LANDFORM OF MT. RIISER-LARSEN, AMUNDSEN BAY, ENDERBY LAND: RESULTS OF A PRELIMINARY SURVEY

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Abstract: Reconnaissance survey of the Mt. Riiser-Larsen area, Enderby Land, was carried out by Japanese field party in February 1982. Geomorphological observation and airphoto interpretation enable us to describe some geomorphic features of the area. Glaciated landforms and the classified morainic features appear to indicate the following events: The formation of alpine landforms prior to the growth of the ice sheet, inundation by the expanded ice sheet up to the summit, retreat of the ice sheet to the present level intervened by one considerable standstill, formation of local cirque glaciers and their extinction. The major ice retreat might have taken place before the last glaciation of the Northern Hemisphere.

1. Introduction

The Enderby Land, marked geologically with its oldest crystalline basement in Antarctica (BLACK and JAMES, 1982), constitutes part of East Antarctica, and is characterized geomorphologically by a noticeable northward bulge of its coastline, as is sometimes called a peninsula. Many mountain peaks or massifs of alpine form and fewer low-lying coastal rock exposures are distributed widely in the area.

The Mt. Riiser-Larsen area is situated on the coast of Amundsen Bay, and forms the northwestern edge of the Tula Mountains (Fig. 1). A Japanese field party consisting of five men visited there in February 1982 for geological and biological reconnaissance surveys. A two-day survey by the senior author and the interpretation of about 1:70000 scale airphotos provided by the Australian Bureau of Mineral Resources gave a chance to examine geomorphic features that are considerably different from those in the Lützow-Holm Bay region west of the Enderby Land. The results of the survey are preliminarily reported here for future detailed investigation.

2. Bedrock Landform

The Mt. Riiser-Larsen area with the maximum height of about 800 m is about 15 km long east-west and 6 km wide north-south. The south end faces a deep inlet which might have been occupied by the outlet glacier in the past, and the north is bounded by the ice sheet. A frozen marginal lake (Richardson Lake) of 5 km long is situated between the ice sheet and the western part of the mountain, and less distinct frozen lakes seem to exist at the northeastern margin.

The bedrock of the area is composed of highly metamorphosed rocks such as granulites and charnockite belonging to the Napier Complex (SHERATON *et al.*, 1980). These rocks themselves are rather massive and gneissose structure is rarely seen. How-

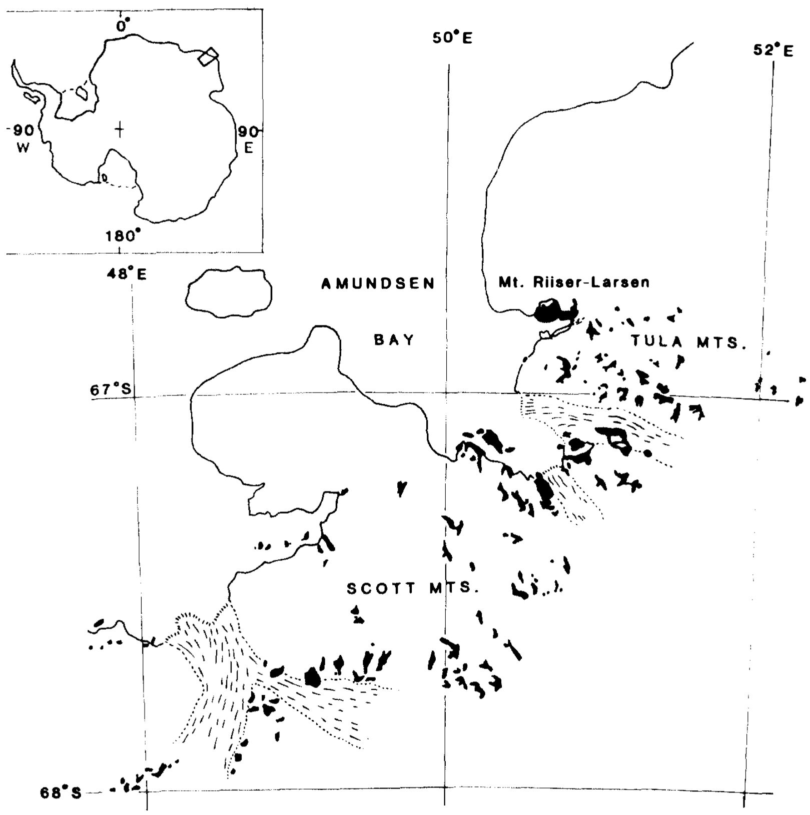

Fig. 1. Location map of Mt. Riiser-Larsen, Amundsen Bay.

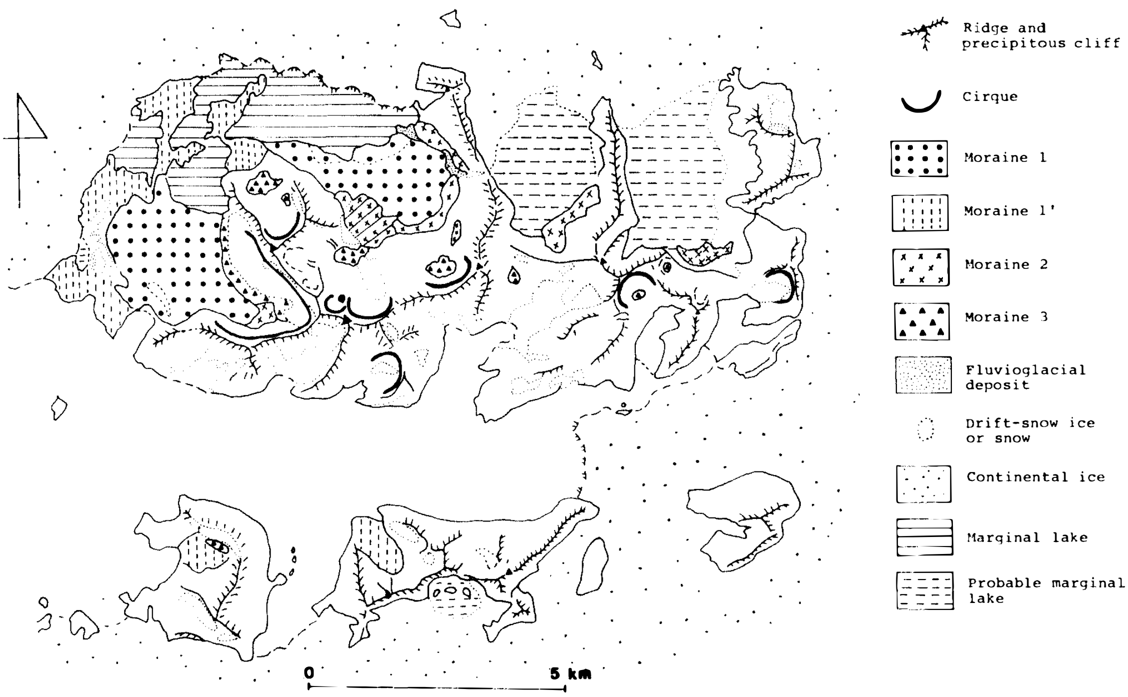

Fig. 2. Geomorphic map of the Mt. Riiser-Larsen area.

ever, the layered structure of the bedrock, derived presumably from original sedimentary rocks (MOTOYOSHI and MATSUEDA, 1982), is well developed as a whole. The long axis of the mountain extends roughly in the east-west direction conformable with the trend of this structure. The mountain has been dissected by glacial and periglacial erosion to form aretes, or knife ridges, in most part, rarely leaving flat or gentle slopes. Four long and one short ridges extend in the direction perpendicular to the long axis of the mountain on the north side, being controlled mostly by the joint system (Fig. 2). The main ridge and these subsidiary ridges surround the low-lying basins on three sides. The bottom of the two of these basins is covered almost completely with moraines, and that of the eastern two is filled with ice which is inferred to be underlain more or less by water layers on the basis of airphoto interpretation of its surface condition (probable marginal lakes in Fig. 2).

Fig. 3. A cirque with basins, sills and moraines.

The ridges form distinct cirque walls in several places. In particular, well-developed cirques with small moraine heaps are distributed on north- or northwest-facing slopes (Figs. 2 and 3).

3. Moraines

Morainic deposits distributed in the northwestern part of the mountain can be classified tentatively into four groups on the basis of their topographic situations, morphology, and degree of weathering. They are as follows:

1) Moraine 1 constitutes wide low-lying basins with remarkably flat surface. Its surface weathering is advanced in comparison with that of Moraine 2 or Moraine 3. Sorted patterns are also developed on the surface in many places. Many of cobbles and boulders in the deposit are angular, but subround ones are often found. It in-

cludes some exotic rocks which are different from bedrocks surrounding the basins. A chaotic depositional facies of the moraine without ice core crops out at a cliff about 15 m in height along a meltwater stream. The maximum thickness of the moraine is difficult to know because of the lack of exposure of underlying bedrock, but is estimated to be more than 30 m based on the relative height between the meltwater stream bed and the upper surface of the moraine. A lower part 200 m wide and 2 km long, marked with an indistinct steep slope 2 to 5 m high (a dotted line in Moraine 1 in Fig. 2), occupies the northeastern margin of Moraine 1 surface. This lower surface is composed of larger fragments like lag concentrates (FLINT, 1971), and suggests that the meltwater formed at the margin of the ice sheet during the retreat washed the surface. Moraine 1 is thought to have been deposited by the ice sheet during its standstill of retreat from the area on the basis of topographic situation and depositional features. The inference is partly supported by the fact that a facies of a ground moraine exposed at the foot of a cliff of the present ice sheet north of the marginal lake is similar to that of Moraine 1.

2) Moraine 1′ thinly covers the undulating bedrock in the northwestern part of the area, and seems to continue smoothly to Moraine 1. It was deposited possibly in almost the same stage as Moraine 1. Difference in bedrock topography might have made it a thin ground moraine.

3) Moraine 2 is distributed in places adjoining the southern margin of Moraine 1. Surface topography of Moraine 2 is characterized by uneven features. In particular, the area indicated by hatching in Fig. 2 consists of several mounds 20 to 100 m in relief. This uneven and relatively less weathered surface and the topographic situation to the mountain slopes suggest that Moraine 2 was formed by cirque glaciers which occupied the north-facing mountain slopes, considerably after the formation of Moraine 1 (Figs. 2 and 4).

Fig. 4. A cirque and parts of Moraine 2 (foreground) and Moraine 3.

4) Moraine 3 consists of small-scale heaps accumulated on a cirque bottom or at a lower end of cirque-like depression. Some are formed as protalus rampart along the lower margin of the existing drift-snow ice. This moraine was probably formed by shrunken cirque glaciers, in part as protalus rampart.

4. Some Characteristics of the Geomorphic Development

It is difficult at present to know correctly from direct evidence whether the mountain was covered completely by the ice sheet at its maximum stage of expansion. However, airphoto interpretation shows that two gentle slopes near the crest are covered with superficial deposits. These deposits appear to have been formed by the former expanded ice sheet in view of their distribution. No sign of areal scouring (SUGDEN and JOHN, 1976) is found in the area, but the selective linear erosion by the former ice sheet is indicated by the inlet south of the mountain where the erosion by a former ice stream exerted lateral glacial abrasion up to the altitude close to the crest line. Therefore, it is probable that the ice sheet once covered the mountain completely.

Then, the ice sheet retreated from the upper portion of the mountain, covered the intervening low-lying basins between ridges up to about 200 m above sea level for some period of time, and deposited ground moraines to form Moraine 1. This fact also suggests that the outline of the mountain form with ridges and depressions of glacial and periglacial origin had been formed before the inundation of the ice sheet.

The mountain or cirque glaciers formed on the mountain slopes after the emergence of the upper portion of the mountain from the ice sheet modified to some extent the landforms which had already been moulded by cirque glaciation or nivation prior to the ice sheet cover, and deposited Moraine 2. Direction of striation on the bedrock of a cirque bottom indicates presence of such cirque glaciation.

The ice sheet retreated again to the present position. The narrow lower surface with lag concentrates in the marginal part of Moraine 1 suggests that wash of till by meltwater might have occurred along the ice sheet margin during the retreat possibly associated with a short standstill. The cirque glaciers receded to near the crest line and deposited Moraine 3. A part of Moraine 3 settled on margins of cirque glaciers or drift-snow ice as protalus rampart. A long bank of recent protalus rampart can be seen along the drift-snow ice in a cirque in the western part of the mountain. Most of cirque glaciers have disappeared by this time.

It was impossible to find the evidence of repeated advance and retreat of the ice sheet. At present, the landform of this area is interpreted as formed by single retreat of the ice sheet with one standstill intervening between the maximum and the present. No data were obtained on the geochronology of the events. However, the degree of weathering, especially of Moraine 1 and bedrock, though only by visual observation, seem to indicate that the area was not covered by the ice sheet during the last glaciation of the Northern Hemisphere. If this interpretation is correct, the view that the East Antarctic ice sheet expanded up to the outer margin of the continental shelf during the Wisconsin Glaciation and buried most part of ice-free areas (STUIVER *et al.*, 1981) does not apply at least to the Enderby Land. In the Lützow-Holm Bay region west of the Enderby Land, the main ice retreat is thought to have occurred also prior to the Late

Wisconsin ice retreat (YOSHIDA, 1983). It is difficult to know at present whether the above-mentioned ice retreat out of phase with that of the West Antarctic ice sheet took place in the wider margin of East Antarctica other than in the Enderby Land and in the Lützow-Holm Bay region. The Enderby Land is situated in a northward protruding position and so it has a dome shape relatively isolated from the main Antarctic ice sheet. This situation may cause the fluctuations in ice cover different from those in the main land. In addition, ice discharge by outlet glaciers at the southeastern and the southwestern ends of the Enderby Peninsula is thought to play an important role in mass balance of this area (MORGAN *et al.*, 1982). These outlet glaciers also might have discharged a considerable amount of ice during the past ice expansion and thus controlled the ice behavior of the Enderby Land, because the deep drowned glacial troughs are found in immediate offing of the glacier terminals. Such local condition also appears to affect the fluctuation of ice level in this area. In any case, the data are scarce for adequate discussion of the above problem. It seems important to know the regional picture of ice cap fluctuation in this area by means of detailed geomorphological survey, not only for the understanding of regional characteristics of glacial history but also for the elucidation of the East Antarctic ice behavior.

5. Concluding Remarks

On the basis of preliminary ground survey and airphoto interpretation, some geomorphic features of the Mt. Riiser-Larsen area are mapped and described. The glacial drifts are classified into four moraine groups. Geomorphic development of the area in connection with the retreat of the ice sheet and cirque glaciers is inferred from the glaciated landforms and the characteristics of the classified moraines.

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