Recent and present-day glaciological and geomorphological processes at Hornsund – Leader Piotr Głowacki

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The Station

The Station was founded in July 1957 by members of the Expedition of the Polish Academy of Sciences working under the auspices of the International Geophysical Year 1957–1958. The expedition was led by Stanisław Siedlecki, a well – known Polish polar scientist and explorer who had earlier taken part in a 1932 – 1933 winter expedition to Bjornaya organized as part of the Second International Polar Year.

The Polish Polar Station is situated on the Isbjornhamna in the Hornsund Fiord on Wedel Jarlsberg Land (Fig. 1) which comprises the southern part of West Spitsbergen. The geographical coordinates at the main building are 77° 00' 04"N and 15° 33' 37"E. The Station stands on a terrace rising 9 m a.s.l. The Polish Polar Station Hornsund is part of the Institute of Geophysics, Polish Academy of Sciences. Direct scientific and logistic management is made by the Polar and Marine Department of the Institute. The station is supported by the Ministry of Scientific Research and High School Education.

The vast expanse surrounding the Station – Torell Land and Wedel Jarlsberg Land – has been studied by Polish expeditions since 1934. The Poles were the first to prepare topographical maps of this region. Polish names of mountains and glaciers are officially recognized in Spitsbergen.

Fig. 1. Polish Polar Station at Hornsund during summer time (photo Archive IGF)

In the early period, research teams residing at the Station conducted the following types of observations: meteorological (the data obtained were used in climatology and in weather forecasts and was transmitted several times daily to the world network); all sky – camera (which included the observation of the ionosphere and aurora polaris); astronomical; actinometrical; glaciological and the study of permafrost; the scanning of radioactive fall – out and of CO_2 content in free atmosphere; and in the summer time geological and geomorphological.

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Fig. 2. Polish Polar Station at Hornsund, April 25, 2007 (photo A. Nawrot)

These studies were part of a global cooperative effort initiated during the International Geophysical Year 1957 – 1958. It was then that the first yearlong research program was carried out, with 10 scientists and technicians, led by Siedlecki, wintering at the Station. In the next twenty years, the Station was used by a summer expeditions sponsored by Polish Universities and the Polish Academy of Sciences. In 1978, the Presidium Committee of the PAS decided to have the Station modernized and enlarged to make it suitable for use in winter again.

The Polish Polar Station Hornsund (Fig. 2) is situated in the centre of Spitsbergen Archipelago, at the junction of Asiatic and American Arctic. This location is very suitable for geophysical investigations. It is ideal for studying lithospheric structure as well as the physical processes in the atmosphere and extraterrestrial space. The glaciers placed nearby the Station are an excellent research polygon for determining the intraglacial physical processes. Seismological recording is the basis for the study of Arctic seismicity and glacial seismic events. The location of Spitsbergen is optimal for studying physical processes in the region of aurora and polar cusp. Measurements of geomagnetic field components together with those of atmospheric electricity elements, ionospheric absorption, and observations of aurora provide information on the processes occurring in the magnetosphere and ionosphere under the influence of solar wind. Another important problem studied there is the determination of factors affecting the solar radiation inflow to the Earth's surface in Arctic. Many programs performed at the Station concern the physical parameters investigated in the framework of the International Global Change Program.

The research is done in the following main directions:

- Geophysical investigations, including:
  - geomagnetic field;
  - seismicity of the Arctic Sea basin;
  - atmospheric electricity;
  - optics of the atmosphere;
  - ionospheric events in the "Polar cusp" region.

  Environmental research:
  - mass balance of glaciers (Fig. 3);
  - long-range transport of pollutants from Europe to the Arctic;
  - local and regional evolution of the environment;
  - geomorphological investigations;
  - biological research.
- Transmission of data to international data centres:
  - IMAGE – International Monitoring for Aurora Geomagnetic Effects;
  - INTERMAGNET – International Real-time Magnetic Observatory Network;
  - WMGS – World Glacial Monitoring Service;
  - WMO – World Meteorological Organization.

Since 1978, there have been some small changes in the scientific programs conducted at the Station and the research has always been carried out in strict compliance with the international standards. The main areas of research interest are as follows:

- Meteorology – gathering data for synoptic purposes and to detect climatic changes (Fig. 4);

Fig. 3. Change of frontal zone of Hansbreen between 1957 and 2003 (photo Archive IGF)

- Seismology – monitoring of world earthquakes, measuring the seismicity of the Spitsbergen Archipelago region, and registering tremors linked to the dynamics of the Hans Glacier;
- Magnetism – registering changes in the XYZ components of the earth's magnetic field;
- Ionosphere sounding to determine the structure of the ionosphere;
- Glaciology – photogrammetric measurements of the head of the Hans Glacier and its dynamic (Fig. 5);
- Permafrost – studding the dynamics of attendant processes;
- Atmospheric electricity – determining the magnitude of the electric field and registering its vertical component;
- Regular environmental monitoring – automatic registering of selected climatic features and conducting analyses of chemical buildup air and water pollution and the isotopic content of the snowcap.
- Geomorphology – investigations are conducted by numerous scientific teams from different universities and countries:
  - morphogenesis of marginal zones for retreating both land based and tidewater glaciers (Fig. 6);
  - processes of mechanical and chemical denudation;
  - contemporary morphogenetic processes on paraglacial areas.

Some of the information's obtained are then regularly forwarded to international Data Centers. The other results are returned to Poland where they are processed and published in national and international journals or in the form of annuals or special issues. In the summer, the Station serves as the base for special programs in earth sciences, biology, ecology and oceanography. The studies are carried out by a number of university research centers as well as by the Polish Academy of Sciences.

In its present state, the Polish Polar Station at Hornsund is a modern, conveniently equipped complex. The Station consists of the main building, the building of the power station, three separate scientific cabins, the store-house for marine equipment for local boat transport.

Scientists will have the access to:

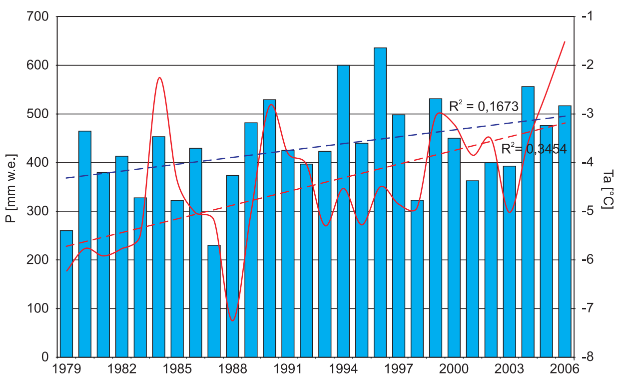


Fig. 4. Course of annual precipitation (P) and air temperature (Ta) in Polish Polar Station at Hornsund

Fig. 5. Frontal zone of Hansbreen, April 3, 2007 (photo A. Nawrot)

Fig. 6. Front of Hansbreen, May 3, 2007 (photo A. Nawrot)

- 13 single bedrooms (for round-year use),
- 7 larger bedrooms (for spring-summer season) – 30 places,
- 8 laboratories,
- a kitchen, a dining-room, bathrooms facilities with running hot and cold water, toilets, a medical room and a storage rooms with freezers, workshop,
- two tractors (one suitable for excavating and bulldozing), a mobile crane, trailers, six snow scooters and two large rubber boats Zodiacs (Fig. 7) with Yamaha 30 engines, two caterpillar amphibians (capable of carrying up to 4 tons each) internet connection.

The Station is provided with electricity 230/400 V, three satellite-communication systems (Iridium, Inmarsat-B). In 1978 the Station acquired a new sewage-treatment plant which can process up to 5 cubic meters of sewage per day. In the summer, the nearby lakes serve as the source of drinking water; in winter the water is obtained by means of melting snow. The Station is serviced by ships specially chartered out during summer (Fig. 8). The Station has the necessary equipment for land-based rescue work. In January 1990, by decision of the Royal Norwegian Mail the Polish Polar Station became a „postal point", and ever since has become an attraction for philatelists from all over the world.

More important instruments working at the Station:
- Automatic weather station Vaisala QLC50
- Torsion photoelectric magnetometer PSM–8911-08, LEMI-004P/96 fluxgate magnetometer, digital logger DR-02, analog recording system PSM/R–8111, proton magnetometer PMP–5–115, fluxgate magnetometer declinometer/inclinometer
- Ionic Chromatograph Compact IC–716, Methrom
- Laser total station TCR–1105, Leica
- Seismological station MK–6
- Ionosonde
- Multifunction Computer Meters CX–742, Elmetron
- Sunphotometer Cimel CE 318
- GPS permanent station Leica GRX 1200 and Leica GX 1230

The Station cooperates with 25 scientific institutions in Poland and 35 institutions from other countries. From 2002 it is one of six flagship sites for biodiversity of Europe.

The Station is open for students from various universities, to collect materials for master's and PhD dissertations and professional training. Courses in connection with the EUROPOLAR ERA-NET project and field workshops for glaciology, geomorphology, geology and biology are also planned.

Our research activity in Spitsbergen is made possible by the Treaty of Paris ratified by the various countries and major world powers in 1920. The Treaty proclaims Norwegian sovereignty in Spitsbergen and confirms the right of the signatories to conduct scientific research in that area. Poland joined the Treaty of Paris in 1931. Today however, Poland is the only non-arctic country to maintain a stationary research station in the Arctic region.

Fig. 8. Research ship SSB Horyzont (Maritime Academy in Gdynia, Poland) and front of Hansbreen in the background (photo Archive IGF)

Fig. 7. Transportation of research groups on boats (photo Archive IGF)

The active participation in studying the region effected in the invitation of Poland by the eight Arctic countries to take a part in the works of the International Arctic Sciences Committee – IASC. Since 1991 Poland has been a full member of this organization. IASC prepares and coordinates all major research programs in the Arctic.

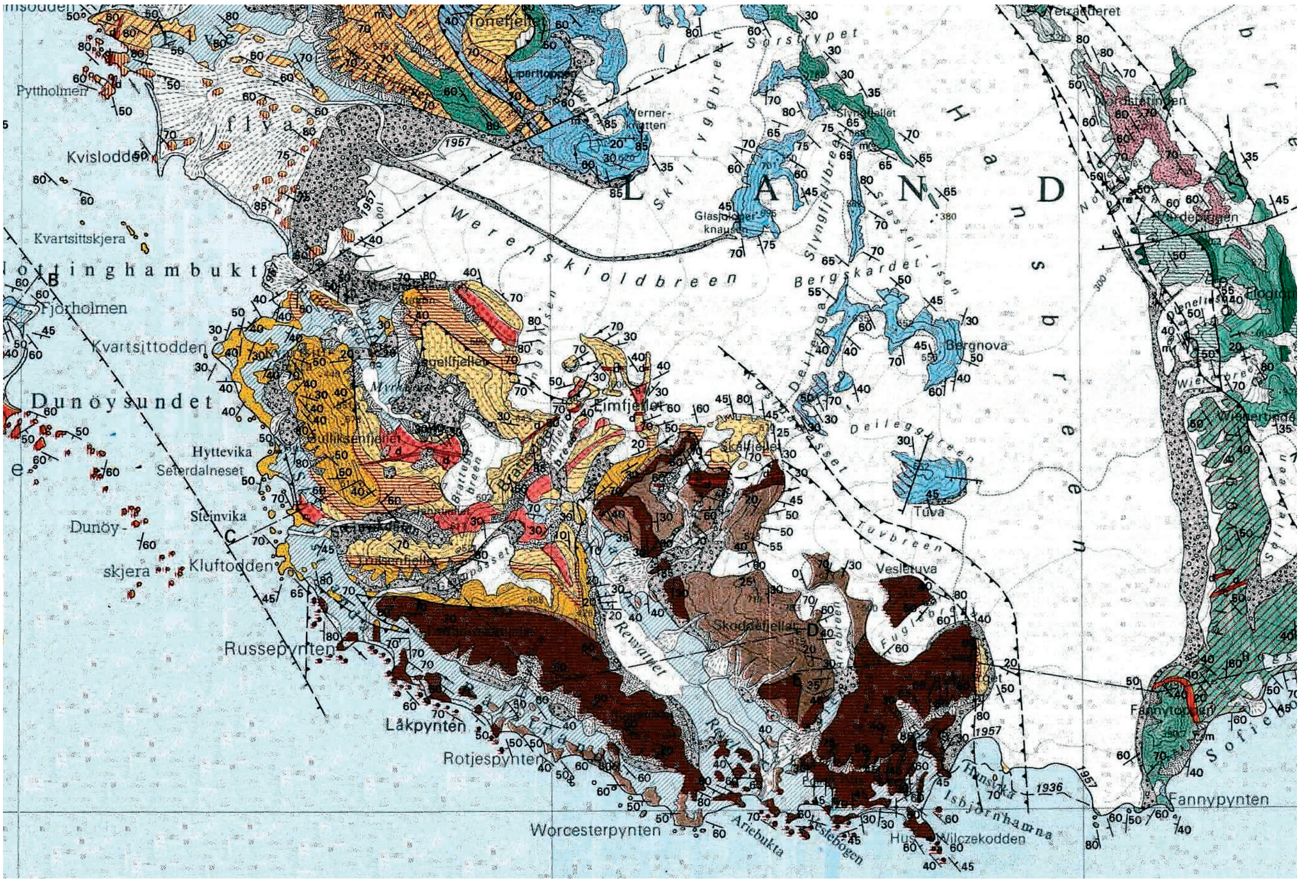
More information: http://hornsund.igf.edu.pl.

The excursion

Fluctuations of glaciers in Southern Spitsbergen are well documented in the past and currently studied. Glaciers were mapped first time by the Russian-Swedish expedition measuring arc of meridian in 1899–1901. Later maps were prepared by terrestrial and aerial photogrammetric survey (the Polish Expedition of 1934) and oblique aerial photos of 1936. There are also maps from German expedition 1938 and number of Polish expedition since the 3rd International Geophysical Year 1957/1958.

Significant recession of majority of glaciers in the vicinity of Hornsund is well visible. Mean annual retreat is in order of 25–50 m. There are also surging glaciers. Hansbreen are systematically observed thanks to permanent operation of the Polish Polar Station in Hornsund (since 1978).

This excursion will demonstrate marginal zones of retreating tidewater Hansbreen. Mass balance, velocity and calving intensity are regularly measured on glacier. Hydrothermal structure, including drainage system is studied by means of radar sounding and direct speleological exploration. During the excursion will be demonstrated glaciological (dynamics of calving glacier, mass balance) and environmental programmes (marginal zone) conducted by the Polish Polar Station, Hornsund – visit to the Station and research sites near and on Hansbreen.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Gulliksenfjellet
Trulsenfjellet
Skoddefjellet
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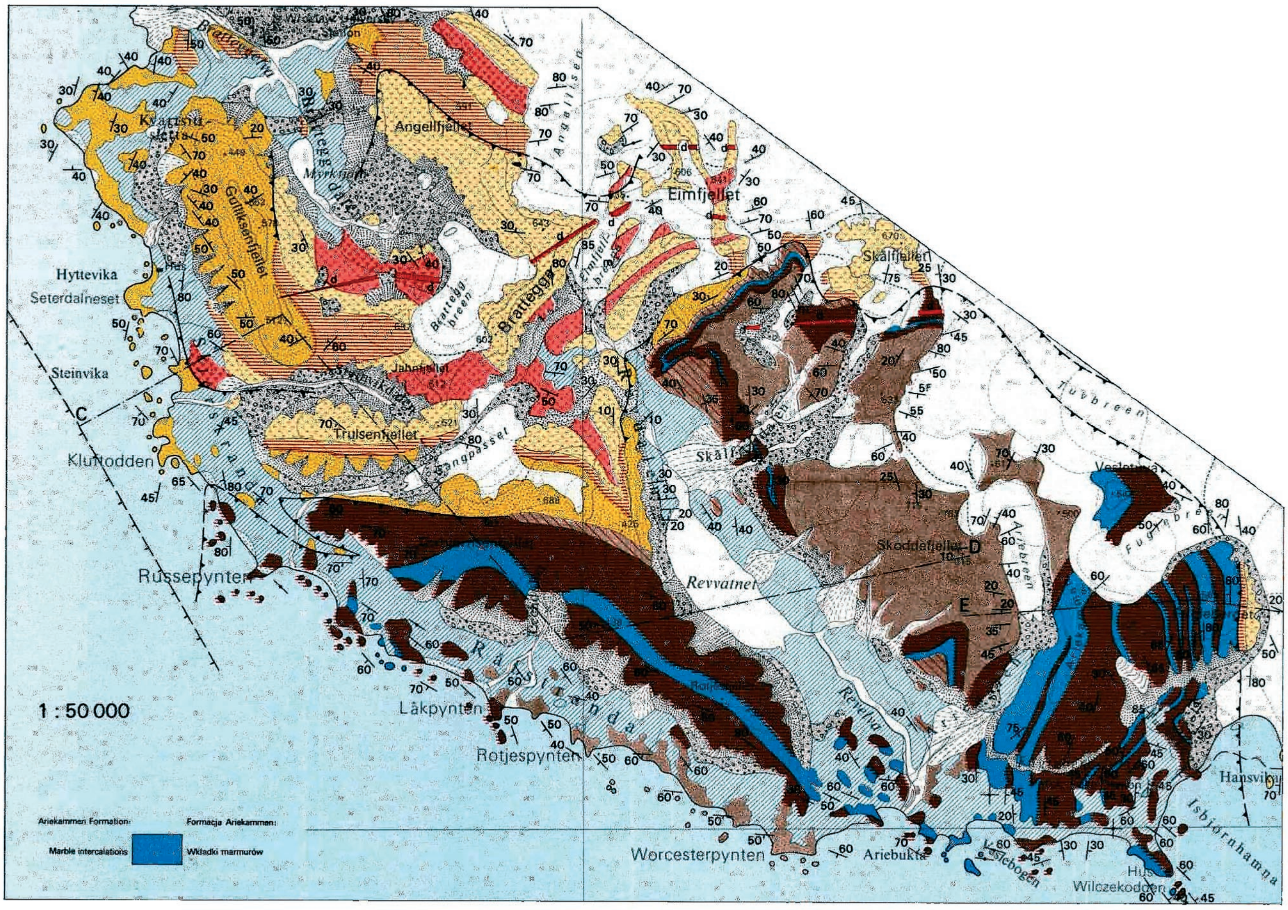
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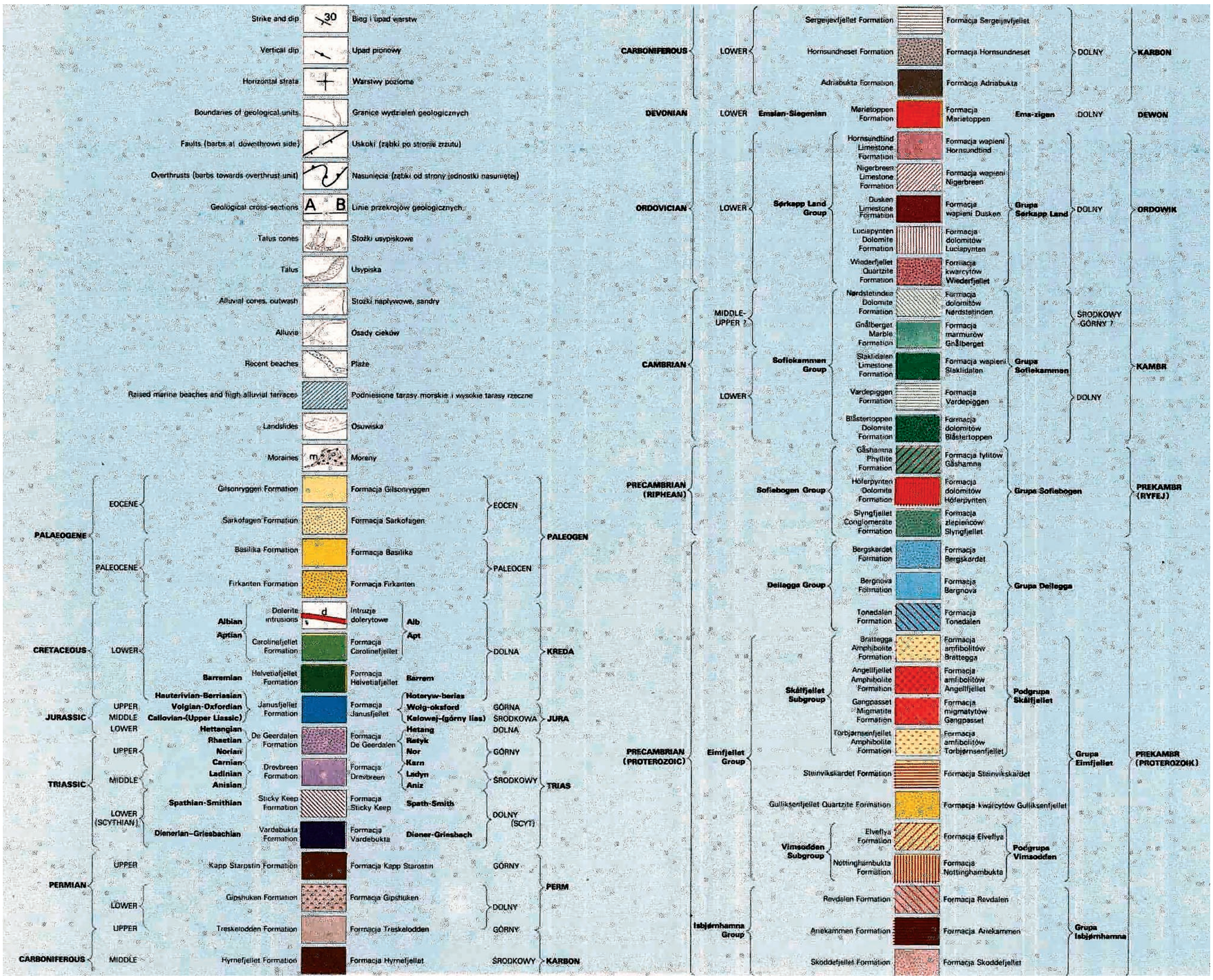
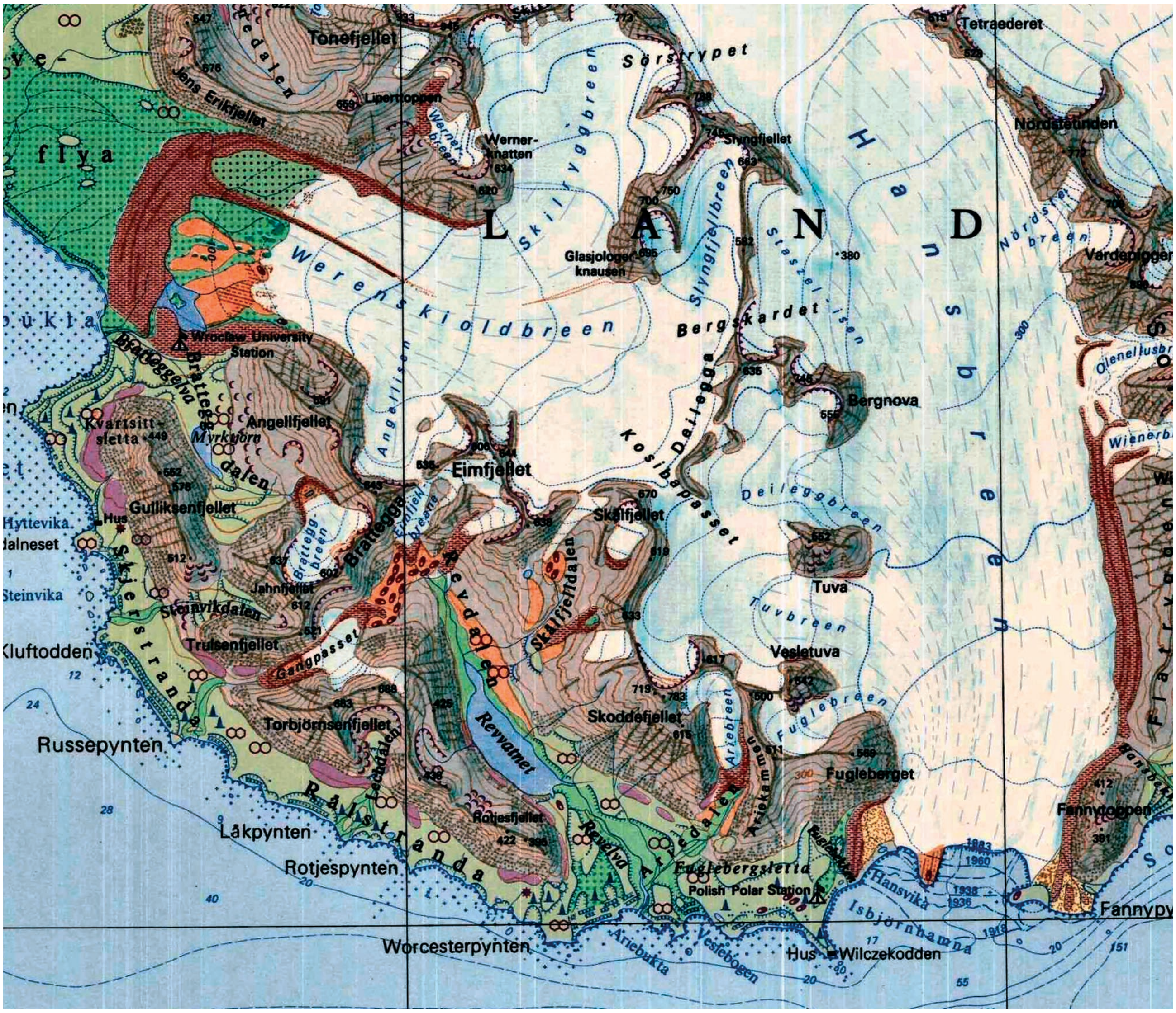


Fig. 9. Geological map of the northern part of Hornsund (Birkenmajer 1990)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Werenskioldbreen
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Wroclaw University
Station
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Angellfjellet
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Rotjesfjellet
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Fuglebergsletta
Polish Polar Station
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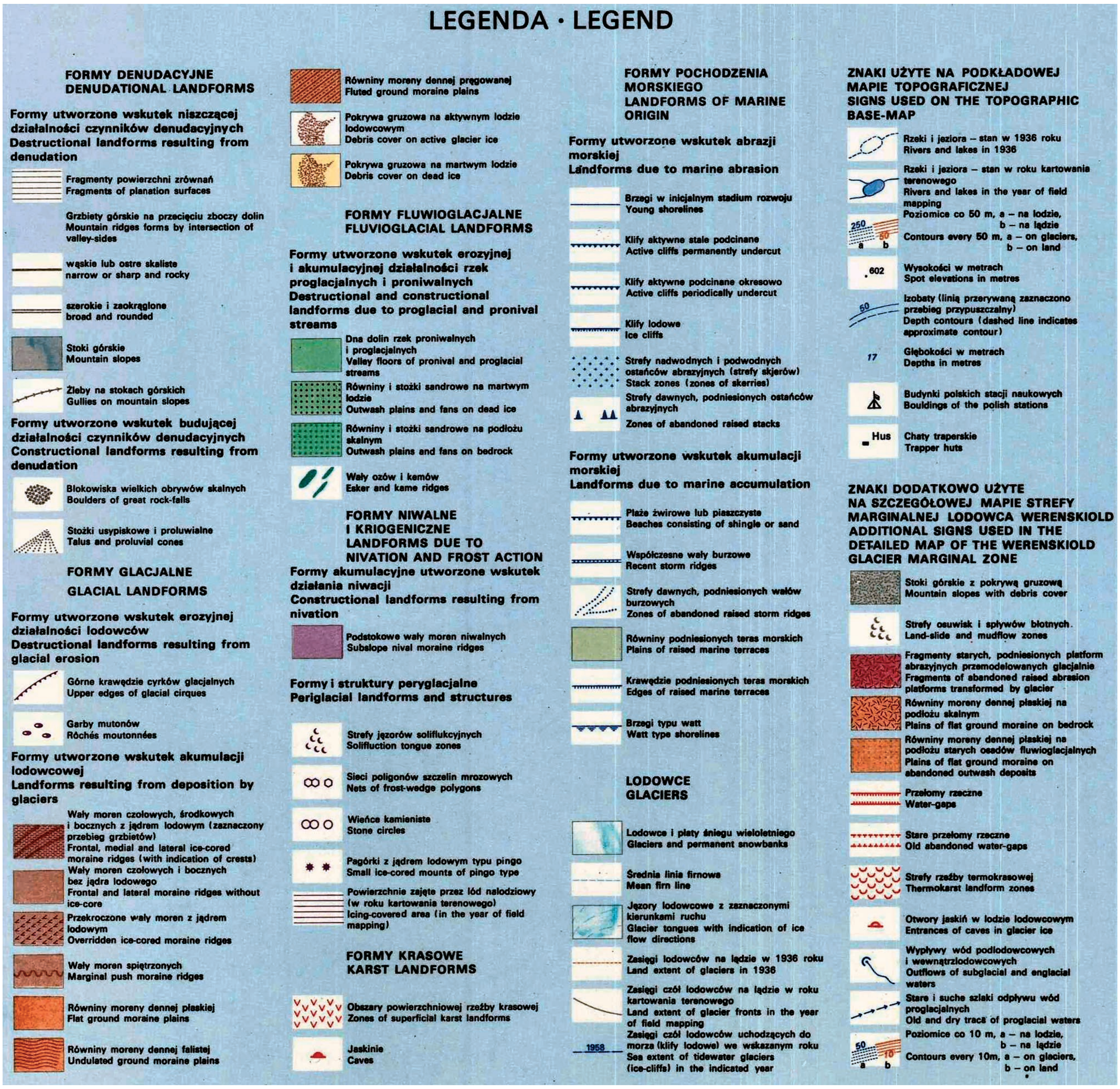

Fig. 10. Geomorphological map of the northern part of Hornsund (Karczewski 1984)

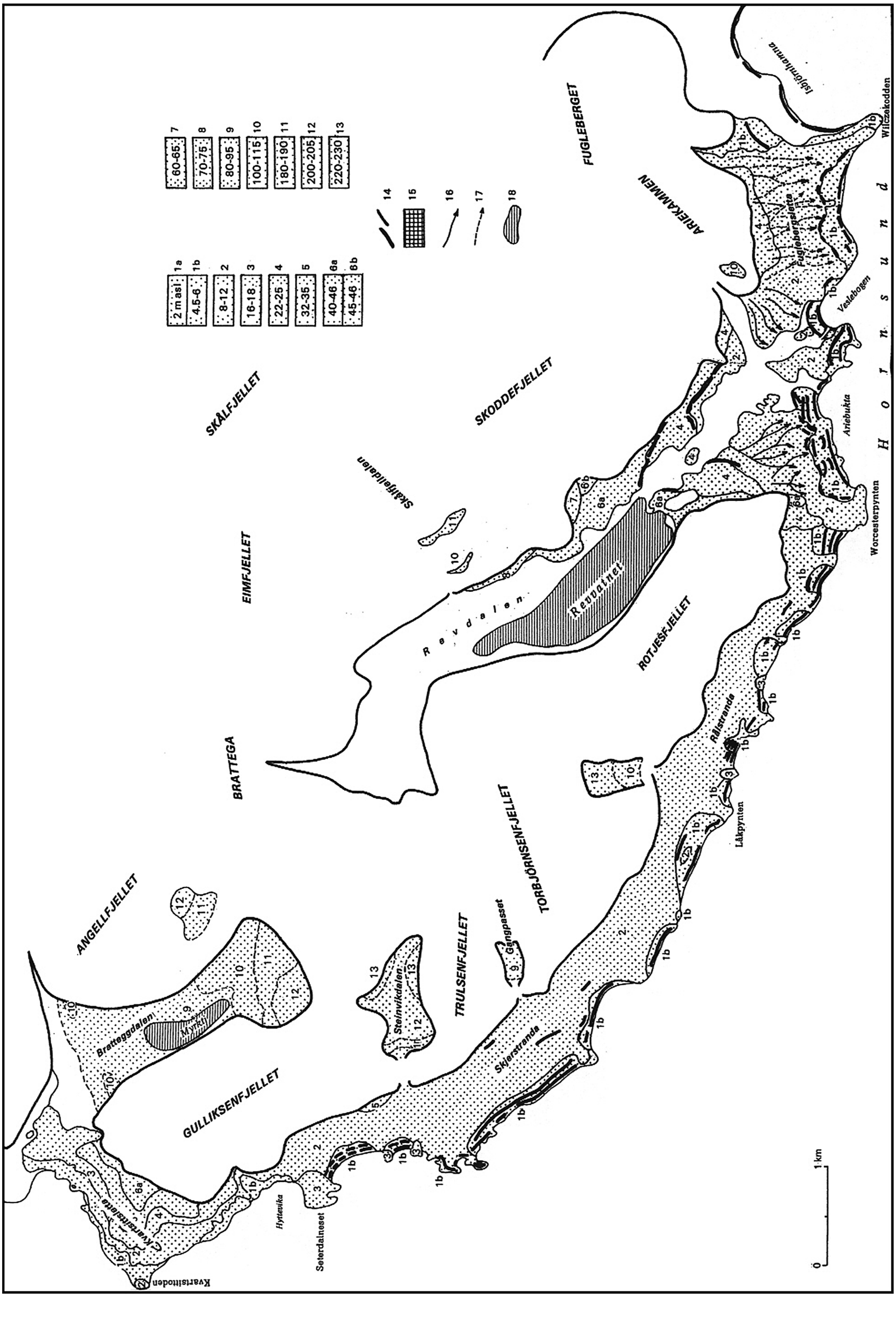

Fig. 11. Raised marine terraces of northern part of Hornsund (Karczewski et al. 1979)
1–13 – levels of raised marine terraces, 14 – front ice-moraine ridges, 15 – storm bank, 16 – channels of melt-out waters, 17 – channels of pronival waters, 18 – lakes

Fig. 12. Hydro-morphological scheme of Sofiekammen Ridge (Pulina 1977)
1 – mountain ridges and hypsometric spots (m a.s.l.), 2 – glaciers, 3 – moraine deposits, 4 – gullies, 5 – talus cones, 6 – debris deposits, 7 – surface with active solifluction, 8 – edges of valleys, 9 – rock gorge or river gap, 10 – edges of marine terraces: I – low terrace with marine gravel, a – narrow beach, b – limestone islands, II – middle terrace with numerous karstic micro- and macroforms, c – limestone cliff, III – high terrace covered by slope deposits, 11 – caves, 12 – surface streams, 13 – subsurface flows within ice and snow cover, a – ponor, b – outflow, 14 – supraglacial streams, 15 – lakes, 16 – karst spring "Orvin", 17 – other springs.

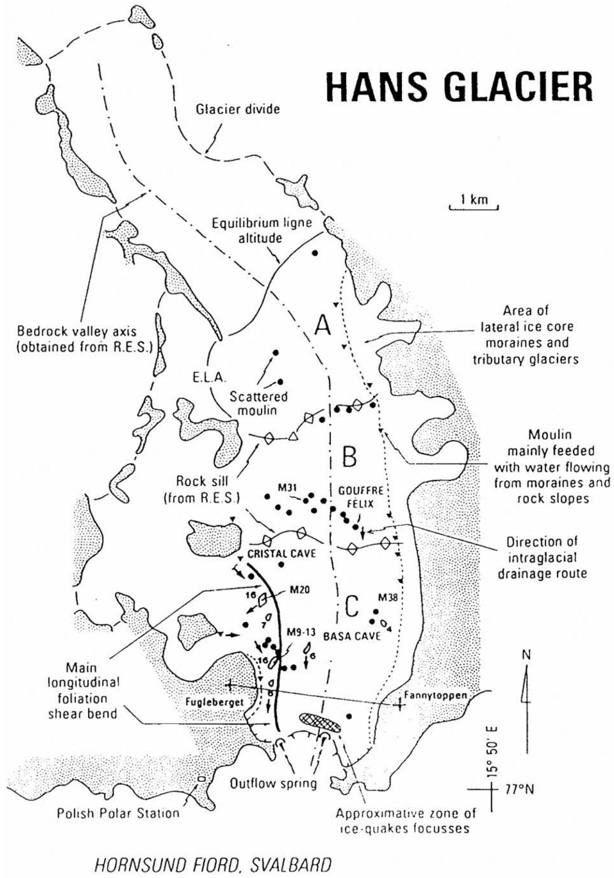

Fig. 13. Location of ice caves in Hansbreen (Schroeder 1995)

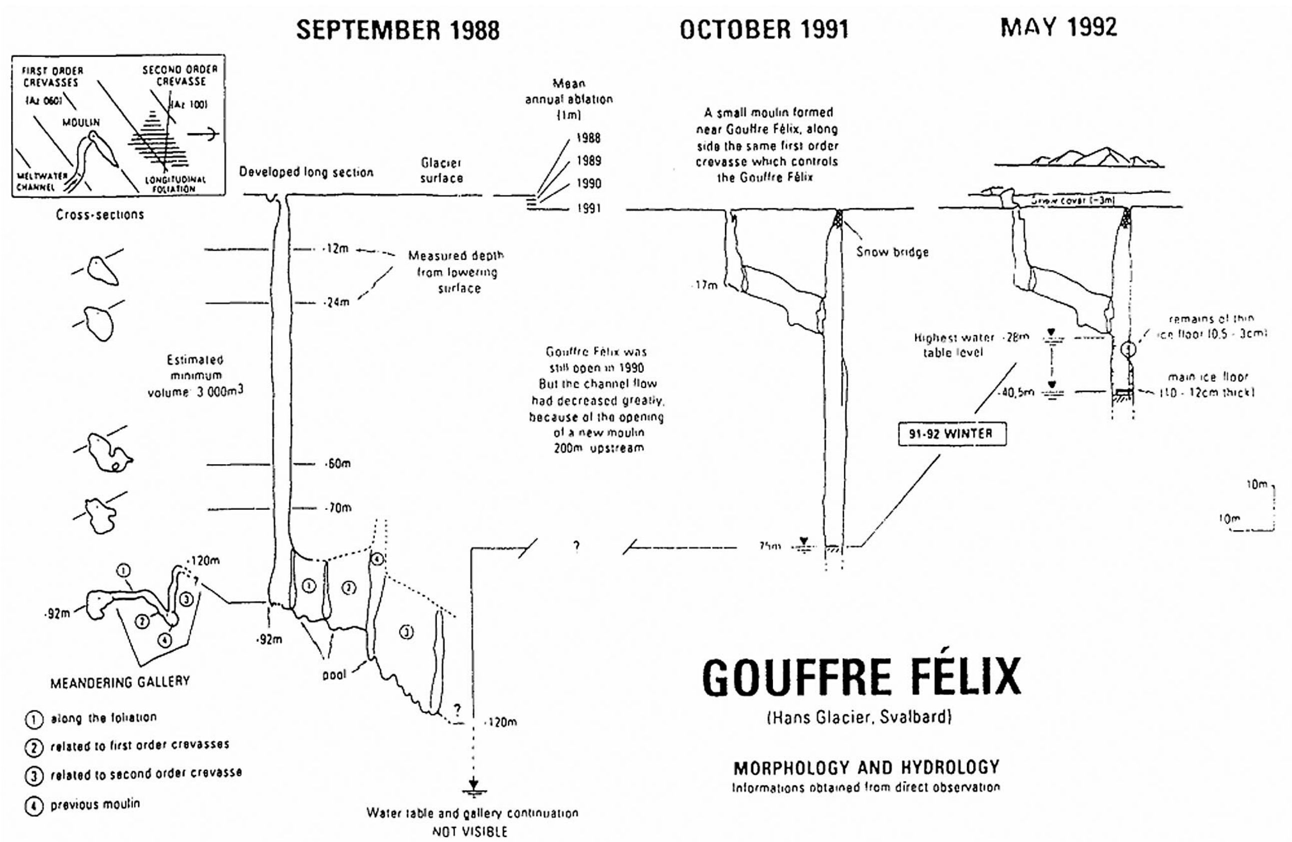

Fig. 14. Gouffre Felix in Hansbreen (Schroeder 1995)

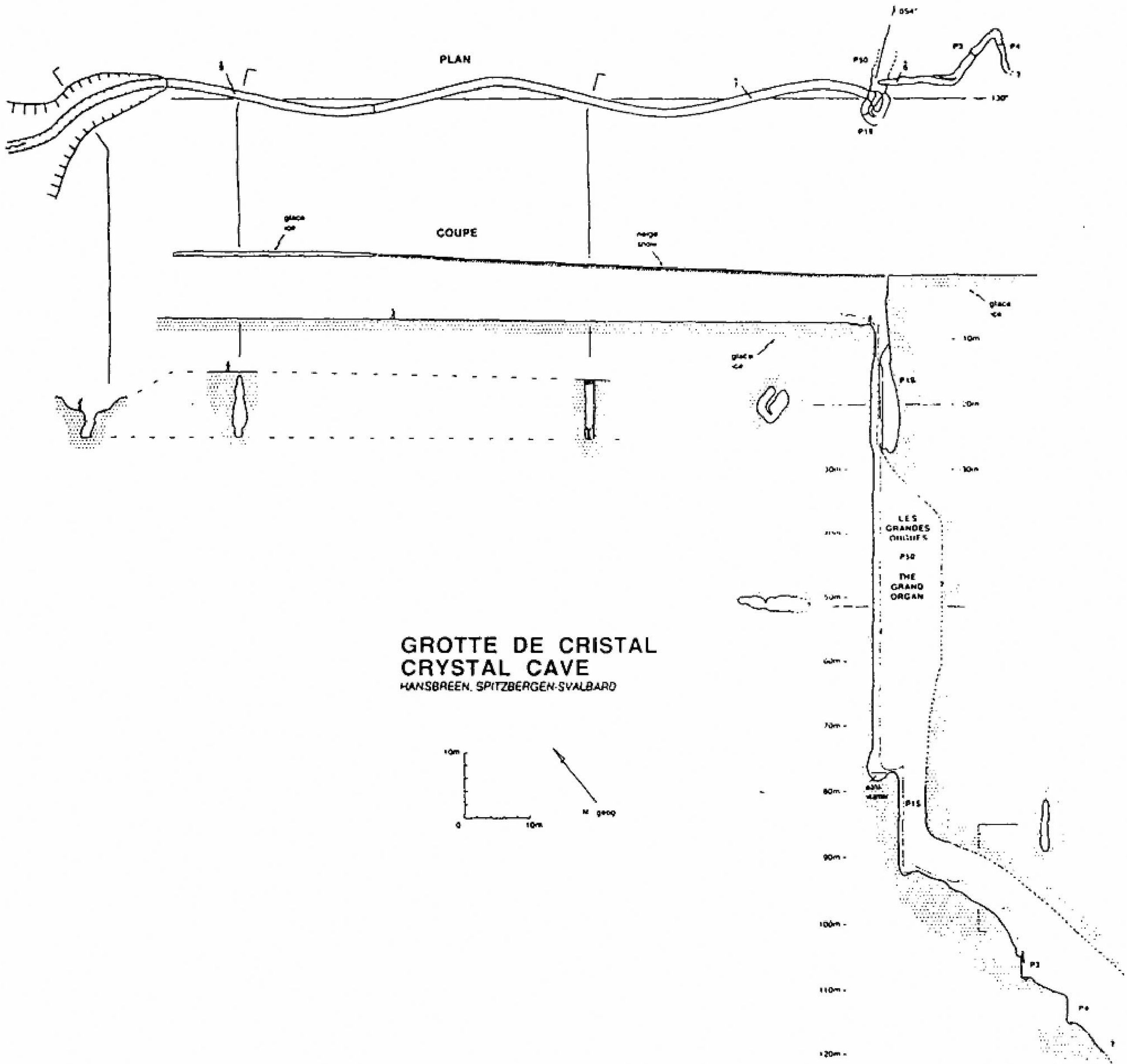

Fig. 15. Grotte de Cristal in Hansbreen (Schroeder 1995)

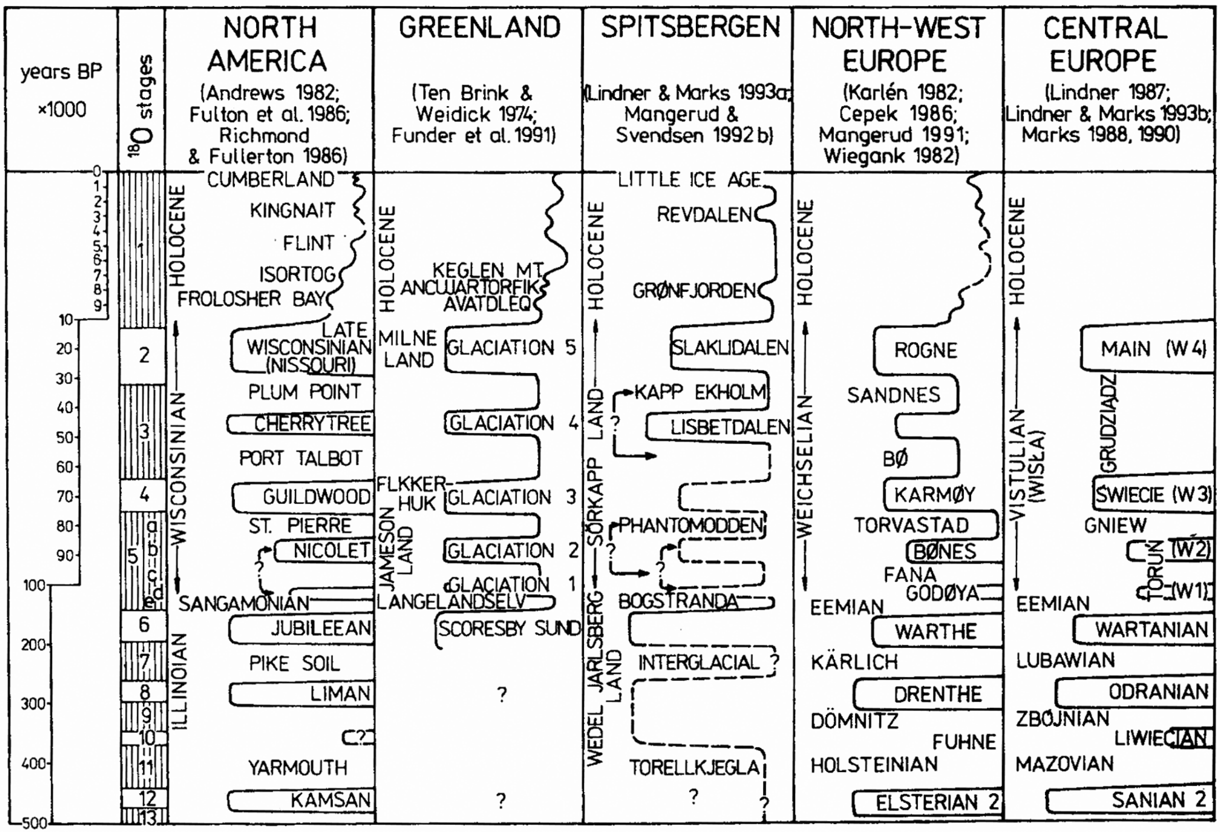

Fig. 16. Correlation of Quaternary stratigraphic schemes for Northern America, Greenland, Spitsbergen and Europe (Lindenr, Marks 1993)

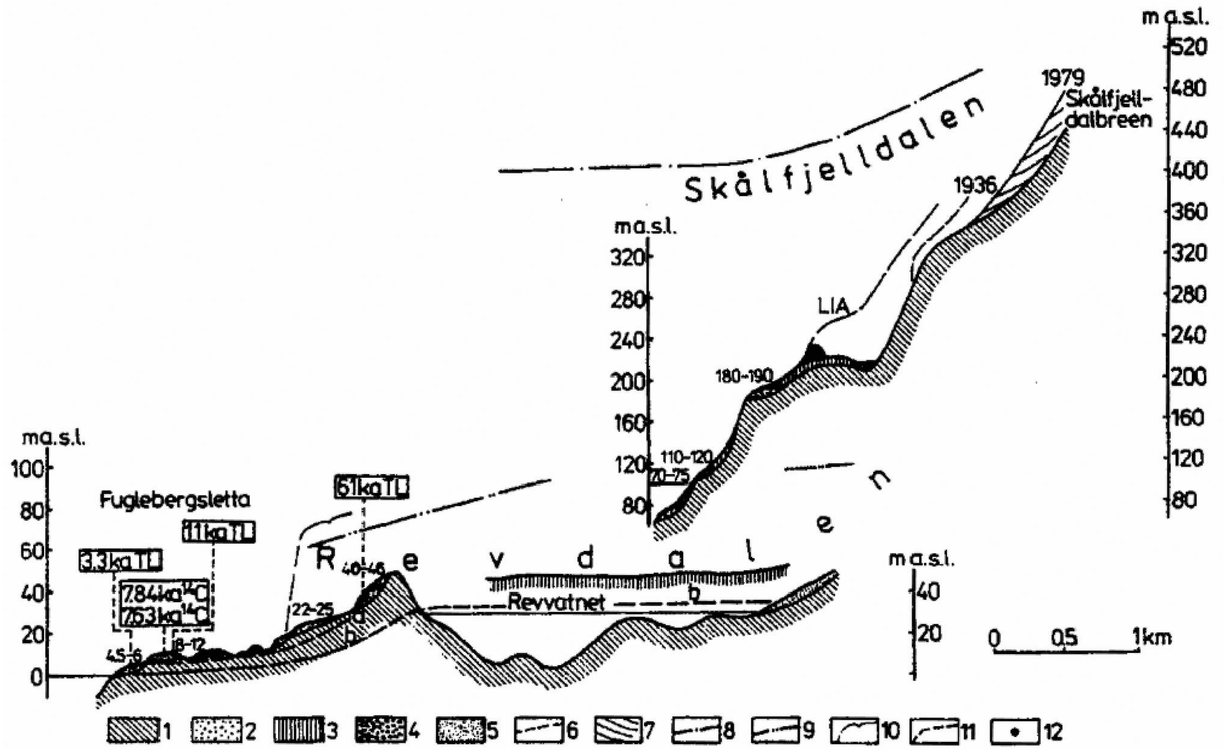

Fig. 17. Schematic geological cross-section through Revdalen and Fuglebergsletta (Lindner et al. 1984, corrected)
1 – bedrock, 2 – marine gravels (altitude of marine terraces in m a.s.l.), 3 – till, 4 – deposits of ice-moraine ridges, 5 – sand and gravel of outwash-plains, 6 – older (a) and younger (b) outwash-plain, 7 – glacier ice, 8 – old glacier fronts, 9 – young glacier fronts, 10 – the biggest range of glaciers in Holocene, 11 – range of glaciers during LIA (Little Ice Age), 12 – sampling sites for dating

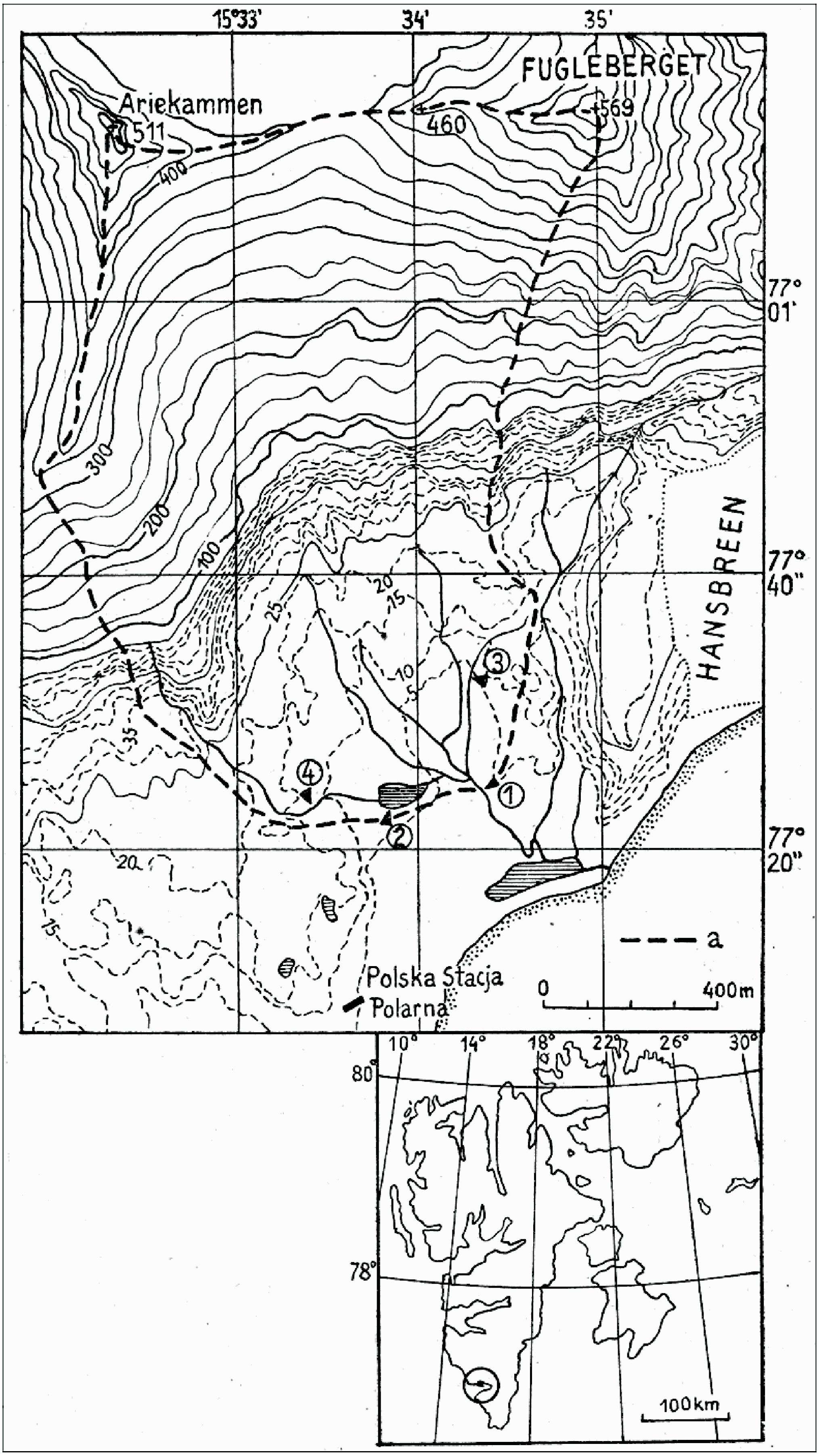

Fig. 18. Map of Fuglebekken catchment (Pulina 1986)
1, 2, 3 and 4 – hydrometric profiles.

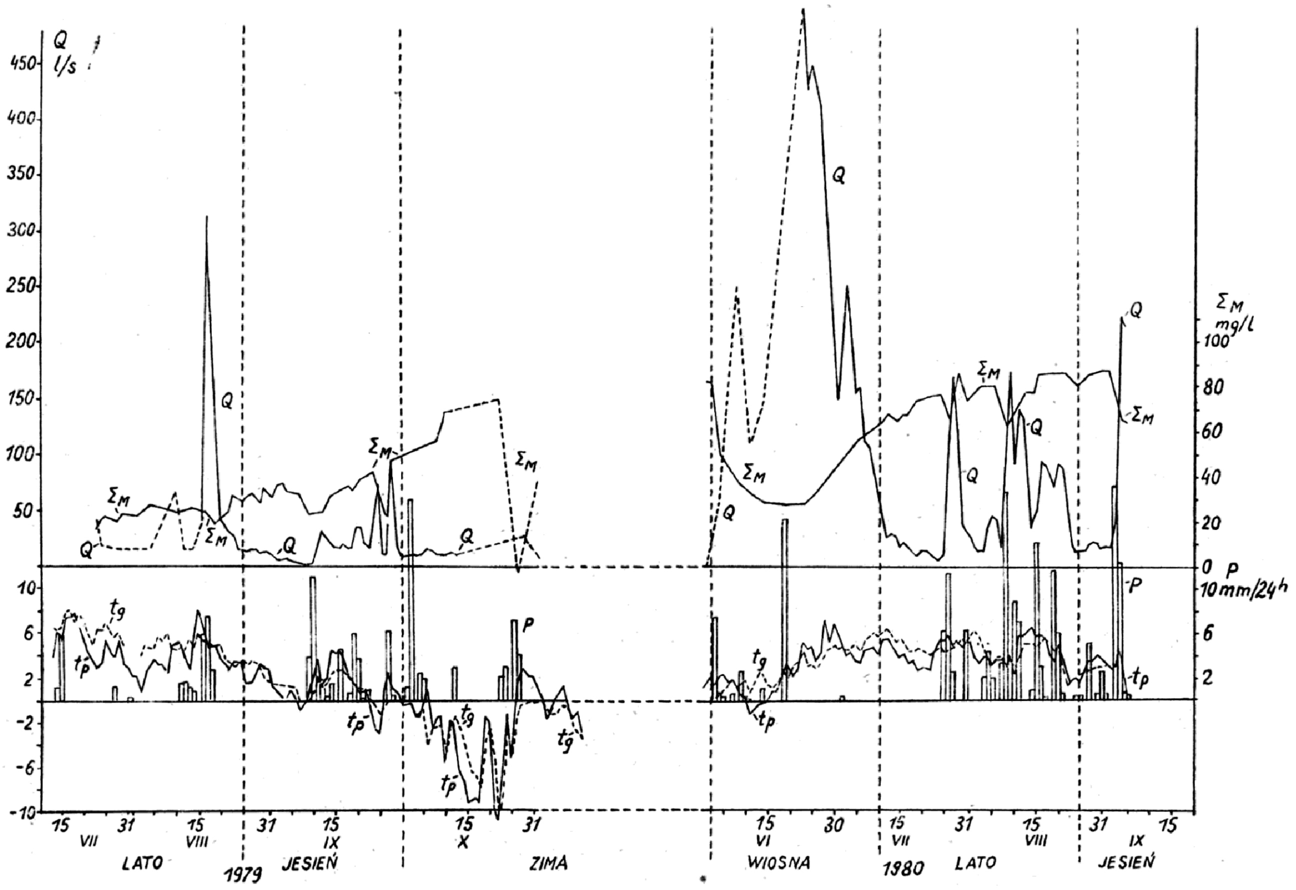

Fig. 19. Course of discharge (Q) in the background of physicochemical properties of stream water and meteorological elements within the Fuglebekken catchment during hydrological year 1979/80 (Pulina 1986)
tg – ground temperature at depth 5 cm, ÓM – total mineralization of stream water, P – precipitation, tp – air temperature.

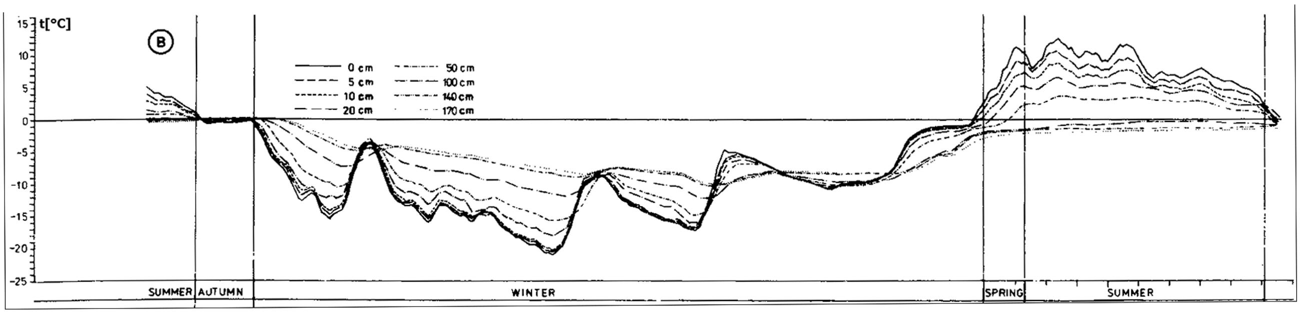

Fig. 20. Annual (1985/86) course of ground temperature at different depth in Fuglebekken catchment (Głowacki et al. 1990)

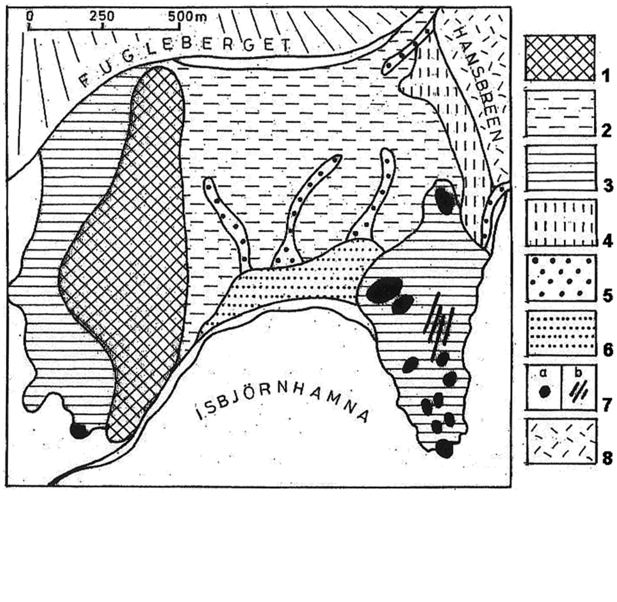

Fig. 21. Sedimentary covers of the south-west foreground of Hansbreen 1998 (Karczewski, Rachlewicz 2004)
1 – moraine cover of ice-moraine ridges, 2 – supraglacial moraine deposits on the dead ice, 3 – lodgement till on the bedrock, 4 – hydrated suprglacial covers on passive ice, 5 – fluvioglacial sand and gravel, 6 – marginal lake deposits of glacier waters, 7a – bedrock, 7b – fluted moraine, 8 – glacier.

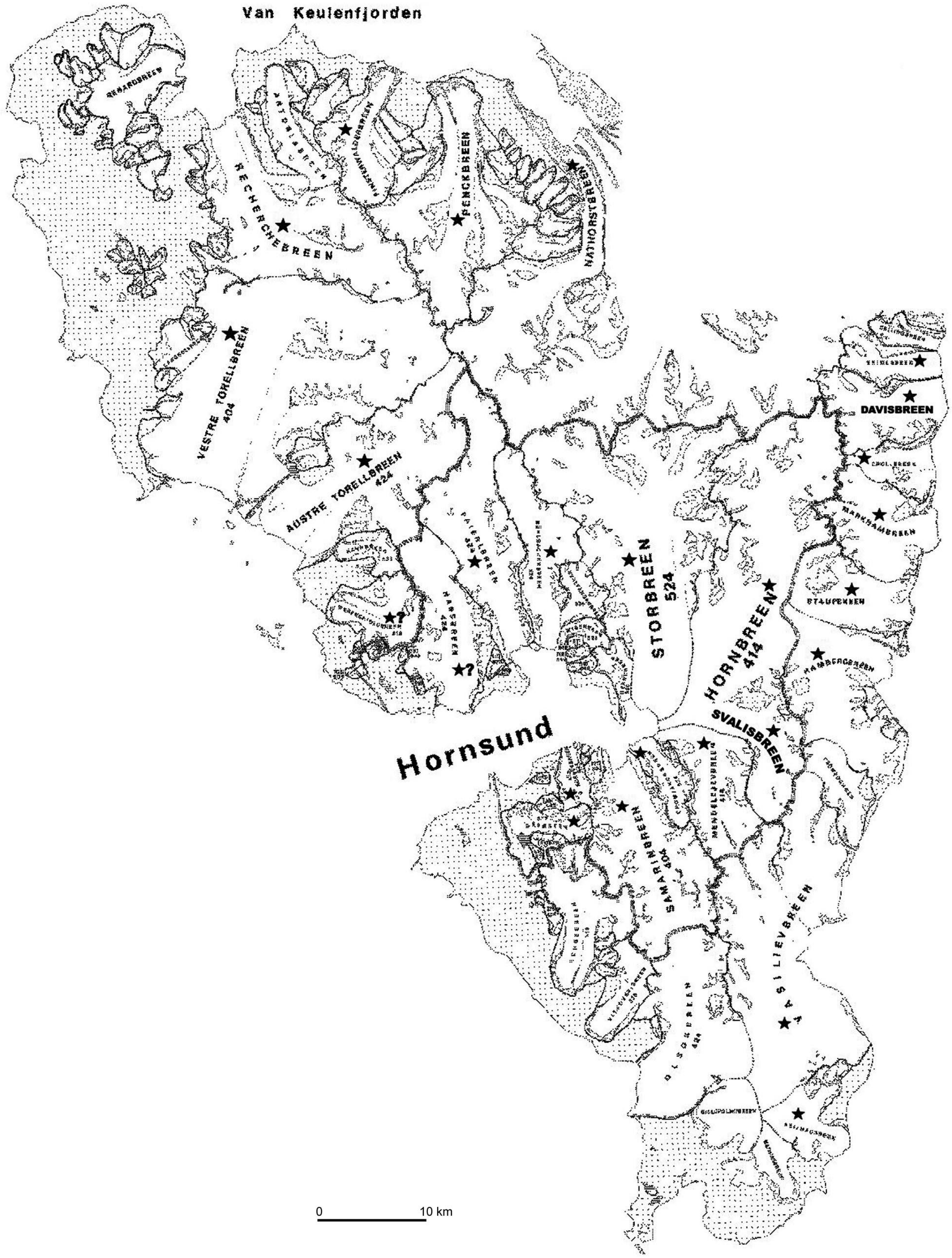

Fig. 22. Glaciers of ice basin Hornsund (J. Jania 2004)
Surge glaciers are marked by asterisk.

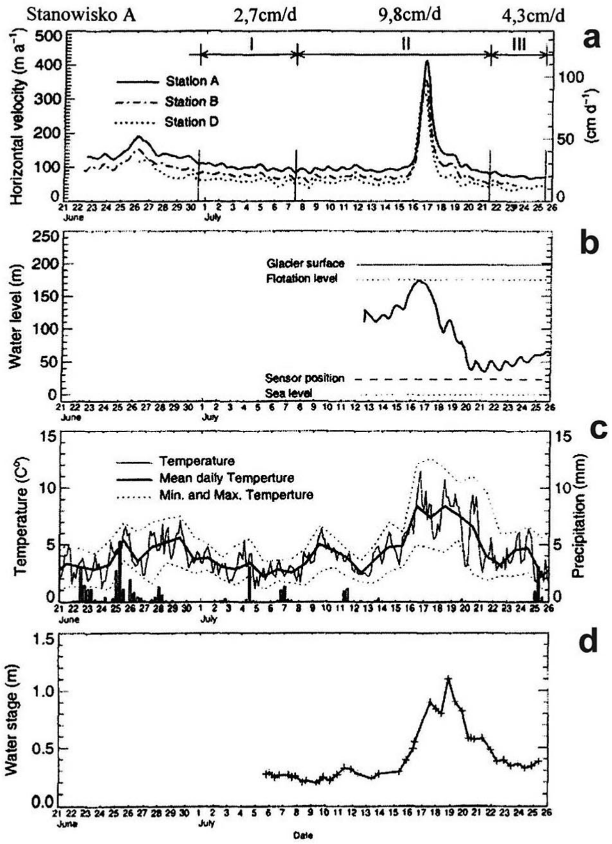

Fig. 23. Dynamics of Hansbreen movements during summer 1999 (Vieli et al. 2003)

a – horizontal velocity, I-III – periods of ablation, b – pressure in ice aven as a water level, c – air temperature and precipitation at Polish Polar Station, d – water level in glacial river of Werenskioldbreen

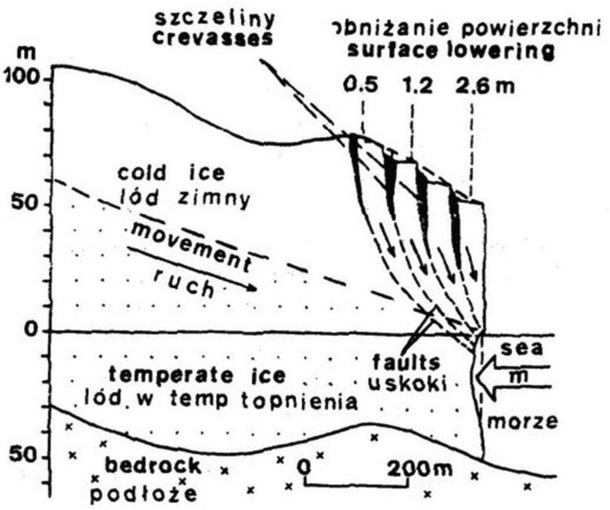

Fig. 24. Cross-section of glacier front, Hansbreen (Jania 1988)

Cross-section shows mechanism of calving in the form of glacial slips; m – subwater melting.

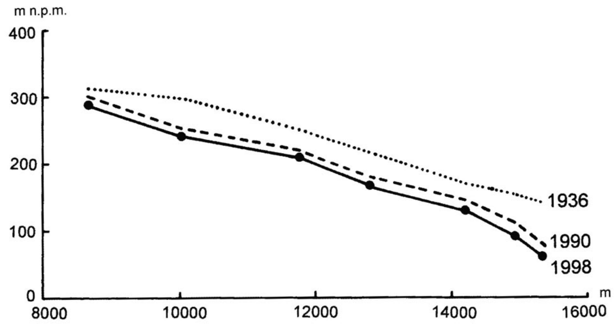

Fig. 25. Changes in thickness of Hansbreen along the ablation zone (Jania 2004)

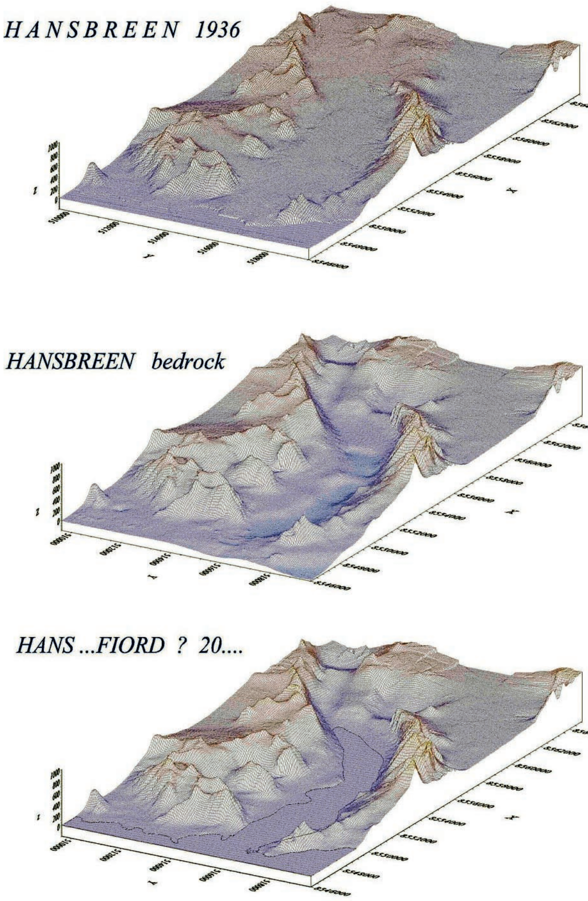

Fig. 26. DTM models of Hansbreen (Kolondra 1993)

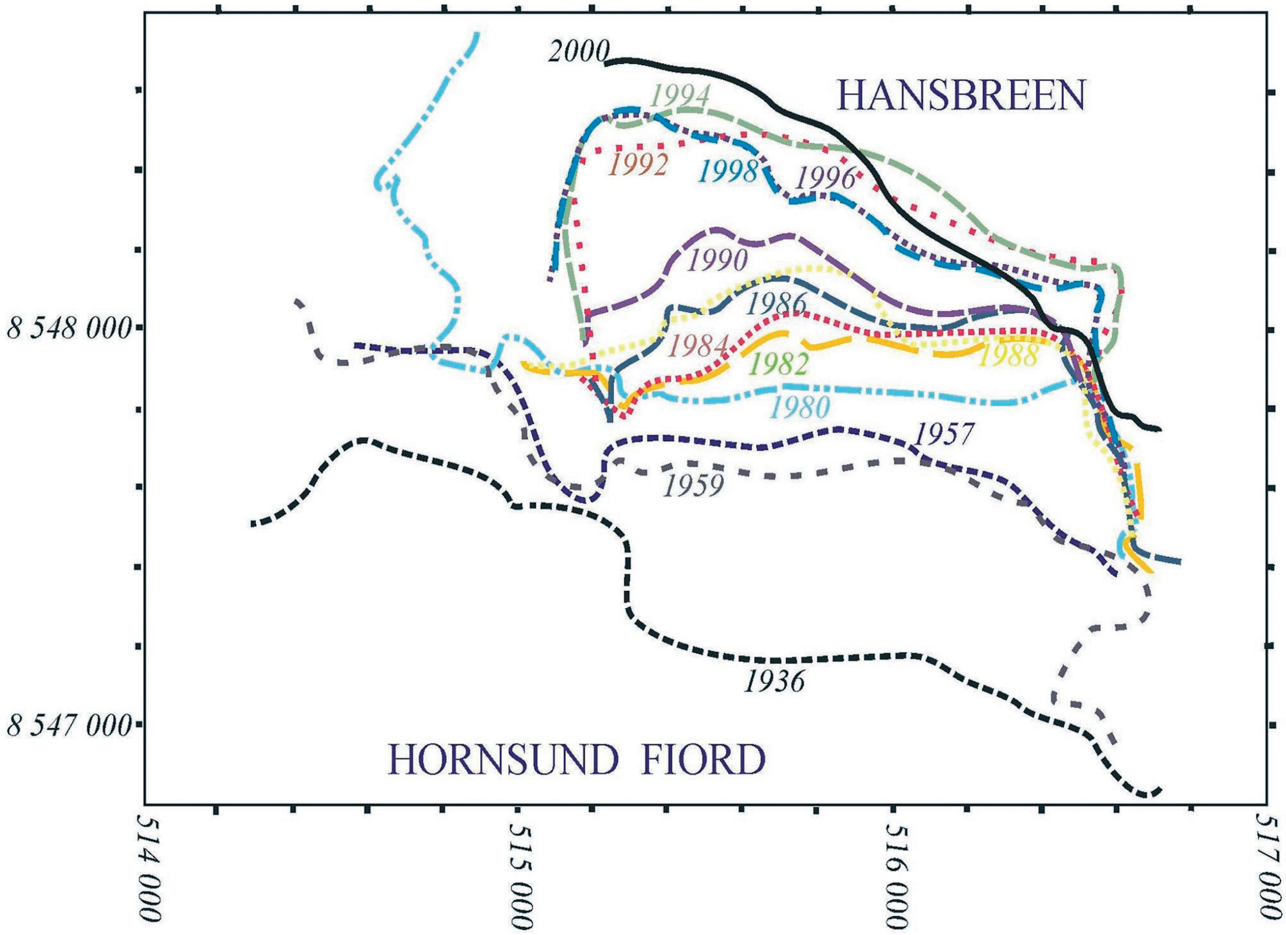

Fig. 27. Changes in front location for Hansbreen (Kolondra 1993)

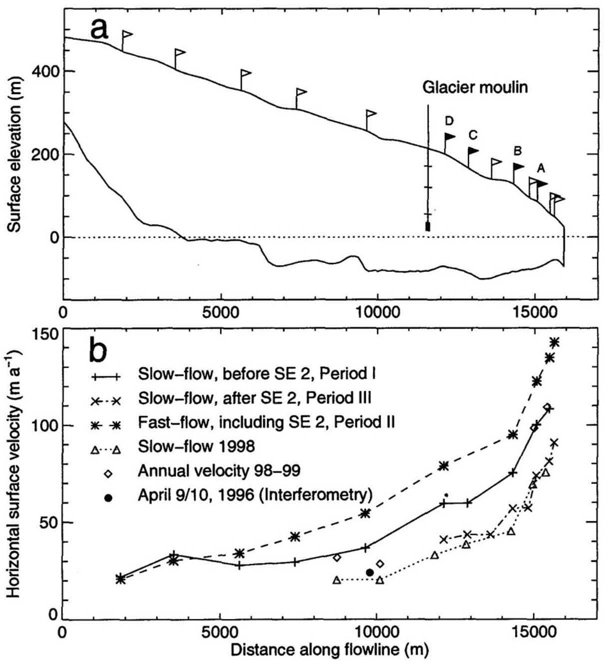

Fig. 28. Velocity of ice surface for Hansbreen (Vieli et al. 2003)

a – sampling sites in glacial avens, b – surface velocity of ice.

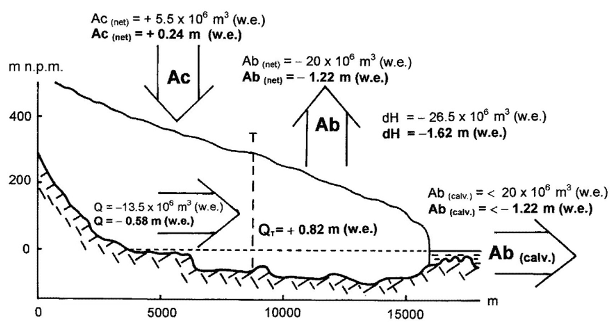

Fig. 29. Mass balance for Hansbreen along longitudinal profile of glacier (Jania 2004) – average values of water equivalent (w.e.) for 1990–1998

Ac – accumulation netto, Ab – ablation netto, Ab (calv.) – ablation by calving, Q_T – flow of ice below ELA, dH – decrease in glacier thickness.

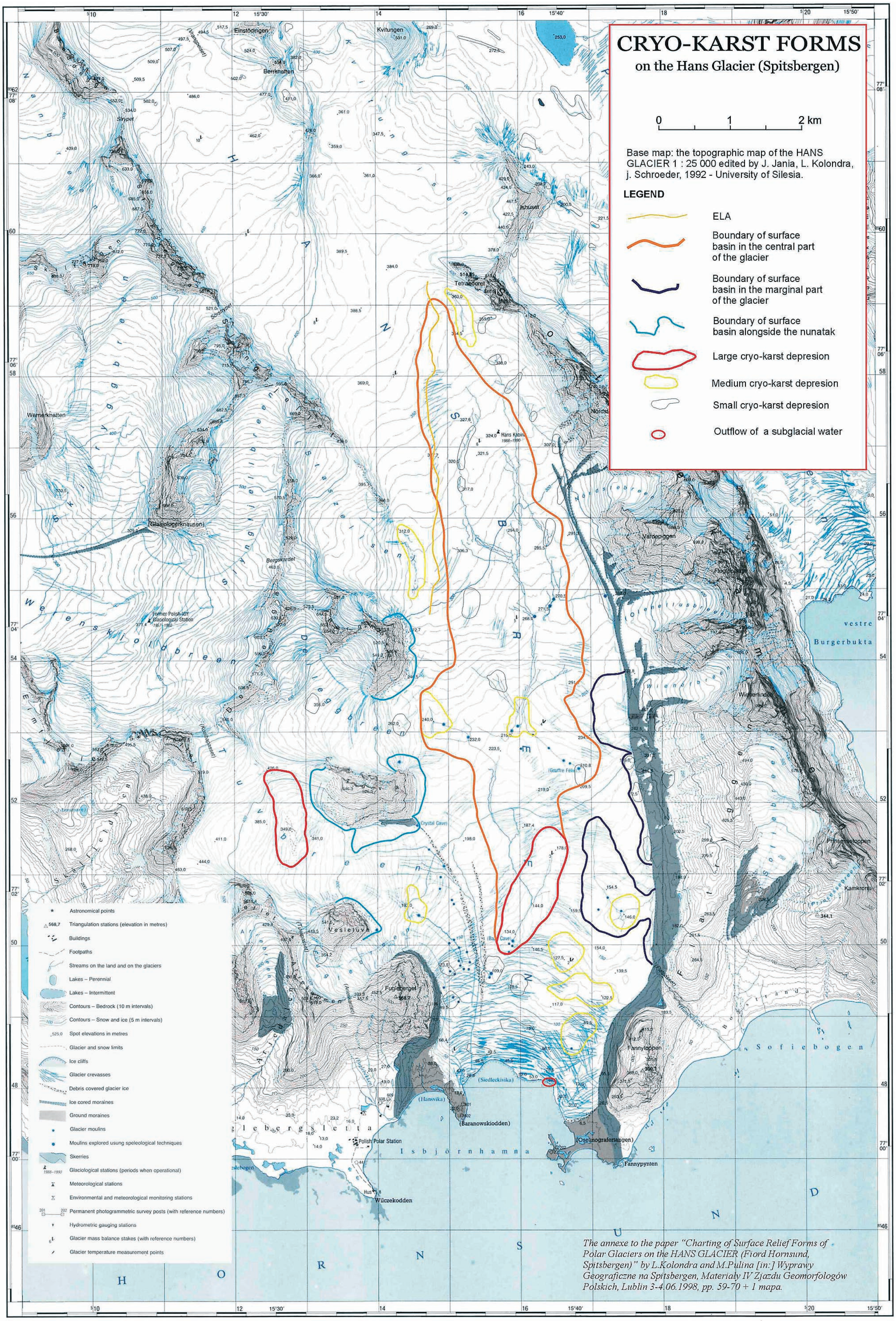

Fig. 30. Distribution of cryo-karst forms on the Hansbreen (Kolondra, Pulina 1998)

Fig. 31. Stone rings (polygonal soils) in Środoń' garden (photo J. Borysiak)

Fig. 32. Tundra vegetation on the northern bank of Hornsund (photo J. Borysiak)