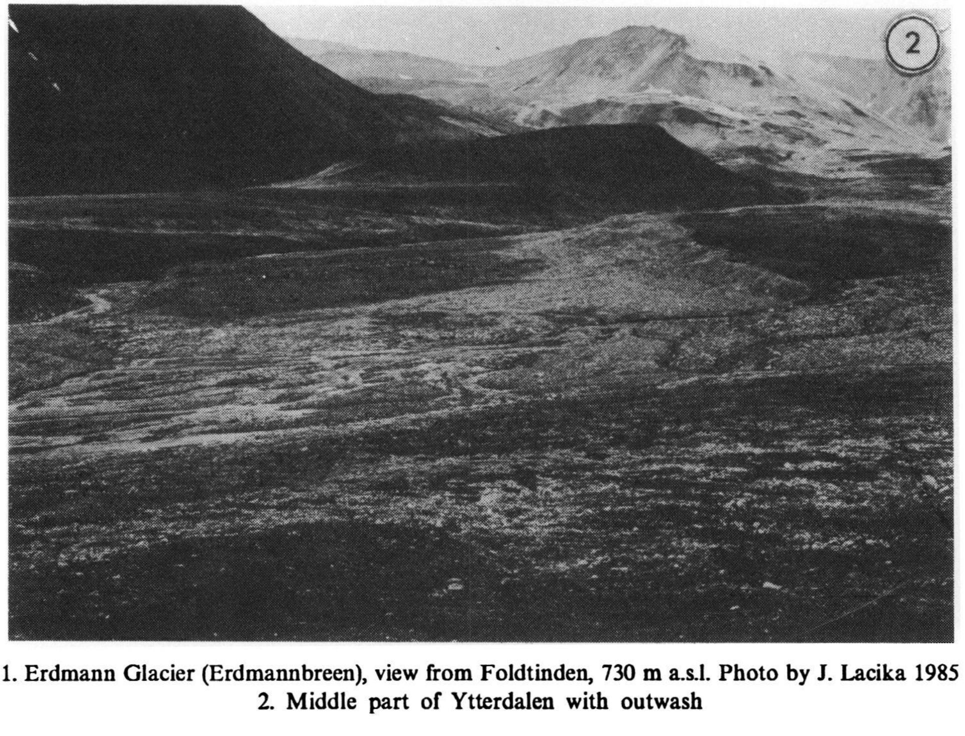
SW część Ziemi Nordenskiölda stanowi obszar urozmaicony zarówno pod względem geologicznym jak i morfologicznym. Rozciąga się tu szeroka równina nadmorska Lågnes oraz przebiegające z NW ku SE grzbiety górskie z najwyższym szczytem Ytterdalsgubben (901 m n.p.m.; fig. 1). Przez tę część archipelagu przebiega granica między silnie zmetamorfizowanymi skałami prekambryjskimi formacji Hecla Hoek a paleozoicznym kompleksem osadowym (Flood i in. 1971; Hjelle i in. 1986). Występują tu (fig. 2) łupki, tillity, lokalnie zmetamorfizowane wapienie (Hecla Hoek), piaskowce kwarcytowe z wkładkami węgla kamiennego (karbon), dolomity, gipsy i wapienie z bogatą fauną ramienionogów (perm) oraz drobnoziarniste, szare piaskowce (trias). Osady czwartorzędowe spotykane w SW części Ziemi Nordenskiölda stanowią produkty wietrzenia skał podłoża w efekcie oddziaływania zróżnicowanych procesów morfogenetycznych (fig. 3). Grzbiety górskie prawie w całości pokryte są tu blokowo-rumoszowymi, lokalnie rumoszowo-gliniastymi pokrywami stokowymi. U wylotu większości żlebów rozwinęły się stożki usypiskowe, których nachylenia często dochodzą do 35°.

Występującym tu lodowcom towarzyszą wały lodowo-morenowe: czołowe, środkowe i boczne (pl. 1, fig. 1). Duży obszar zasypania glacjofluwialnego obserwuje się w dolinie Ytter na przedpolu Lodowca Erdmanna (pl. 1, fig. 2). Największe powierzchnie w tej części archipelagu zajmują osady pochodzenia morskiego, budujące rozległe poziomy morfologiczne, wkraczające na kilka kilometrów w doliny (pl. 2, fig. 1). Tarasy morskie rozpoznano na wysokości: 2 m n.p.m., 7—8 m n.p.m., 15—18 m n.p.m., 27 m n.p.m., 30—32 m n.p.m., 43—44 m n.p.m., 54 m n.p.m., 57—59 m n.p.m., 72—74 m n.p.m. (pl. 2, fig. 2).

Wśród osadów czwartorzędowych często spotyka się tu eratyki (Musiał 1983, 1984). Najliczniejszą ich grupę tworzą otoczaki morskie jasnoszarych piaskowców kwarcytowych karbonu, znajdywane w różnych sytuacjach morfologicznych: na tarasach morskich, na stokach górskich na wałach lodowo-morenowych, u wylotu dolin itd.

Powtarzające się wielokrotnie transgresje lodowców, rozdzielone okresami zalewów morskich spowodowały przemieszczenie materiału skalnego (Karlèn 1972). Największy stopień osiągnęło ono w górnych odcinkach dużych dolin, gdzie lodowce rozwijały się wielokrotnie.

Praca wykonana została w ramach tematu CPBP 03.03.



1. Erdmann Glacier (Erdmannbreen), view from Foldtinden, 730 m a.s.l. Photo by J. Lacika 1985
2. Middle part of Ytterdalen with outwash

1. Glacial and marine sediments in the mouth of Ytterdalen with the Erdmann Glacier (Erdmannbreen) in the background
2. Lågnesflya with sea terraces