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Late Quaternary tectonics in western Sörkapp Land, Spitsbergen

ABSTRACT: Photogeologic analysis and fieldworks in the Bunge Glacier area indicate symptoms of the Late Quaternary tectonic phenomena in western Sörkapp Land, southern Spitsbergen. The fault zones cut pre-Quaternary outcrops of Stupryggen and Kulmrabben as well as the raised marine beaches. This tectonics is due to land release during the late Sörkapp Land (= Vistulian, Würm) Glaciation when a considerable retreat of glaciers in Spitsbergen occurred. Evidences of such Late Quaternary tectonic movements call for a revision of the commonly applied hypsometric correlation of raised marine beaches in this area.

INTRODUCTION

The paper presents the Late Quaternary phenomena, the symptoms of which are observed in the field as well as on air photos in western Sörkapp Land, southern Spitsbergen. Such phenomena are marked by lineaments on air photos (OSTAFICZUK & *al.* 1982), being several metre high edges (developed not only on mountain slopes) and specific patterns of meltwater depressions in a seaside plain.

These tectonic phenomena are best recognizable in the western surroundings of the Bunge Glacier (Text-fig. 1) where their occurrence seems to have been connected with a quick deglaciation of the area during the Late Quaternary, followed by a glacioisostasy and revival of the fault running along the western side of Kulmrabben (*cf.* FLOOD & *al.* 1971). According to the present authors a similar fault occurs also at the eastern side of Kulmrabben (*see* Text-figs 1 and 4).

KULMRABBEN — STUPRYGGEN AREA

This area (Text-fig. 2) was studied in detail due to fieldworks (KŁYSZ & LINDNER 1982) and the analysis of air photos (OSTAFICZUK & *al.* 1982; LINDNER, MARKS & OSTAFICZUK 1984). The pre-Quaternary rocks are represented here by dolomites and locally by phyllitic limestones and quartzites of the Hecla Hoek Formation (*see* FLOOD & *al.* 1971). Azimuths of the strata are almost meridional whereas the dips change from 45° to 65° W.

The Quaternary rocks cover not only the pass between Stupryggen and Kulmrabben but also the downslope fragments of these mountain massifs (Pl. 1, Figs 1—2). Besides, the southeastern part of the Stupryggen massif is partly covered by the Bunge Glacier (*Bungebreen)* and its lateral ice-cored moraine (Text-fig. 2 and Pl. 2, Fig. 1).

Amidst the main tectonic elements (faults) there are steep northern slopes of Kulmrabben (Pl. 3, Fig. 1), several metre high edges (inclined northwards and southwards) on the southern slope of Stupryggen (Pl. 1, Fig. 1), continued by a meltwater gorge in the lateral ice-cored moraine of the Bunge Glacier (Pl. 2, Figs 1—2). All these elements run meridionally and thus are perpendicular to the fault that resulted in the development of the Kulmrabben—Stupryggen pass and the outwash plain along the western margin of the Bunge Glacier snout (*see* Text-fig. 1).

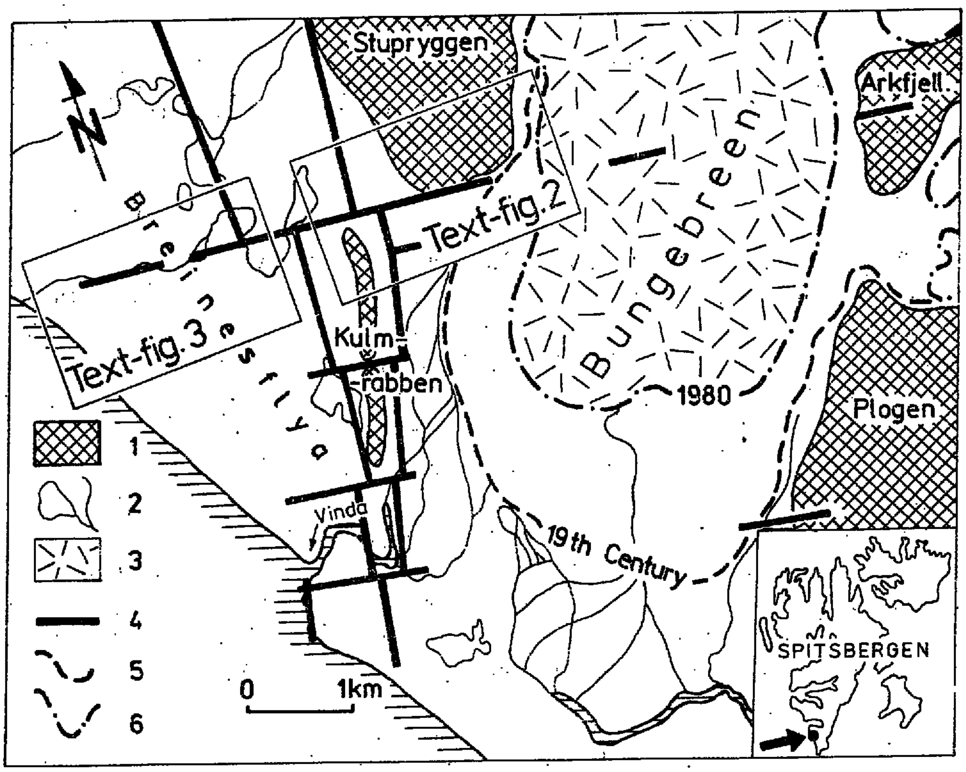

Fig. 1. Location sketch of the investigated area in western Sörkapp Land, Spitsbergen

1 — outcrops of pre-Quaternary bedrock, 2 — lakes and streams, 3 — glacier, 4 — main faults, 5 — glacier extent in 19th century, 6 — glacier extent in 1980

The described area has been previously covered by glaciers, as proved by ancient moraines on Stupryggen and till patches near the summit of Kulmrabben. The following deglaciation occurred only several thousand years ago (KŁYSZ & LINDNER 1982; LINDNER, MARKS & OSTAFICZUK 1984; LINDNER, MARKS & PĘKALA 1984). For this reason, the tectonic phenomena must have been formed at the turn of the Pleistocene and the Holocene. They are probably still active now, as proved by the location of the present gorge in a lateral ice-cored moraine just along a fault (see Text-fig. 1).

BREINESFLYA AREA

A meridional meltwater valley, 200—300 m wide, is the main morphologic element in this area (see Text-fig. 3 and Pl. 4, Fig. 1). This valley is incised into three raised marine beaches at 20—26, 15—18 and

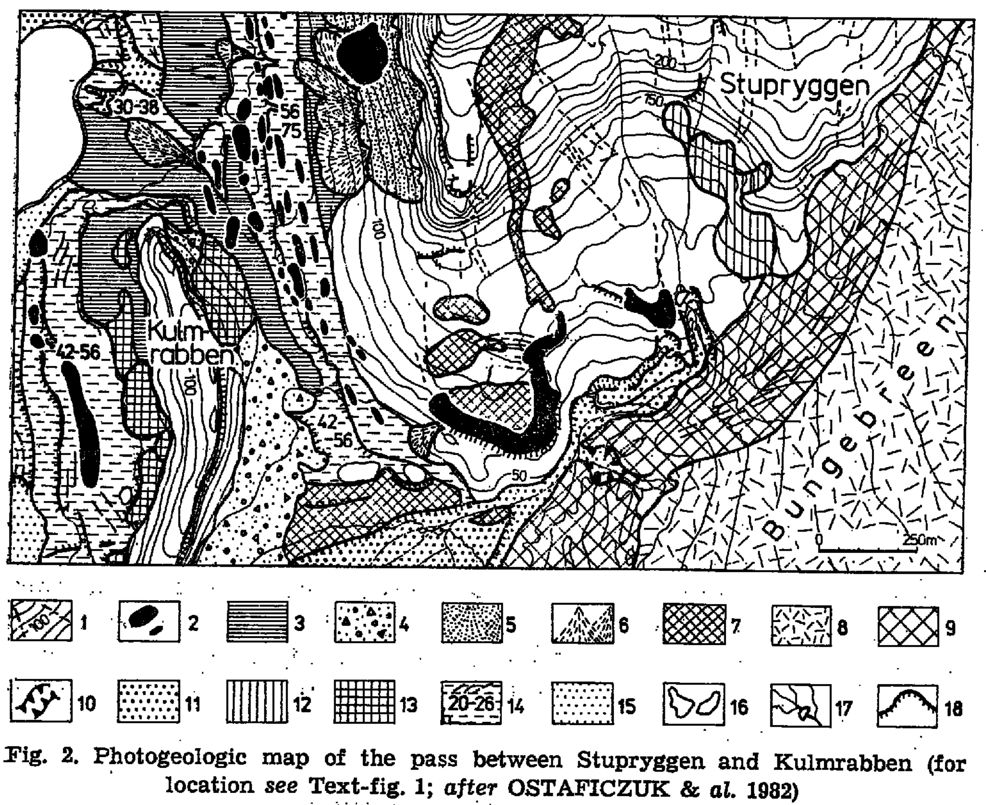

Fig. 2. Photogeologic map of the pass between Stupryggen and Kulmrabben (for location see Text-fig. 1; after OSTAFICZUK & al. 1982)

1 — mountains with a waste cover, 2 — monadnocks, 3 — delluvial covers, 4 — debris falls, 5 — landslide fans, 6 — alluvial fans, 7 — ancient terminal and lateral moraines, 8 — compact glacier ice, 9 — lateral ice-cored moraines, 10 — meltwater gorges, 11 — sandur, 12 — snow patches, 13 — protalus ramparts, 14 — raised marine terraces (altitudes in metres a.s.l.), 15 — valley and depression bottoms, 16 — lakes, 17 — streams and waterfall, 18 — morphologic edges

8—12 m a.s.l. (*see* OSTAFICZUK & *al.* 1982; LINDNER, MARKS & OSTAFICZUK 1984). The terraces are composed of shingle, 1—5 m thick, arranged in numerous generations of storm ridges, separated one from another by channel-like depressions that form dark tones on air photos, through which projecting are the monadnocks built of Carboniferous sandstones (Text-fig. 3 and Pl. 3, Fig. 2).

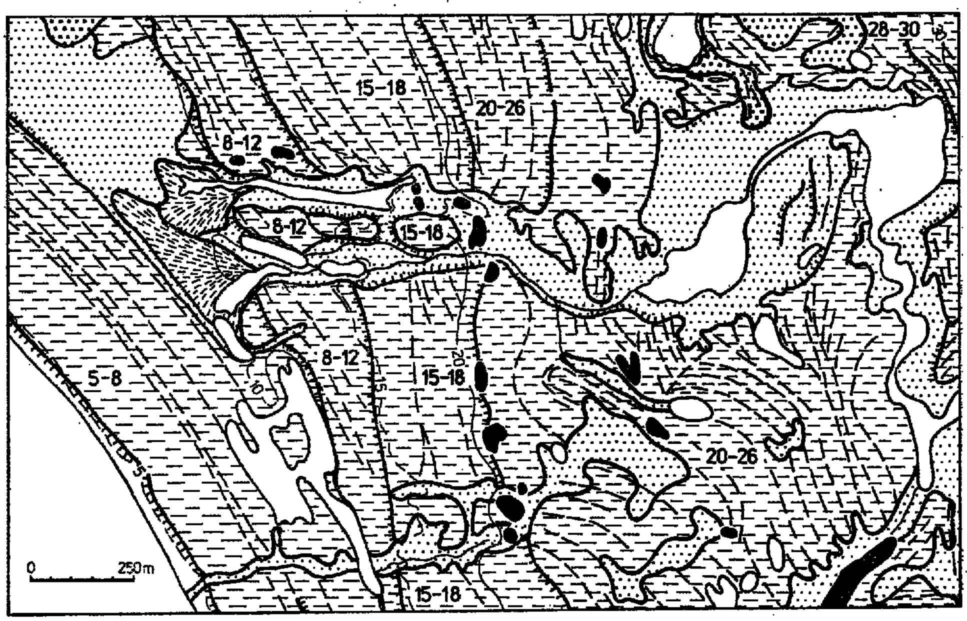

Fig. 3. Photogeologic map of the northern part of Breinesflya (for location *see* Text-fig. 1; *after* OSTAFICZUK & *al.* 1982); explanations the same as for Text-fig. 2

A paleogeomorphologic analysis of this area indicates that the primary meltwater runoff occurred slightly more southwards than the present-day one (Text-fig. 3). Its relics are still visible in the terrace 20—26 m a.s.l., in a zone with a disturbed pattern of storm ridges, and then it runs towards the sea. This fact as well as a lack of continuation of the present-day meltwater valley towards the sea, define precisely the time of its development. The available data on age of marine terraces in this part of Spitsbergen (*cf.* LINDNER, MARKS & PĘKALA 1984) suggest that the meltwater runoff changed its course at the turn of the Pleistocene and the Holocene.

TECTONIC INTERPRETATION

The presented data indicate that tectonic phenomena have occurred and still occur in this area, and influence the present exogenic processes, especially the changes in a meltwater runoff.

The longitudinal faults distinguished by FLOOD & *al.* (1971) and the authors at the eastern and western sides of Kulmrabben are the main symptoms of this tectonics (Text-fig. 1). The other faults (OSTAFICZUK & *al.* 1982; *see also* Text-fig. 1) run meridionally and thus perpendicularly to the longitudinal ones. The setting of these faults and the landscape analysis allows to recognize the structure of Breinesflya and the neighboring massifs (*see* Text-fig. 4). The deglaciation of southern Spitsbergen resulted in a considerable decrease in the value of the ice load. The land got uplifted and the arisen tensile stress formed a system of meridional normal faults. Coevally the older longitudinal faults at eastern and western sides of Kulmrabben could be rejuvenated. The activation of these faults in the Late Quaternary is proved by the location of numerous elongated lakes in Breinesflya along the western fault as well as by a deeply incised meander in a graben of the Vinda River at the southern end of Kulmrabben (*see* Text-fig. 1, 4 and Pl. 4, Fig. 2).

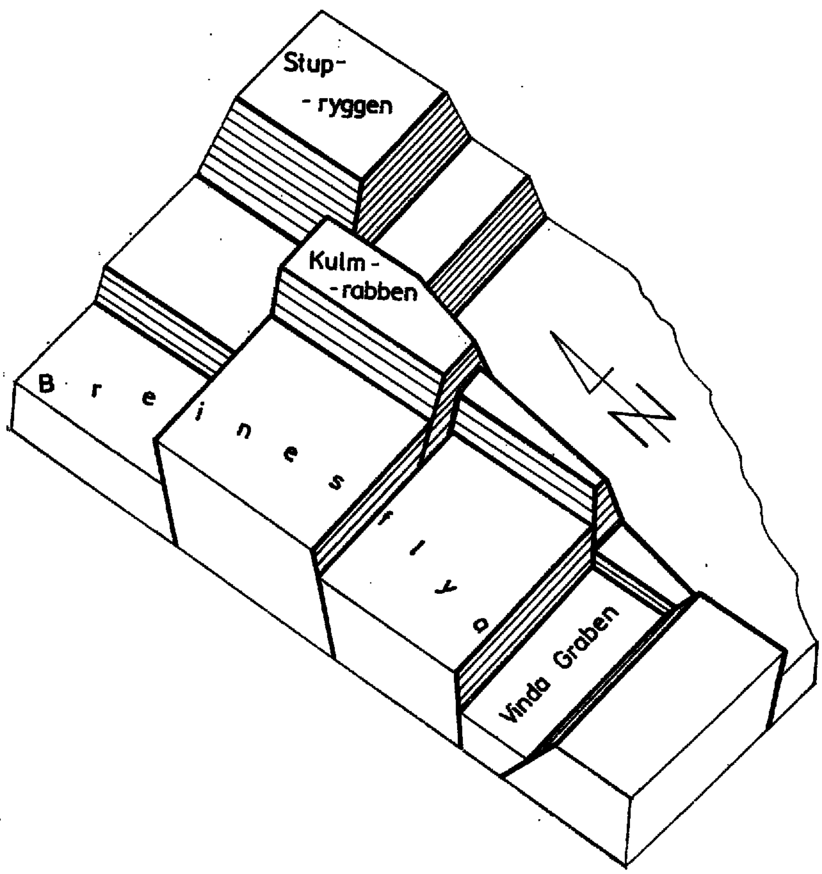

Fig. 4. Blockdiagram, to show a fault pattern in the Stupryggen — Kulmrabben — Breinesflya area

The maximum vertical displacements on western slopes of Stupryggen and Kulmrabben reached 100 m. Similar events of glacioisostatic origin were noted by LUNDQUIST & LAGERBÄCK (1976) and LAGERBÄCK (1978) in Scandinavia, and by SHOTTON (1965) throughout the British Isles. In Spitsbergen, similar faults were described for the Forlandsundet graben (WÓJCIK 1981) and suggested (STRAKOV & *al.* 1983) also in the Nordenskiöld Land and Sörkappöya.

In Breinesflya, symptoms of the tectonic phenomena are reflected by the described meridional melwater valley incised in raised marine beaches (*see* Text-fig. 3) and by location of the Vinda mouth at a prolongation of the fault on the Plogen slope (*see* Text-fig. 1). Besides, a fault is marked on the Arkfjellet slope, being probably continued under the Bunge Glacier and passing into ameriddional fault that separates Stupryggen from Kulmrabben (*see* Text-fig. 1) and is observed further north, on slopes of Wiederfjellet and Gavrilovfjellet (Pl. 3, Fig. 2).

In Breinesflya, the meridional faults can be dated by the marine beach 20—26 m a.s.l., unevenly developed at both sides of the meltwater valley. This terrace was accumulated at the end of the Sörkapp Land (= Vistulian, Würm) Glaciation (*cf.* LINDNER, MARKS & PĘKALA 1984) and probably in this time the meridional faults originated. The absence of these faults in the lowest marine beach of Breinesflya (*cf.* Text-figs. 1 and 3) indicates that in some areas their development has not continued until the present times. On the other hand, in the Vinda mouth and in the meltwater gorge in the lateral ice-cored moraine of the Bunge Glacier, the faults have remained active until the present days.

CONCLUSIONS

The recognized young tectonic phenomena of a glacioisostatic origin, indicate a block structure of the Quaternary bedrock in southern Spitsbergen. Therefore, a correlation of raised marine beaches is considerably difficult in this part of Spitsbergen, even at small distances, and the commonly applied hypsometric criteria (*cf.* JAHN 1959; BIRKENMAJER 1960; KARCZEWSKI & *al.* 1981; ANDRZEJEWSKI & *al.* 1981) should be revised.

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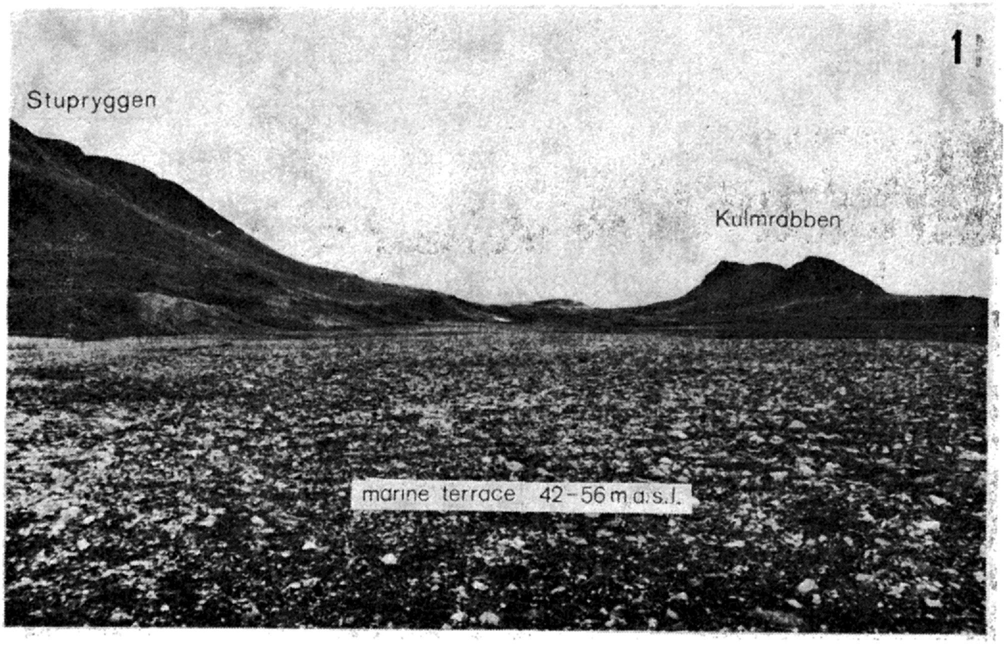
MŁODOCZWARTORZĘDOWA TEKTONIKA W ZACHODNIM SÖRKAPP LAND NA SPITSBERGENIE

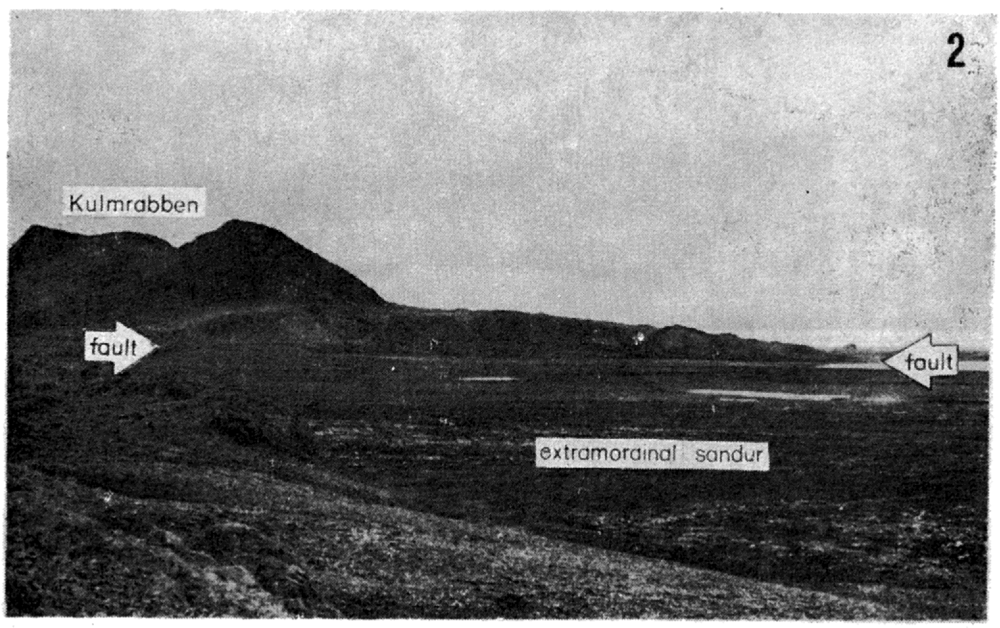
(Streszczenie)

Przejawy młodej tektoniki na obszarze zachodniego Sörkapp Land w południowym Spitsbergenie są widoczne w postaci kilku- lub kilkunastometrowych krawędzi, utworzonych na zboczach masywów górskich, oraz prostolinijnych układów obniżeń wykorzystywanych przez wody roztopowe i jeziora na Breinesflya (*patrz* fig. 1—3 oraz pl. 1—4).

Zanik lodowców południowego Spitsbergenu doprowadził do wyraźnego zmniejszenia obciążenia podłoża skalnego, a tym samym do glaciizostatycznego wypiętrzenia obszaru oraz powstania naprężeń rozciągających. Te ostatnie spowodowały z kolei powstanie ścięć i uskoków normalnych. Niejednakowy rozwój tarasu morskiego 20—26 m n.p.m. po obu stronach strefy uskokowej wykorzystywanej obecnie przez dolinki wód roztopowych wskazuje, iż zjawiska neotektoniczne zostały zapoczątkowane u schyłku zlodowacenia Sörkapp Land (= Vistulian, Würm). W niektórych obszarach wygasły one w młodszym holocenie, natomiast w strefie ujścia rzeki Vindy do morza oraz w przełomie wód przez boczny wał lodowomorenowy lodowca Bunge są one czynne do dziś (*por.* fig. 1 oraz 4).

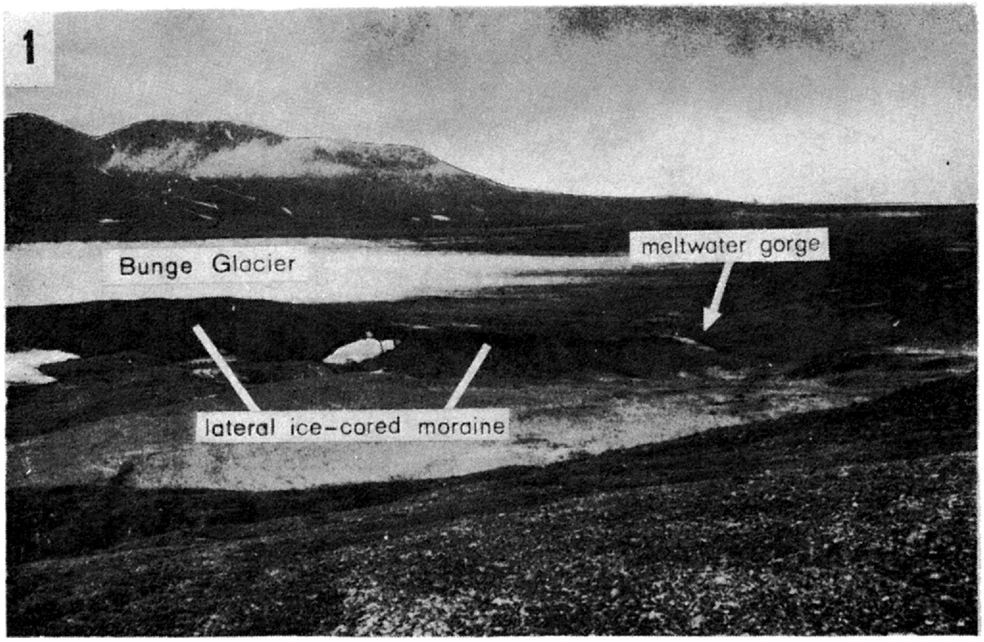
Przedstawione młode zjawiska tektoniczne uwarunkowane glaciizostazją wskazują na blokowy charakter budowy podłoża czwartorzędu badanego obszaru. W istotny sposób utrudnia to hipsometryczną korelację wyniesionych tarasów morskich w południowej części Spitsbergenu.

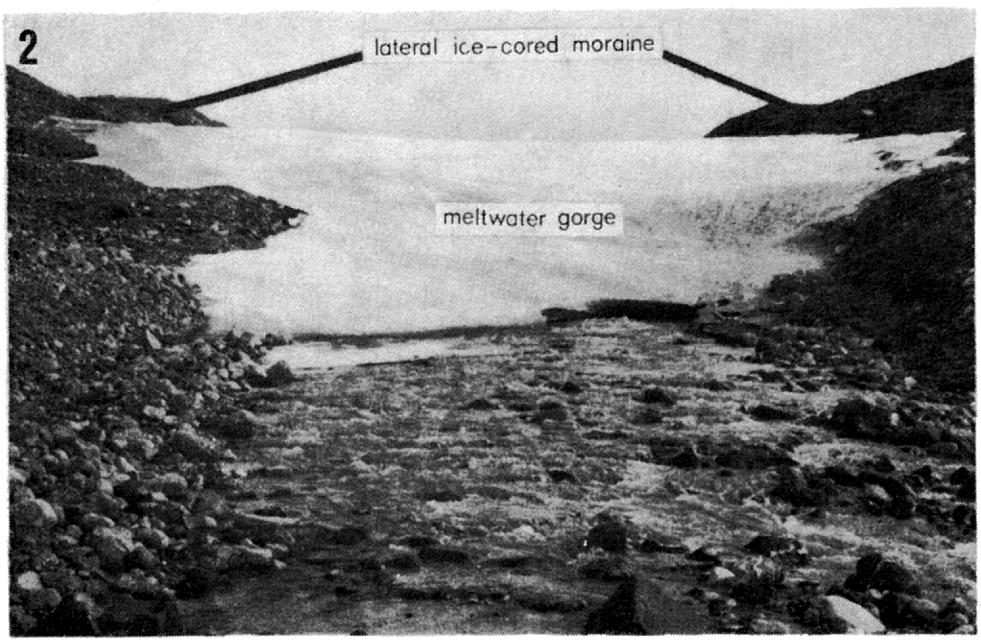




1 — The pass between Stupryggen and Kulmrabben located in a rejuvenated fault zone; July 1985

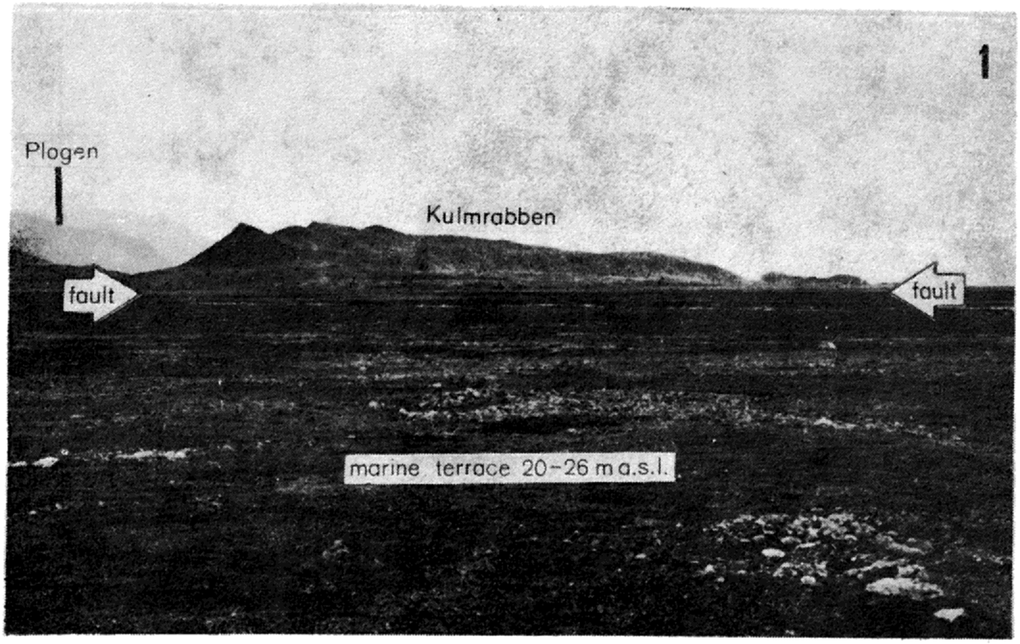
2 — Kulmrabben cut from the north by a fault zone, now used by nival waters; July 1980

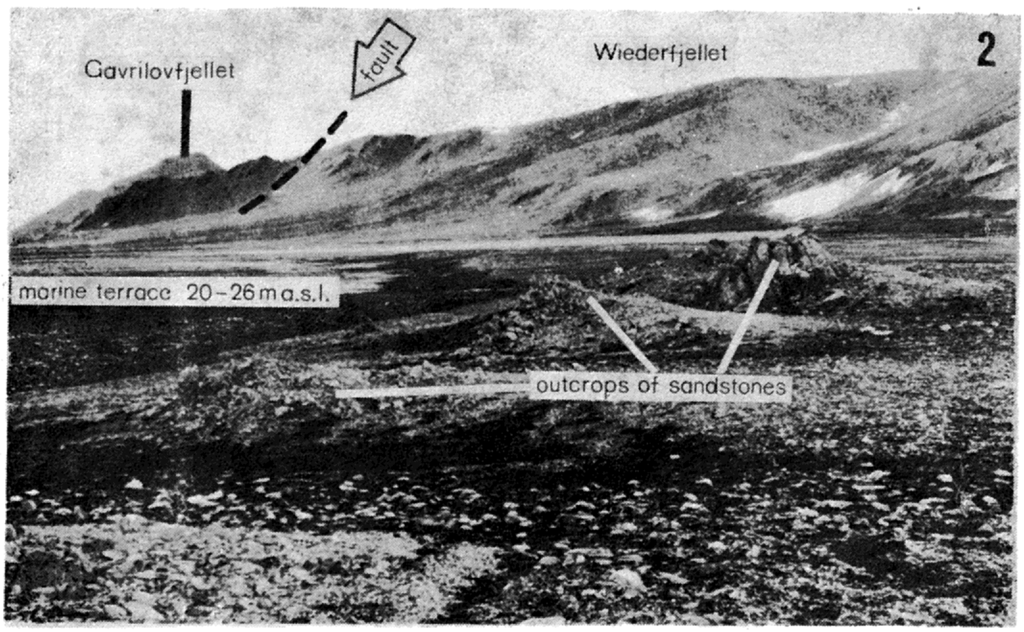




1 — Snout of the Bunge Glacier with a meltwater gorge (*arrowed*) in the lateral ice-cored moraine (*cf.* Fig. 2 in this Plate); August 1985

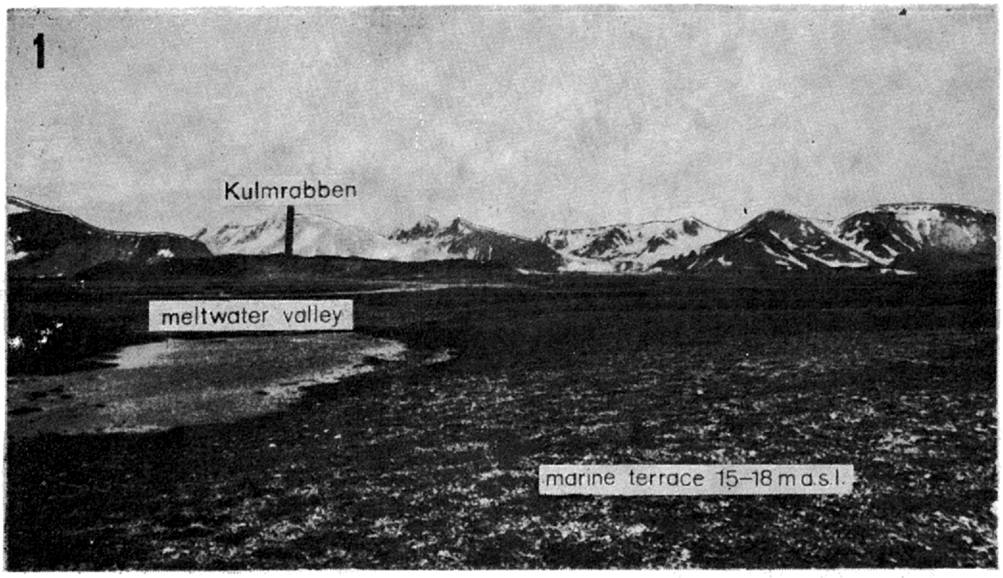
2 — Meltwater gorge in the lateral ice-cored moraine of the Bunge Glacier; July 1980

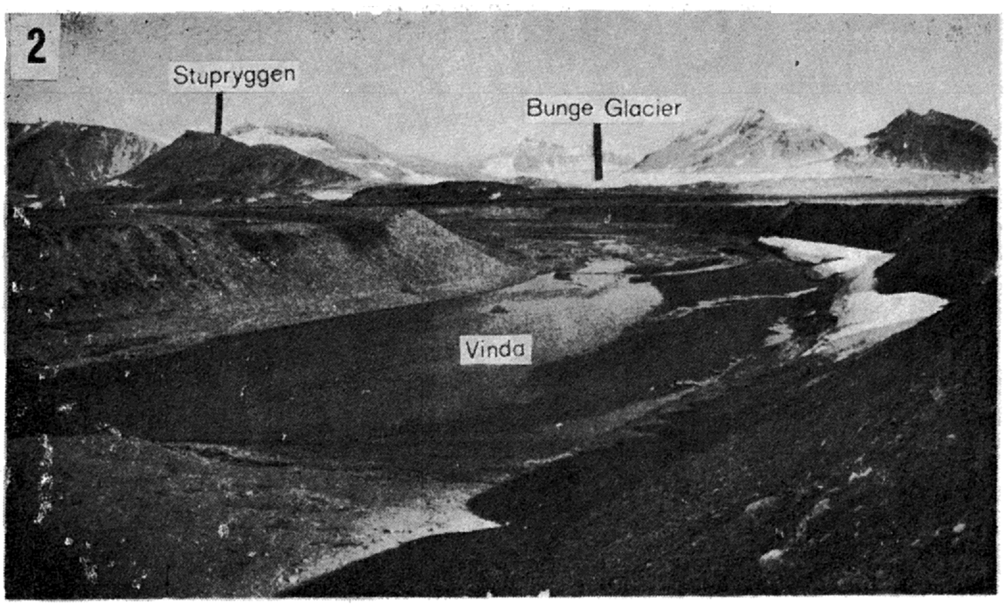




1 — Kulmrabben cut from the west by a fault zone; July 1980

2 — Monadnock of Carboniferous sandstones at the edge of the marine beach 20—26 m a.s.l. in Breinesflya; July 1980





1 — Meltwater valley in the fault zone formed in Carboniferous sandstones which underlie the marine beaches in Breinesflya; July 1985

2 — Mouth of the Vinda River located in the Vinda Graben in the southern part of Breinesflya (*cf.* Text-fig. 4); August 1985