Ninth Indian Expedition to Antarctica, Scientific Report, 1994
Department of Ocean Development, Technical Publication No. 6, pp. 219-225

Terminal Moraines in Grautfatet, Humboldt Mountain, East Antarctica — Indicators of Rate of Glacier Recession

N.C. PANT, R. RAVINDRA AND M.J. D'SOUZA

Antarctica Division, Geological Survey of India, Faridabad

Abstract

Grautfatet is a vast, morainal flat within the Humboldt Mountain. The Somovken glacier branching into the Grautfatet and Humboldt glaciers has controlled the deposition of terminal moraines in this flat. The disposition of the two sets of terminal moraines, along with the relief pattern of the surrounding ridges have been used to decipher an ice level lowering of 350 to 400 metres and a retreat of Somovken glacier by 7.5 km since the last peak ice condition. This recession, in conjunction with the inferred age of last peak ice condition, indicates an average retreat rate of 75 metres per 100 years for Somovken glacier.

Introduction

Humboldt mountains and adjacent nunataks constitute a group of disjointed, irregularly shaped hills showing variations of height from 1800 m above m.s.l. in the north to over 2700 m above m.s.l. in the south. The ground level varies from about 1500m to about 1900 m above m.s.l. Grautfatet, located within the Humboldt mountain is a vast amphitheatrical morainal flat bounded by ridges in northern, eastern, southern and southwestern margins with wide opening towards west.

Geomorphology of the area around Grautfatet

A detailed description of geomorphology of Humboldt and adjacent areas, including the landscape evaluation, has been discussed by Ravindra *et al.,* (1991). The landforms described by them and Sekyra (1971) have been listed in Table 1. Both polar as well as alpine type of landforms have been reported and the overall landscape is comparable to the composite erosional landscape described by Sugden and John (1976).

In an earlier study, detailed work was carried out by Bardin, 1971, on the moraines of Nordvestoya nunatak and three age subdivisions of morainic material were made using several factors such as the height level and morphology of moraines, degree of surface geochemical weathering, wind polishing, growth of lichens, development of cryogenic forms and development of honeycomb weathering. The subdivisions, named as Insel I, II and III were found to be comparable with Koettlitz, Taylor and McMurdo glaciations (Pewe 1960) respectively.

Table 1: Landforms Developed in Humboldt Mountains and Adjacent Nunataks
(Data from Ravindra *et al,* 1991 and Sekyra, **1971)**

	Erosion related landforms		Ice and snow dynamics related landforms
I.	Block fields	I.	Sastrugi
II.	Cavernous pits	II.	Wind scoop
III.	Cirques	III.	Ice apron
IV.	Aretes	IV.	Crevasses
V.	Horns	V.	Patterned ground
VI.	Tors	VI.	Moraines
VII.	Exfoliated hills	VII.	Frozen proglacial lakes

Disposition of moraines in Grautfatet

The Grautfatet, spread over an area of nearly 72 sq.km, exposes multipatterned, crescent shaped terminal moraine trails, locally modified by medial moraines. Two main sets of curved terminal moraines are recognizable (Fig.l) marking the retreat of Somovken and Humboldt glaciers which were directed into Grautfatet.

The bigger set of terminal moraines (TM_1) are in form of curved, crescent shaped ridges (Fig.2) showing a distinct convexity towards east. The moraines, extending in a north-south direction, attain lengths of over 1 km. The thickened central part of the ridge contains larger blocks (of the order of several metres) along with smaller ones, while the gradually thinning edges are made up of smaller sized fragments (6 cms to 35 cms). The clast characters indicate local provenance (Ravindra *et al,,* 1991). The TM_1 set of moraines extend for nearly 7.5 kms from east to west in the northern half of the Grautfatet. The second set of terminal moraines (TM2) are present in the south eastern part of Grautfatet (Fig.l) and consist of curved fragment trails which are convex towards northwest. The individual moraine, extending northeast-southwest, is around 500 metres to 1 km long. The clast compositions and sizes are similar to the other set of moraines.

The maximum height of both TM_1 and TM2 moraines, generally thickened at the centre, varies from 20 metres to 35 metres. The distance between the successive moraine ridge varies between 50 to 300 metres. However, this could not be measured accurately due to severe time and logistic constraints.

Present and past ice levels in Grautfatet

The bowl shaped Grautfatet valley is flanked by Somovken glacier in the west and Humboldt glacier in the east. The Somovken glacier is diverted into this flat through its western opening and this diversion is marked by the presence of flow lines on the surface of glacier and by the position of tensional crevasses northwest of the diversion (Fig.3). The Somovken glacier movement within the valley, has been guided by the northern edge of the Humboldt flat, which is a ridge having elevations of the order of 2000 to 2200 m. The disposition of the moraines indicates control of the northern ridge over the ice movement within this part of the Grautfatet. It is apparent that it always acted as a barrier which was

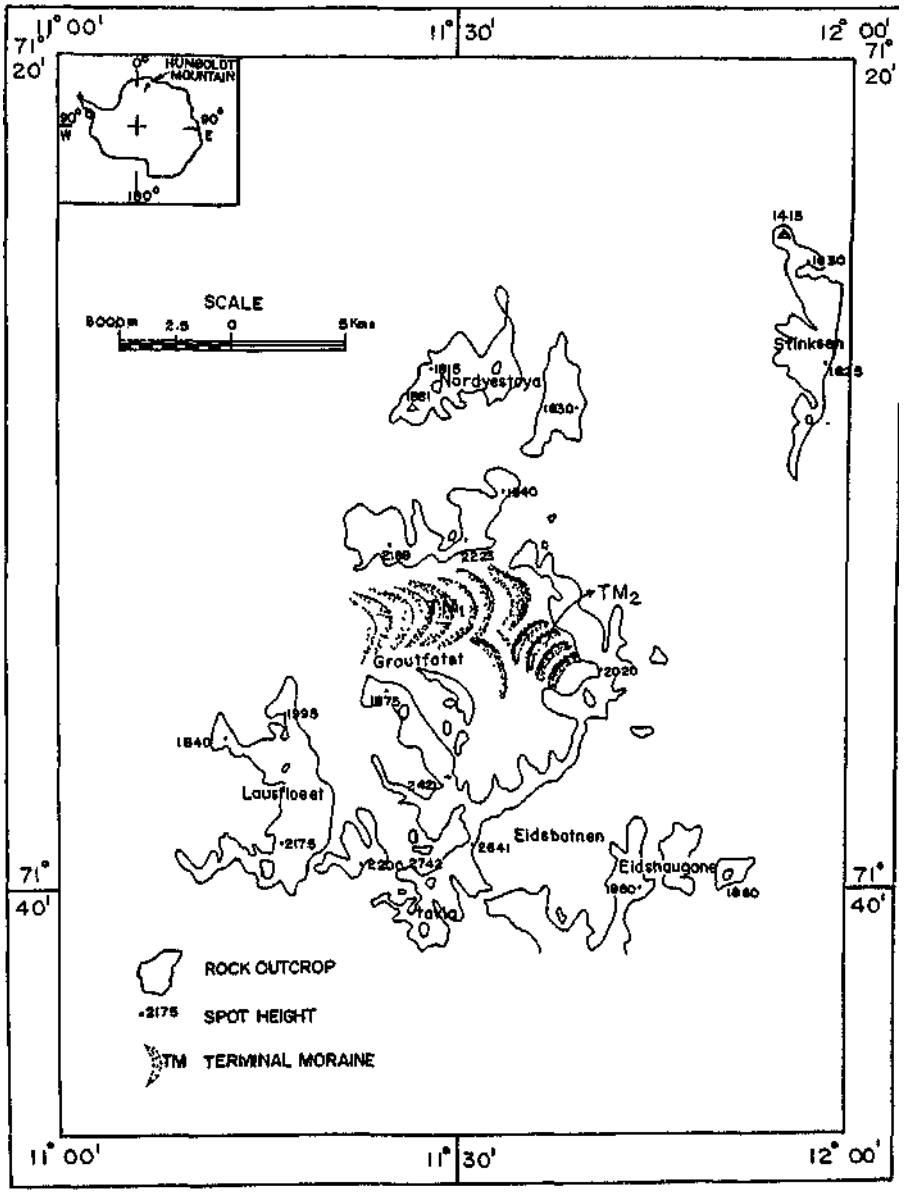

Fig. 1. Disposition of terminal moraine sets TM_1 and TM_2 in Grautfatet. Inset shows the location of Humboldt Mountain in East Antarctica.

Fig. 2. Lateral view of the terminal moraine TM_1.

not topped even at the peak of the last glaciation. This sets the limit of 2000 m for the highest level of ice in the northern part of Humboldt flat, at the time of the last peak glaciation.

Second set of the terminal moraines is present in the south-eastern part of the valley (Fig.l). The curvature of these moraines indicates a north-north westerly movement of ice for which a present day barrier ridge in the southwestern part of Grautfatet (of nearly 1900 m height) must have been breached at the peak ice level. In the light of this, the maximum level of ice can now be revised to be between 1900 and 2000 m within the Grautfatet at the time of last peak glaciation.

Thus it appears that at the time of peak ice conditions, the average ice level in Grautfatet was slightly over 1900 m which is nearly 400 m higher than the present day ice level. This conclusion is further strengthened by the presence of moraines at elevation of about 200 m to 250 m from the present day base level. The lowering of the ice level in Grautfatet was accompanied by the recession of glaciers. The Somovken glacier receded by about 7.5 km as evidenced by the extent of the terminal moraines.

Rate of recession of Somovken glacier

The successive trails of terminal moraines in Grautfatet represent periods of abnormal melting and bedload deposition. Intervening spaces are signatures of relatively low rate of melting.

Thus the recession of parent glaciers took place in a series of slow and fast melting episodes. The net withdrawal of ice, in the case of Somovken glacier, was such that a

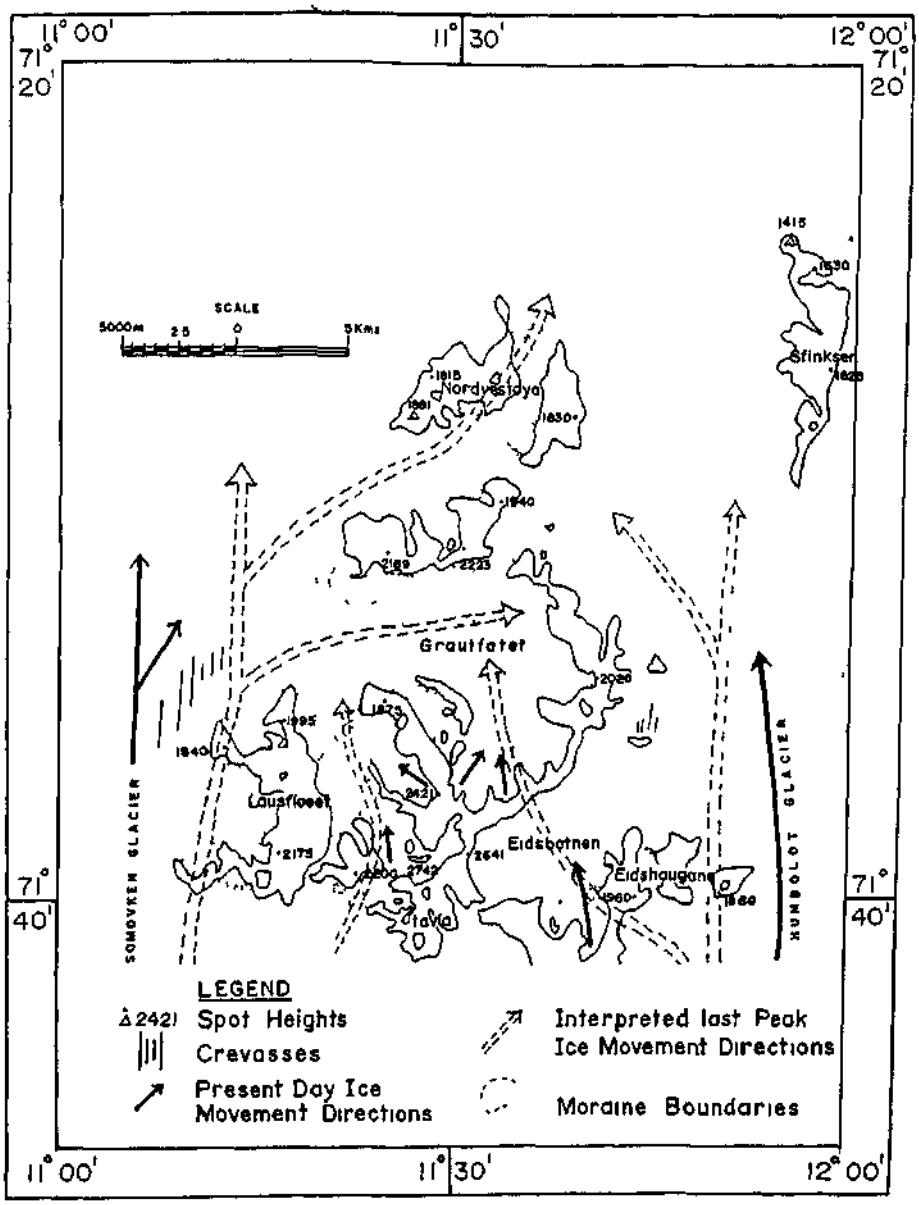

Fig. 3. Present ice movement directions and inferred movement directions at the time of last peak glaciation.

succession of terminal moraines were deposited over a distance of 7.5 km from east to west, concomitant to an overall ice level lowering of the order of 350 to 400 metres in the Grautfatet. It is not an abnormal retreat as evidenced by several independent studies in other parts of Antarctica (Miller 1959, Prentice *et al.,* 1985, Denton *et al.,* 1984).

There have been several estimates of the age of last peak ice condition in Antarctica. In a study mainly concentrating in the sector 45°E and 80°E longitudes, it was concluded that the major glacial recession was initiated not less than 10,000 years ago (Miller 1959; Denton *et al.,* 1970). Radiocarbon dating of perched lacustrine deltas in Explorers Cove Basin in McMurdo Sound area give ages of 8900 and 8340 years indicating the presence of grounded ice forming a dam. Denton *et al.,* (1985), while dating these lacustrine deltas in the valley mouth and mid valley thresholds indicated ages ranging from 23,800 to 11,820 years (Late Wisconsin age) for a thick Ross sea ice in the McMurdo Sound area.

Thus it appears that the last major recession (of ice) in Antarctica started sometime around 10,000 years ago. Using this data for the Queen Maud Land area, it becomes apparent that the Somovken glacier retreated by about 7.5 km. during last 10,000 years indicating a rate of recession of 75 metres per 100 years, assuming gradual retreat.

Acknowledgements

Logistic support in Antarctica provided by 7th Antarctic Expedition at Humboldt Camp is gratefully acknowledged. Relevant literature received from Shri M.L. Parimoo, helped immensely. Authors are grateful to Shri M.K. Kaul, Director, Antarctica Division for guidance suggesting improvements in the text.

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