Andrzej Musial
Department of Geomorphology
Warsaw University,
Poland

Wyprawy Geograficzne na Spitsbergen
UMCS, Lublin 1992

MORPHOLOGY OF THE LOWER PART OF BERZELIUSDALEN (NORDENSKIOLD LAND)

The valley system in high latitudes is a result of complex morphogenetic processes, exogenetic and endogenous. The results of external processes connected with the polar climate can be particularly well seen. The operation of the movements of the Earth's crust triggered off by neotectonic and glacitectonic processes is also prominent. Seasonal, annual and perennial changes in relief are visible as well. The valleys of complex origin in the region around the pole, with frequently shifting morphogenetic cycles, constitute a valuable source of information about the development of the relief in the past and at present. The information used in this article has been collected during the University Polar Expedition to Spitsbergen '88 in the summer of 1988.

Berzeliusdalen is located in the western part of Nordenskiold Land on Western Spitsbergen on the northern side of Van Mijenfiorden. It is 21 km long, 2.6 km wide in its upper part and 6 km wide at its mouth. The bottom of the valley is almost level, sloping steadily at no more than 17%. Berzeliusdalen lies meridionally and is fed by Aurdalen, Furdalen and Kolfjelldalen. In its upper part there lies Marstranderbreen which culminates in two distinct glacier tongues. Moreover, the basin of Berzeliusdalen is filled by firn and cirque valley glaciers: Gleditschfonna, Snokamp, Iskoll, Folkvard Bugge, Snosal, Jamdals and northern and southern Aurdals. The neighbouring valley situated to the West is filled by Fridtiovbreen culminating in a sharp ice cliff in Fridtjovhamna. The hydrographic hub of the region is Berzeliuselva with its asymetric basin and a prevailing number of right hand side tributaries. The nival glacier character of these rivers causes the heaviest flow to take place during spring thawing in May and beginning of June.

Berzuliusdalen is closed from the North by the Skavlefjellet ridge (845 m a.s.l.), which is the highest point in the valley vicinity. Fragments of old Tertiary planation surfaces are found on the eastern and western ridges: for instance, south of the 525 m a.s.l. peak and in the neighbourhood of the peak 655 m a.s.l. (Fig. 1). The bottom of the valley lies at 0-200 m a.s.l. It is covered by lichen and grass. Large quantities of eliophorum grow in the lower part. The valley had been formed on the western collar of a Tertiary fault basin, which extends over the central part of Western Spitsbergen. The Mesozoic deposits

found in the neighbourhood of the Fridtjof Glacier west of Berzeliusdalen consist of: Triassic mudstones and sandstones, dark grey and black shales with Juraic interbeddings of grey mudstone, and Cretaceous shales, mudstones and sandstones (Flood et al., 1971, Hjelle et al., 1986). The Tertiary series are represented by light grey and green-grey sandstones, black shales interstratified with black coal, and blackband ironstone. They make up the eastern slope of the valley.

Quaternary sediments in this part of the Svalbard Archipelago are composed of glaciofluvial, marine, glacial-marine and slope glacial deposits. Mountain ridges are almost completely covered by block-rubble slope mantles, and locally by clay-debris mantles, which are dissected by nival-corrasion and erosion chutes, where bed rock is exposed. The block-rubble slope mantles are thickest at the foot of the ridges composed of black Juraic shales (western slope of Sefstromkammen). These deposits often completely cover the buried landscape made of sills, breaks, old cliffs, etc. In the terraces in the vicinity of Kapp Morton, 2-8 m a.s.l., there are numerous deposits of varigrained sands and marine silts with a large quantity of Mya truncata, Saxicava arctica and Saxicava rugosa mollusc shells. They are covered by an 80 cm layer of macroclastic (glacial--marine?) material composed of poorly shaped sandstone boulders 40-50 cm large, single boulders and sharp-edged debris. The described terraces lying at the height of 8-10 m a.s.l. extend over an area of 2 km from the bank of Van Mijenfiorden towards Berzeliusdalen. Higher, the terraces disappear under extensive alluvial cones. They correspond genetically to the neighbouring flattenings 36-39 m a.s.l. Another fragment of the marine terrace has been observed at the height of 45 m a.s.l. before the Iskoll Glacier. Higher areas transformed by the sea are found on the eastern slope of Sefstromkammen at 55, 80, 91, 117 and 247 m a.s.l.

There is an extensive system of alluvial cones on the bottom of Berzeliusdalen, which have been accumulated by the brooks from the valleys feeding into Berzeliusdalen (Kolfjelldalen, Iskolldalen, Aurdalen, Flathaugdalen). The cones are often as long as 3 km and their continuous development causes the river bed to be pushed towards the other side of the valley. In the places where the cones are facing one another, the river bed is much narrower. Above these places, stagnation lakes have been formed out of the hummocking water, and sedimentation of finer fractions takes place. At low water level, many stone fields and islands appear. The morphology of the cones is varied because of the presence of flush river beds and abandoned channels.

At the mouth of Aurdalen within the area of an old marine terrace, a pingo has been formed (Fig. 2). It is 10 m a.s.l. and 100-120 m in diameter. It is composed of concentric banks which are broken on the northern and southern sides. There is a small water reservoire in the centre. In August 1988 a mudflow left the reservoire and reached the foot of the pingo. It was 45-50 m long. There are

numerous crevasses on the surface of the hill. The pingo is covered with lichen and moss. From the eastern side, the pingo hill was undercut by a river. There were fine silts and gravels in the exposure.

Berzeliuselva escapes to Van Mijenfiorden forming a delta. Probably, during severe storms and high tide a deltaic fan is formed.

The morphology of the valley is largely determined by glaciers. The glaciers situated at the river basin feed melt-water into the valley, transporting large quantities of mineral material. There is no outwash in front of the Marstrander Glacier. The presence of deeply incised valleys on its foreland suggests the prevailing activity of erosion over accumulation. Therefore, the upper part of Berzeliusdalen is a transit area for the rubble which gathers in the lower part. The erosion power of the main river is made stronger by the presence of the alluvial cones from the tributary valleys which block the growth of the river bed. Solifluction covers extend at the foot of the mountain ridges. They are composed of stone and debris stripes, solifluction and mud-debris tongues.

Based on the facts given above it is possible to reconstruct the events which have led to formation of Berzeliusdalen's relief at the end of Pleistocene and Holocene. The origins of the valleys relief can be traced back to the Tertiary.

The traces of the Pleistocene advance of the sea on the Svalbard Archipelago can be seen in the form of crystalline rock erratics of beach pebbles. The height at which they have been found does not correspond to that at which they had been deposited. This is indicated by their topographic situation — their presence on a highly inclined slope. Therefore, the rock material was probably displaced by mass movements. Taking the above conditioning under consideration, crystalline rock erratics have to be treated as a significant indicator of the extent of the old coastline. The presence of crystalline rock incrops in the north-eastern part of the Svalbard Archipelago allows for only one way of transporting the fragments to the western coast. It could be done by floating ice fields or icebergs. Current observation show that crystalline rock erratics are quite common on the beaches of Nordenskiold Land. They had been transported by ice-fields from the eastern and southern coasts of the archipelago. The phenomenon was observed in August 1988, when an ice-field found its way to Van Mijenfj orden floating between Akselöya and the land. Crystalline rock erratics can also be found on ancient storm ridges and on higher marine terraces (Musiał et al., 1989). The higher these rocks are situated, the more weathered they are. Therefore the redeposition of these deposits by glaciers has been overemphasized by the author (Musiał, 1985).

The problem of timing the origins of the marine terraces and their corelation has been debated for a long time (Birkenmajer 1960, Chmal 1988, Jahn 1959, Lindner et al. 1991, Marcinkiewicz 1961, Musiał 1985, Pękala, Repelewska-Pękalowa 1990, Salvigsen 1981, Stankowski 1981, Troitsky et al. 1975).

The geomorphological analysis and the erratic indicator of the boundaries of

the old sea have allowed to group the marine terraces in Berzeliusdalen. The author lists the levels of: 8 m a.s.l., 36-39 m a.s.l., 45 m a.s.l., and 55 m a.s.l. as Holocene (after L. Salvigsen, 1981). The higher levels of: 80-84 m a.s.l., 91 m a.s.l., 110-117 m a.s.l., 152 m a.s.l., 187 m a.s.l., 200-216 m a.s.l., 245-247 m a.s.l. belong to the Pleistocene. With the present amount of knowledge about the valley, it is risky to determine the age of these formations more precisely. In the Holocene, gradual recession of the sea had taken place.

So far, Pleistocene frontal moraines have not been found in the described region, even though they are well developed in the close vicinity (Musiał, 1989). They are likely to have been destroyed by the abrasion of the sea.

Currently, Berzeliusdalen is modelled mainly by glacio-fluvial, glacial and periglacial processes.

REFERENCES

Birkenmajer K., 1960: Raised marine features of the Hornsund area, West Spitsbergen. Studia Geol. Polon., vol. 4.

Chmal H., 1988: Late Quaternary sea-level changes and glacial history of the Hornsund area, Spitsbergen. 15 Polar Symposium, Wrocław.

Flood B., Nagy J., Winsnes T. S., 1971: Geological map of Svalbard 1:500 000, Sheet 1 G Spitsbergen southern part. Norsk Polarinstittut; Oslo.

Hjelle A., Lauritzen O., Salvigsen O., Winsnes T. S., 1986: Geological map of Svalbard, 1:100 000 sheet 10 G, Van Mijenfjorden. Norsk Polarinstitutt. Oslo.

Jahn A., 1959: The raised shorelines and beaches in Hornsund and the problem of postglacial vertical movements of Spitsbergen. Przegl. Geogr., t. 31.

Lindner L., Marks L., Roszczynko W., 1991: Age of raised marine beaches of northern Hornsund Region, South Spitsbergen. Polish Polar Research, vol. 12, z. 2.

Marcinkiewicz A., 1961: Podniesione tarasy nadmorskie południowego wybrzeża Bellsundu i Fiordu Van Keulena między lodowcami Recherche i Hessa (Zachodni Spitsbergen). Biul. Geol. t. 1, cz. 1, Warszawa.

Musiał A., 1985: Traces of glaciations in the northwestern part of Nordenskiold Land (Western Spitsbergen). Polish Polar Research, vol. 6, 4.

Pękala K., Repelewska-Pękalowa J., 1990: Relief and stratigraphy of Quaternary deposits in the region of Recherche Fiord and southern Bellsund (West Spitsbergen); Wyprawy Geograficzne na Spitsbergen. UMCS Lublin.

Salvigsen O., Nydal R., 1981: The Weichselian glaciation in Svalbard before 15 000 BP. Boreas, 10.

Troitsky L. S., Zinger E. M., Koriakin V. S., 1975: Oledienienije Spitsbergena (Svalbarda). Izd. Nauka. Moscov.

STRESZCZENIE

Berzeliusdalen położona jest w zachodniej części Ziemi Nordenskiolda na Spitsbergenie Zachodnim po północnej stronie Van Mijenfjorden. Uchodzą do niej: Aurdalen, Furdalen i Kolfjelldalen. Górną część Berzuliusdalen zajmuje Marstranderbreen; w jej dorzeczu znajdują się

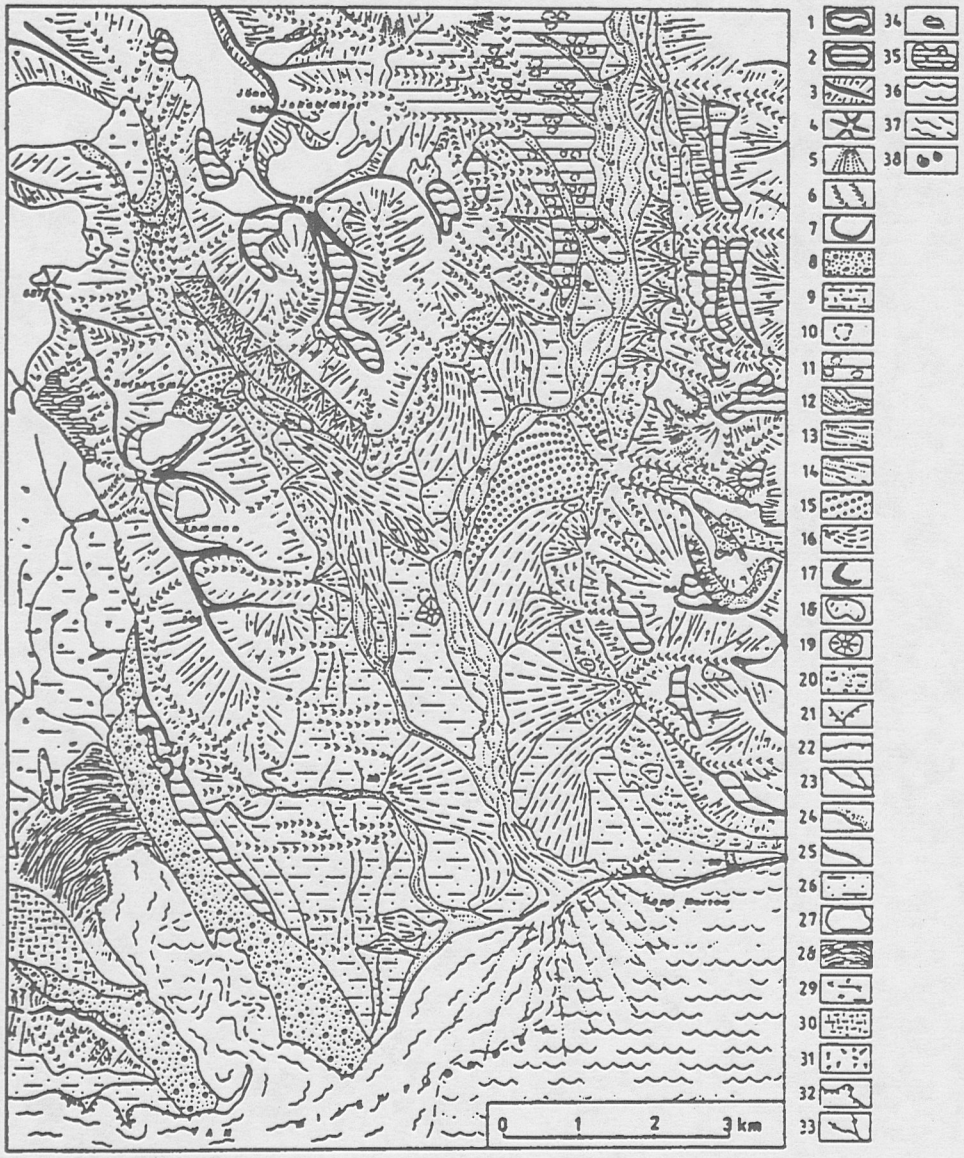

Fig. 1. Geomorphological Map of Berzeliusdalen surroundings (Western Spitsbergen)
Denudational landforms. 1 — fragments of planation surfaces, 2 — structure terraces, 3 — mountain ridges with the debris slope covers, 4 — peaks, 5 — talus cones. Fluvio-denudational landforms, 6 — v-shaped valley. Glacial landforms, 7 — glacial cirques, 8 — frontal, medial and lateral ice-cored moraine ridges, 9 — ground moraine on dead ice. Thermokarst landforms, 10 — pingo degraded basin, Fluvioglacial Landforms, 11 — fragments old bottom valleys with frost structure, 12 — river channel, 13 — deltas, 14 — outdeltas, 15 — outwash fans, 16 — alluvial cones, Landforms due to nivation and frost action, 17 — nival cirques, 18 — many years old snow banks, 19 — pingos, 20 — solifluction cover, Marine landforms, 21 — headland, 22 — cliff, 23 — edges of marine terraces, 24 — beaches, 25 — bay-bar, 26 — marine terraces with the storm ridges. Surface features of névé and glaciers, 27 — snow cover on the glaciers, 28 — glaciers crevasses, 29 — hydrated snow cover on the glaciers, 30 — glaciers, 31 — rock glacier, 32 — ice cliff, 33 — supraglacial rivers, 34 — supraglacial lakes, Additional signs, 35 — frozen lake, 36 — fiord, 37 — turbidity currents, 38 — mollusc shells.

ponadto lodowce dolinne, szreniowe i karowe. Dno doliny leży w poziomie 0-200 m n.p.m. Założona ona jest na zachodnim obrzeżeniu trzeciorzędowej niecki tektonicznej zajmującej centralną część Spitsbergenu Zachodniego. Utwory mezozoiczne — mułowce i piaskowce triasu w kierunku wschodnim przechodzą w ciemnoszare i czarne łupki z przewarstwieniami szarych mułowców jury oraz łupki, mułowce i piaskowce kredy. Serie trzeciorzędowe reprezentują jasnoszare i zielonoszare piaskowce, czarne łupki, lokalnie z cienkimi wkładkami węgla kamiennego oraz żelaziaki ilaste. Osady czwartorzędowew tej części archipelagu wykształcone są w postaci utworów glacjalnych, glacjofluwialnych, morskich, glacjalno-morskich i zboczowych. W obrębie Berzeliusdalen zaznaczają się co najmniej dwa różne wiekowo systemy poziomów morskich:

— holoceński 8-10 m npm, 36-39 m npm, 45 m npm, 55 m npm

— plejstoceński 80 m npm, 91 m npm, 117 m npm, 152 m npm, 187 m npm, 200 m npm, 216 m npm, 247 m npm.

Na wielu z nich znaleziono otoczaki morskie skał krystalicznych. Stopień zwietrzenia otoczaków wzrasta wraz ze wzrostem wysokości na jakiej występują. Dno Berzeliusdalen wyścielają rozległe systemy stożków napływowych, akumulowanych przez potoki z dolin bocznych. Górna część Berzeliusdalen pełni funkcje tranzytowe dla rumowiska, które zrzucane jest u jej ujścia. W obrębie zachowanego tu tarasu morskiego powstały pagórki pingo.

Dotychczas na omawianym obszarze nie natrafiono na plejstoceńskie moreny czołowe, chociaż w bezpośrednim sąsiedztwie są one dobrze wykształcone.

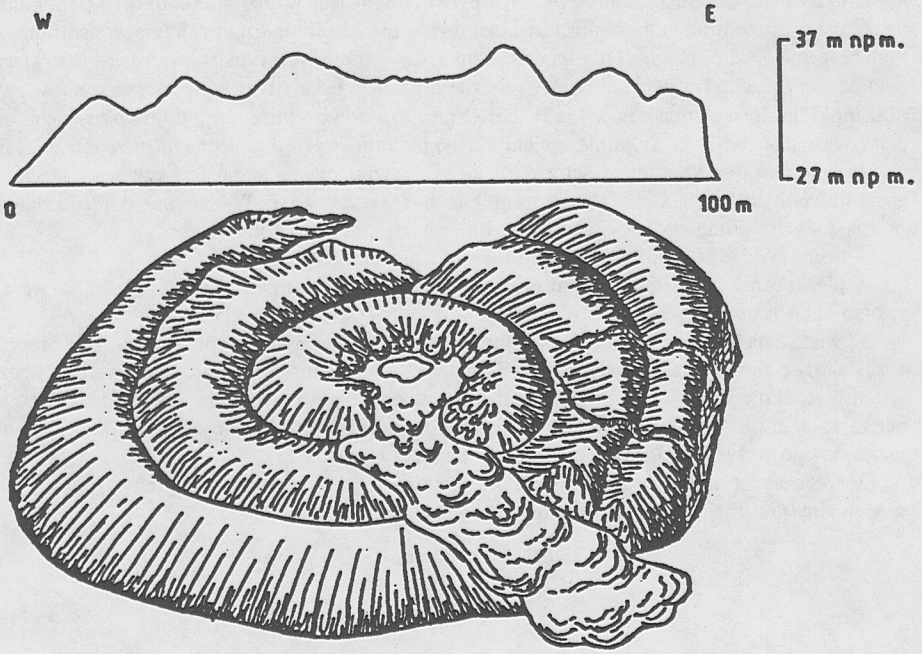

Fig. 2. Pingo. General view and section.