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Some Observations on the Glacial Geomorphological Features of Wohlthat Mountains, Central Queen Maud Land, Antarctica

D. SRIVASTAVA, M.K. KAUL, R.K. SINGH, S. MUKERJI AND S. JAYARAM

Geological Survey of India
Faridabad-121001

Abstract

The part of central Queen Maud Land between the Indian station Dakshin Gangotri at shelf and about 200 km inside, towards south, encompasses four distinct geomorphological units: namely the shelf area, piedmont zone, the mountain barrier and polar ice plateau. Glacial geomorphological features of the mountain barrier, formed by the Wohlthat mountain chain, were studied during the Fifth Indian Expedition to Antarctica and are briefly described in this paper. The prominent features comprise the differential relief, various types of moraines, wind scoops and desert weathering (honeycomb features). Level of glaciation has been inferred and several features associated with deglaciation have also been described.

Introduction

The Wohlthat mountain range in the central Queen Maud Land is a distinct physiographic unit girdling this part of Antarctica. The mountain chain exposed between about 200 to 350 km from the shelf (Princess Astrid Coast) trends in a NE - SW direction. The area from the coast to south of Wohlthat range, from where the polar plateau starts, has a gradual rise in slope from sea level to beyond 3000 m.a.s.I. The section between the coast and the polar plateau has been divided into four disinct morphological units: (1) the ice shelf, (ii) the piedmont zone of polar ice sheet, (iii) the mountain barrier, dissected by outlet glaciers and (iv) the polar plateau. All these divisions have their own characteristics. The aim of this paper is to bring out the major glacial geomorphological features in and around the mountain barrier (Wohlthat mountains), which were observed during the Fifth Indian Expedition to Antarctica.

Glacial Relief

An interesting feature of the Wohlthat mountains is the conspicuous difference in relief between the southern and northern faces of the mountain chain. In the southern face the exposed parts of the mountain in Gruber and Petermann areas are generally upto 600 metres from the present ice surface. These show a young

relief and **restricted periglacial effects. The northern** face, **on the contrary,** exposes a mature **alpine relief. Here some of the peaks are as high** as **2800 m.a.s.l. The** absolute height of the Gruber massif in the eastern sector ranges from 600 m.a.s.l. to 2790 m.a.s.l. Westwards, the absolute height of the ranges go upto 3000 m.a.s.l. However, further west the peaks are generally 300 to 600 m higher than the present ice-level, whereas in the east they are 500 m to more than 1700 m higher than the present ice-level. The upper 500 to 700 m of the mountain, especially in the Gruber and Petermann ranges, present alpine characteristics in the form of horns and serrated ridges.

Level of Glaciation

No firm identification of the level of glaciation i.e. the height above the sea level up to which the glaciers occupied the mountain relief, can be attempted without more evidence in the higher sections of these mountain ranges. But considering the preliminary data collected during the expedition, the location and distribution of glacial benches and vertical extension of moraines, indicate the level of glaciation of Gruber and Petermann ranges to be about 2000 m.a.s.l. This may lead to the conclusion that the highest peaks of Gruber and Petermann were never under the blanket of continental ice and emerged as nunataks during the period of high glaciation. But it can conversely be argued that the glaciers did occupy higher levels, which were later vacated and de-glaciated, a possibility supported by the periglacial effects so pronounced on the higher peaks. Further data is, therefore, essential for establishing the level of glaciation in this area.

Deglaciation

The de-glaciation of the ice from eastern part of the Wohlthat mountains must have taken place in at least three phases. This is indicated by the recessional moraines bordering the outcrops (Fig. 1). Deglaciation has led to the formation

*Fig. 1. Recessional **moraine's** in Wohlthat mountains.*

of now "dry glacial valleys" in Gruber and Petermann ranges which are generally oriented in north-south or northwest-southeast directions. Few of these trend in a northeast-southwest direction. (Fig. 2) Polished surface and striations have been observed at around 2000 m.a.s.i. In Gruber the direction of these striations is southeast-northwest implying a northwesterly flow. Striation with same orientation were observed at several other locations in the mountain range.

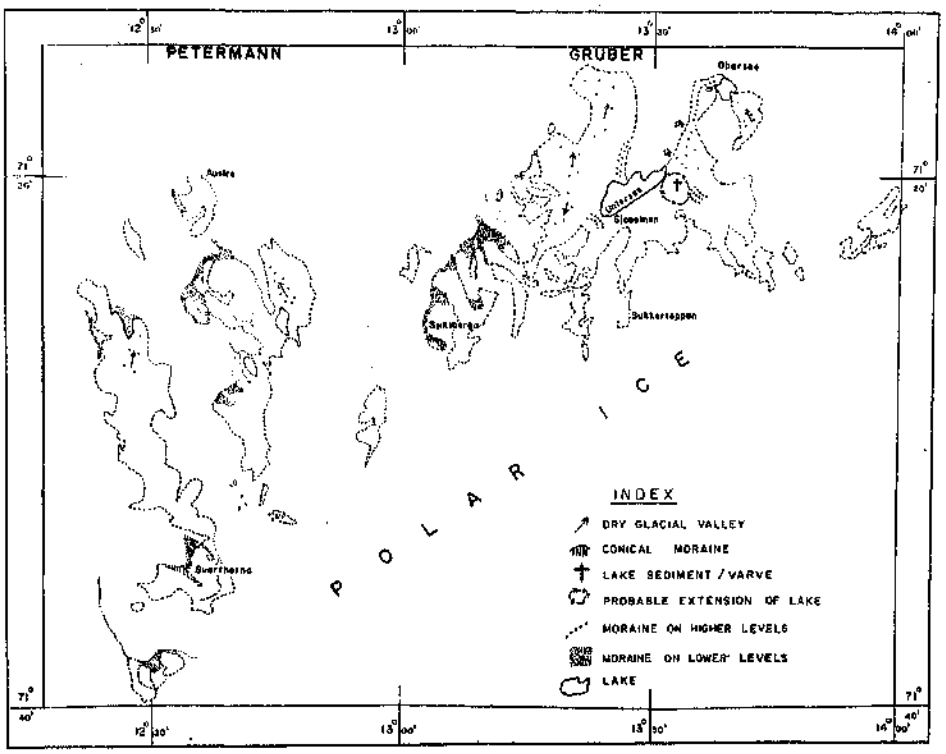

Fig. 2. • Geomorphological map of part of Wohlthat mountains, East Antarctica

In the process of de-glaciation several remnant glaciers in the form of small static ice bodies have been left behind, perched on the mountain slopes. A total of 122 of them were identified. Most of such glaciers (about 60% of total) are oriented in west or northwest direction. They are generally small i.e. upto 1 km^2 in area.

Honeycomb weathering is a very common feature (Fig. 3). It is present irrespective of altitude, both on the easterly and westerly faces. The cavities are at times 25 cm to 30 cm in diameter and the bottom of the cavities is occupied by the material derived generally of the same rock in which they occur. Blowing wind imparts rotational motion to the particles causing attrition which is considered to be dominantly responsible for shaping cavities.

The growth of lichens was also observed upto a height of 2000 m.a.s.l. The growth is quite poor, imperfect and not concentric. However, their incomplete gowth reflects, among other things, burial of the bedrock under ice not long ago.

Within the moraine deposits of Gruber, a breeding place of Antarctic petrels was observed in the fissure of a boulder (Fig. 4). Such places have been observed elsewhere in Antarctica. The petrels deposit their stomach content, thus accumulating within such fissures the organic matter, so-called "mumiyo", to about 0.5 m in the form of layers. The present occurrence is made of such a waxy material in layers ranging in colour from brownish to yellowish. Eggs of the petrel were also seen alongwith this deposit. The radiometric age of this material throws light on the event of de-glaciation and climatic change and helps in fixing a minimum age for the ice to have vacated this area, thereby allowing the petrels to occupy the breeding places. One such deposit from Gruber has been dated for C14 values and has yielded a maximum age of 4000 years (Hiller and Wand, 1984).

Lakes

A very prominent geomorphological feature of the eastern. Wohlthat is the presence of two big fresh water lakes, which are frozen. These are present in the central and northeastern parts of. Gruber massif. The larger of the two; the 'Untersee lake' (named as 'Gayatri lake' during the expedition) is oblong in shape and elongated in a northeast-southwest direction. It has a maximum length of 6.5 km and maximum width of 2.5 km The upper 3 to 5 metres of the lake is frozen, even in austral summer. But the lake exposes melt water on its peripheries during summer, probably due to the 'hot house' effect of nearby moraine expanse. The 'Gayatri lake' appears to have shrunk greatly in size. The presence of lacustrine deposits in the form of varves at least 2 to 3 metres above the present lake surface and 15 m to 20 m away from the periphery of the lake indicates its recent shrinkage (Fig. 5). The northern periphery of the lake is delimited by the polar ice while rest of the three sides are nearer to rock exposures.

The 'Obersee lake' (named as 'Gargi lake' during the expedition) is smaller than the 'Gayatri lake'. The lake has a dimension of about 2.5 km by 2.5 km. Glacier ice from the southern side and northern side confine its limits while the eastern and western limits are nearer to rock outcrops. About 2 to 3 metres from the surface remains frozen even during the austral summer, though like 'Gayatri lake', melt water appears along the peripheries only during this time.

Moraines

Different types of moraines are manifest in the Wohlthat range which have a well defined spatial distribution. It is seen that western and northwestern slopes show conspicuous development of moraines as compared to the eastern counterparts. The slope evolution and generation of supraglacial moraines appears to be more active on the western faces. The restricted exposures of moraines on the eastern slope may be possibly due to their burial, under the snow drift.

Fig. 3. Honeycomb weathering feature in eastern Wohlthat mountains

Fig. 4. Breeding place of Antarctic petrels showing "mumiyo".

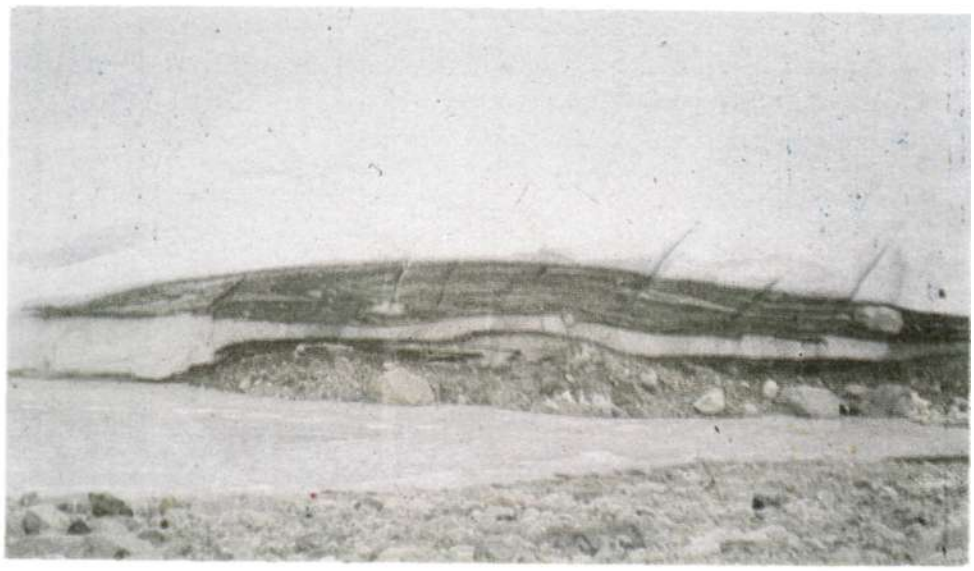

Fig. 5. A *varve deposit in the vicinity of "Gayatri Lake".*

Fig. 6. Conical hillock of moraines.

The development of terminal and lateral moraines has taken place at locations where the remnant glaciers join the outlet galciers emanating from the main continental ice sheet. There are at least four, though ill-preserved, generations of such moraine ridges surviving in the mountain range. Current development and concentration of moraines is spectacularly indicated at Vasskilsata nunatak north of Gruber massif. The other such morainic trails are conspicuous at the western edge of Gruber and on the eastern and western sides of Vestre nunatak in the Petermann ranges. These are further mentioned elsewhere in this volume (Kaul, e*t al.,* pp 247-256). Lobate moraines have also been observed.

A complex development of moraines is noticed southeast of 'Gayatri lake' in the depression at Sjobotnen region, where an amalgamation of various types of moraines is revealed, possibly due to conjunction of various ice streams in the past. Some circular moraines have also developed due to complex glacial processes. Besides, there are linear ridges and conical hillocks of moraines several metres high. Some circular moraines have depression in centre, probably caused due to wasting away of dead-ice within.

An interesting feature observed on the polar ice surface is the occurrence of a few conical hills of moraine (Fig. 6). The moraines are constituted of fine sand and small boulders, cemented together by ice or interstices of permafrost. Trail (1964) in Prince Charles mountains and Souchez (1968) in western Sor-Rondane mountains describe similar features. The formation of such a hillock is attributed to the presence of sub-glacial morainic boulders on a shear plane in glacier ice. The hot house effect produces water due to melting of ice in the immediate vicinity of the boulders. Refreezing of this water causes frost shattering. Fig. 7 explains the formation of the hillocks. When at the surface of the glacier, the hot house effect imparted by the moraines results in the formation of a shallow depression around the moraine.

Wind Scoop

Wind scooping is very common phenomenon in this area due to obstruction offered by the outcrops to the prevailing easterly and southeasterly winds. Around the rock exposures on the windward side, a gentle ice slope is abruptly cut by a crescentic trench by the side of the exposure as deep as 40 to 50 metres. The leeward side shows snow dunes continuing for some distance. The crescentic trench is occupied by morainic boulders of various sizes.

Conclusions

The glacial activity around the Wohlthat mountains which has taken place in recent past and is going on at present also is the only example of glacial action by a glacier of continental dimensions, and its offshoots. This would throw valuable light on the past glacial processes which have taken place elsewhere in the world during the Ice Age. It is suggested that studies of glacial geomorphology

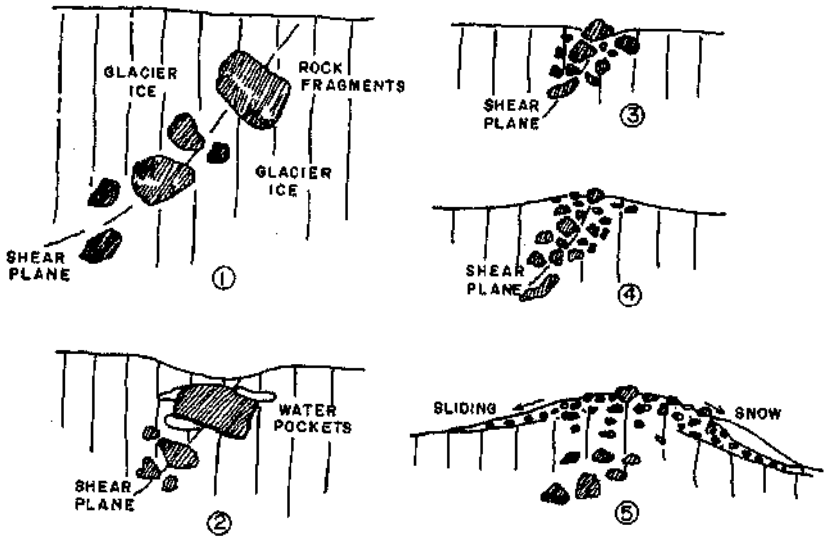

fig. 7. Adopted from Souchez (1968):

1. Lateral shear plane in glacier materialised by rock fragments
2. Hot house effect due to presence of rock fragments near the glacier surface
3. Concentration of frost shattered fragments at the surface
4. High concentration of frost shattered fragments. Protection against ablation due to insulating effect
5. Moraine developed by sliding of the rock fragments on the ice

be augmented in the Wohlthat mountain region to enable delineation of significant features for proper synthesis of glacial geomorphological processes.

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