CHINESE GEOGRAPHICAL SCIENCE
Volume 3, Number 2, pp.179—186, 1993
Science Press, Beijing, China

DISTRIBUTION OF PERIGLACIAL GEOMORPHOLOGY AND THE RELATIONSHIP BETWEEN PERIGLACIAL GEOMORPHOLOGY AND GLACIATED HISTORY ON FILDES PENINSULA, KING GEORGE ISLAND, ANTARCTICA

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ABSTRACT: As for the formation of the submerged trough of Maxwell Bay and the external agent geomorphic—phenomena of Fildes Peninsula, we can use glaciated theory to explain them. Moreover, based on a large number of field investigation by foreign colleagues and the authors, we can consider that the last glaciated ice—stream which had a great effect on current periglacio—landform distribution, mainly flowed along the direction from northwest to southeast. The periglacio—geomorphic distribution of the peninsula has a deep brand of glaciated history. Three kinds of different profile assemblage features show that the periglacial landform have an internal relationship in genesis. They also show a difference between stoss and leeward slopes by glaciated effect.

KEY WORDS: Fildes Peninsula, periglacial geomorphology, glaciated history

Fildes Peninsula is located at the southern ice—free area of King George Island of the South Shetland Islands of Antarctica. It is 10 km long, 2.5—4 km wide, and covers an area of 30 km^2 or so. Its highest point—Huoshanjing (Horatio Stump) is 164.2 m a.s.l. According to meteorological data obtained 1985—1988 at the Great Wall Station, the mean annual air temperature is −3.3℃, and mean annual precipitation is about 605 mm. Before establishing the Great Wall Station foreign scholars have investigated geology and geomorphology of the area[1—2]. After building the station in 1985, Zhang Qingsong and Xie Youyu et al. have ever investigated the landform feature and the chemical weathering feature[3-4]. Based on the previous works during the fourth and fifth Chinese Antarctic expeditions of 1987–1989, we carried out many times of field investigations in distribution of periglacial landform and the relationship between the periglacial landform and the glaciated history on Fildes Peninsula[5].

I. GEOLOGY AND ENVIRONMENT BACKGROUND

Regarding Fildes Peninsula, its east is Maxwell Bay, south is Fildes Strait and Nelson Ice Dome, northwest is Drake Strait and wide skerries belt, and northeast is Collins Ice Dome which covers 90% area of King George Island. King George Island is the biggest one (area is 1,160 km^2) on the South Shetland Islands. It and its southwest series islands not only consist of the main body of the South Shetland Islands, but also are essentially part of Scotia Ridge[1] (Fig.1), being composed largely of Jurassic to Tertiary volcanic and sedimentary rocks associated with lines of structural weakness[6]. Volcanic activity has

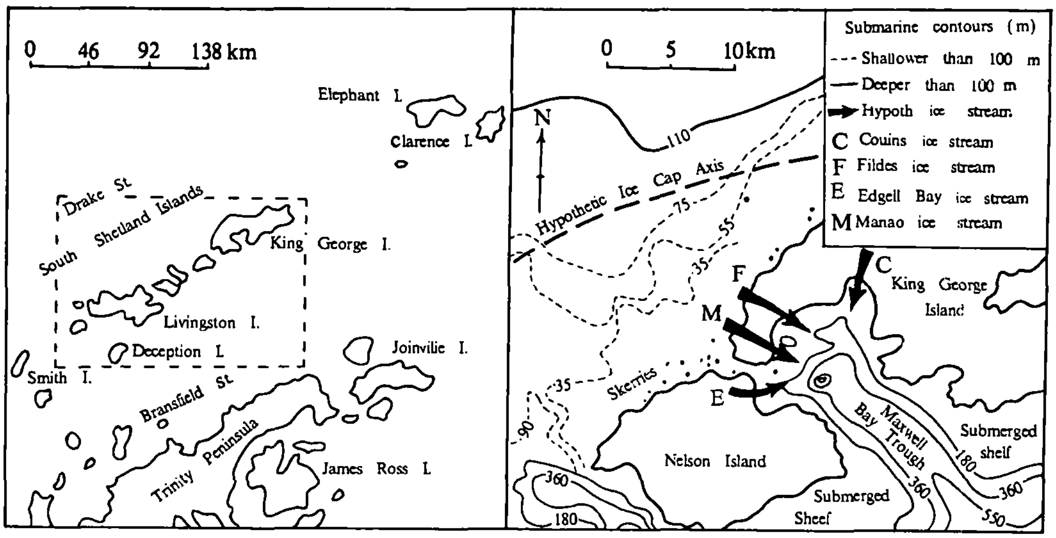

Fig.1 (a) Geographical situation of the South Shetland Islands; (b) the submerged trough in Maxwell Bay as well as hypothetical directions of ice movement during the Pleistocene (modified from B.S. John Fig.2)

continued through the Quaternary on a smaller scale[7], and in recent centuries Bridgeman Island and Deception Island have experienced eruptions[8]. Areas of alpine relief are limited to parts of Livingston Island and Greenwich Island. There are a few nunataks in the interiors of the islands, while the exposed northern shores are characterized by a wide belt of skerries. The most part of the landscapes are dominated by low ice–domes fringed at the coastline by ice cliffs[9]. According to investigations by Liu Xiaohan et al.[10] , Fildes Peninsula mainly consists of basaltic lava. Thin pyroclastic—sedimentary rock only exposes on Fossil Hill, Half Three Point and the north of Ardley Island. Central and south parts of the peninsula are mainly thick layer agglomerate lava and subvolcanic rock. By the analysis of stratigraphic structure and isotopic age determination, it shows that the volcanic activity from Eocene epoch continued through Oligocene epoch. Early eruption centre concentrated on the west of the peninsula, afterwards, it transferred to the east. Its rock layer shows a gentle monocline, no obvious horizontal compression were experienced.

II. DISCUSSION ON GLACIAL EROSION AND MORAINIC TOPOGRAPHY

Foreign scholar[1] and expeditionary ship have discovered that a submerged trough of 128—730 m deep lies below surface of Maxwell Bay. According to the trough trend which shallow place in northwest and deep in southeast, foreign colleagues inferred that the trough has a glacial erosion feature, it was formed by a powerful ice stream in Weichselian period flowing from northwest to southeast. Fig.1 (b) is submarine contours below Maxwell Bay surface suggested by B.S. John[1]. He considered that ice stream F is a main ice stream which runs northwest to southeast across the waist of the peninsula, and forms erosion to Maxwell Bay (Ice stream M is another main ice stream suggested by the authors).

By many times of actual field investigations, we consider, on the one hand, glacial—erosion theory can be used to explain a large number of glaciated and moraine landform of the peninsula with west high and east low topography. Because in Pleistocene epoch, Antarctic ice—sheet general direction. Tectogenesis formed main style of topographic relief at that time, yet extensive glacial erosion further reformed the style. Today we can see a forceful evidence, for example, in north of Korean King Sejong Station of King George Island, the ice stream of Potter Cove and Marian Cove flows from high (northeast) to low (southwest) with underlying relief. Therefore, the viewpoint can be established that the Pleistocene ice—stream ran northwest to southeast across the waist of the peninsula. On the other hand, B.S. John[1] suggested that the ice stream could erode the peninsula and form topography of "two high and one low" ("two high" means north and south tablelands, "one low" means Marsh central depression). We consider that John's opinion is not tally with the fact. The fact should be "three high and two low", that is, besides north and south tablelands and central depression, there is still a central highland which consists of Mingyueshan (132.8 m a.s.l), Fossil Hill (106.5 m a.s.l.) and Youyifeng (99 m a.s.l.), as well as Manaotan—Yuquanhe depression between central highland and south tableland. On the valley south shoulder of Manaotan—Yuquanhe depression, we can find numerous very typical glacial drift boulders (local bedrock are volcanic agglomerate and basalt, but the drift boulders are hard diorite and granite). On the bottom of the valley, we can see roche moutonnee with glaciated feature. If along the valley go to southeast, we can find the following landform features, we can see Unnamed Island which distance from seashore is less than half a kilometer, on the northwest slope of the island which faces the outlet of Yuquanhe valley is gentle slope (18° −20°). Besides a fan accumulation form which consists of fine and loose material, we seldom saw slump massive bedrock (volcanic agglomerate). But on the back southeast slope, we can see that the slope is steep (23° −31°), and the bedrock is cataclastic. On the foot of the slope there are numerous gigantic bedrock block (diameter of the long axis can reach to 3—4 m) for accumulation (because the bedrock slope is far away from seashore, we can exclude the effect of sea wave washing and sapping action). These phenomena can be used as a suitable theory to explain, that is, because the Yuquanhe ice stream flowed from northwest to southeast, it made the stoss slope to be pressed and become gentle, and leeward slope to be refrozen plucking and become steep as well as cataclastic.

The above—mentioned facts show, at that time, the main ice stream of running across the peninsula and eroding the Maxwell Bay should be two branches, but not one. That is, north branch was Marsh central depression ice stream (F in Fig.1 (b)), and south branch was Manaotan— Yuquanhe ice—stream (M in Fig.1 (b)). In regard to the intensity of the ice stream, B.S. John suggested that single ice stream F with main flowing direction and near perpendicular Collins and Edgell ice streams can erode and form the submerged trough with several hundred meters deep. We consider that his view is doubtable. But if considering two ice streams with main flowing direction, we can accept the opinion easily. It is worth notice that other region with highland topography were also covered by ice stream at that time besides the two main ice streams, but in those region, their ice body had less thickness and weaker eroding stress merely. The following periglacio—distribution feature can verify the effect of the glacial erosion on the other hand.

III. DISTRIBUTION OF PERIGLACIAL GEOMORPHOLOGY AND THE RELATIONSHIP BETWEEN THE PERIGLACIAL GEOMORPHOLOGY AND THE GLACIATED HISTORY

On Fildes Peninsula, besides "three high two low" relief as a whole, we can divide its topography into five grade terraces in detail. That is, first grade is from 2 to 6 m (a.s.l.), second from 6 to 10 m, third from 10 to 16 m, fourth from 16 to 20 m, and fifth is above 40 m (Fig.2). The main periglacial landform have periglacial tor, block sea, talus, block slope, debris island, block strip, sorted circle, sorted and nonsorted strip and nets, stone pavement, gelifluction step, striated soil, rock glacier, debris terraces, debris flower and gravel sorted circles of sea beach. In respect to the distribution, it is concentrative and complete on the southeast of the peninsula. In regard to profile feature, the periglacial landform can be divided into three kinds of typal combinations.

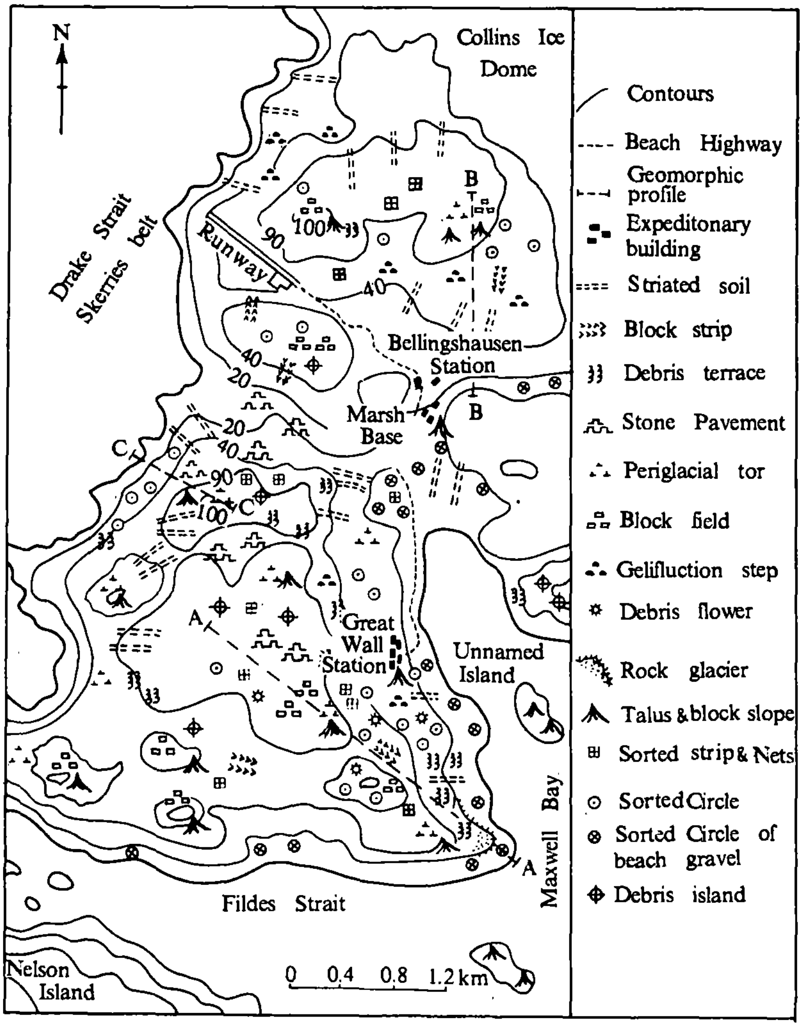

Fig.2 Distribution of five grade terraces and periglacial landform of Fildes Peninsula

1. On the line from the top of the south tableland with concentrated periglacial landforms to Shanhaiguan Hill (154.68 m) to Half Three Point (profile line A in Fig.2): we can see from high to low place, that periglacial evolutionary series is periglacial tor and block sea—talus and block slope—sorted circle, debris flower and sorted strip and nets—sorted circle, debris terrace and rock glacier—gravel sorted circle of sea beach.

2. On the line from Zuigaofeng Hill (156 m) of the north tableland with numerous and thick fine sediments to the beach of the Russian Bellingshausen Station (profile B in Fig.2): from high to low, we can see that periglacial series is periglacial tor and block sea—talus and block slope—stone circle—block strip and gelifluction step—striated soil—gravel sorted circle of beach.

3. On the line from Mingyueshan Hill (132.8 m) of central tableland which has finer sediments and large height difference between two grades terraces to Seal–beach of Biology Bay of west seashore (profile C in Fig.2): we can find that the profile feature has a large difference with the formers. That is, from high to low, the series of periglacial tor and block field–block slope–stone pavement and striated soil slope–mudy sorted circle–small snow bank–sandy beach.

In respect to the above–mentioned three kinds of different periglacio–geomorphic assemblage types, we consider that it has the following reasons.

1. All kinds of types have an internal relationship in their genesis. Generally speaking, lower forms are the inheritance and development to their adjacent higher forms. The material of active talus and block slope, for instance, both of them are provided by weathering debris from periglacial tor and bedrock slope at high place. But the talus and the block slope will experience processes of roll, smash, bump during moving downslope. After long time moving and weathering, their debris diameter will be reduced decreasingly. Furthermore, after long time accumulation in gentle belt, the debris also furnishes a coarse material base for all kinds of frost–thawing sorting and nonsorting forms (i.e. sorted circle, debris flower, debris isle, stone pavement and nonsorting strip and nets).

2. Owing to the above–mentioned reasons, on the line from Shanhaiguan Hill of south tableland to Half Three Point which have rich weathering debris, their dominant periglącio–landforms are talus, block slope with mass movement feature and megagrained sorted forms.But from the top of north tableland to the beach of Russian Bellingshausen Station, their debris material are gradually reducing. Beginning from the middle part of the profile, fine–grained periglacial forms, for example, gelifluction steps and striated soil etc. are gradually dominative. On the line from Central Highland to Seal–beach, since the debris source is less, talus only appears at the southeast side of periglacial tor and the hilltop, major periglacial forms are striated soil and muddy sorted circles. We can see that the sandy beach is extensive on the first grade terrace of the line, but few gravel sorted circles which appear very more on the east seashore can be seen.

3. It must be admitted that geology, glaciation history and postglacial periglacio–environment are the basic reasons to form above profiles and assemblage feature. In respect to particular volcanic rock and tectonics as well as main ice stream flowing direction from northwest to southeast in Pleistocene epoch, the northwest side of the peninsula is stoss slope and the southeast side is leeward slope. According to glacial erosion theory, on the leeward slope, by violent refrozen plucking, the bedrock is very cataclastic, moreover, on the postglacial period it would be easily weathered and spalled. And on the stoss slope, it would be mainly pressed, in the postglacial period, the bedrock mainly expressed a stress relief to form scaling of rock surface. But its breaking and spilling degree is not as violent as the leeward slope. It became clear that above–mentioned fact is just the root cause to the following phenomena. That is, more debris sources, more talus and more coarser–debris

sorted periglacio–types appear on the southeast side in the area, on the contrary for the northwest side. It should be said that the current periglacio–geomorphic distribution has been carved a deep brand of the glaciated history. Further, we can consider that the whole Fildes Peninsula in the glacial period, like a huge roche moutonnee experienced a complete glaciated process.

IV. CONCLUSION

(1) In regard to the formation of the submerged trough of Maxwell Bay and the external agent geomorphic–phenomena of Fildes Peninsula, we can use glaciated theory to explain. Moreover, based on a large number of field investigation by foreign colleagues and the authors, we can consider that the last glaciated ice stream which had a great effect to current periglacio–landform distribution, it mainly flowed along the direction from northwest to southeast.

(2) After the last glaciated erosion, the general geomorphic–pattern of the area only remains "three high and two low" (not "two high and one low") relief. In the last glaciated period, as for main ice stream which run across the peninsula, besides the branch of Marsh central depression, there is still a branch of Manaotan–Yuquanhe Valley, which flowed to southeast and formed erosion and accumulation. Today remaining drift boulder, roche moutonnee and scratch of the valley, as well as the different feature between the northwest and southeast slope of Unnamed Island, are just the historical traces of the main ice stream.

(3) The periglacio–geomorphic distribution of the peninsula has a deep brand of glaciated history. Three kinds of different profile assemblage features show that the periglacial landforms has an internal relationship in genesis. They also show a deference between stoss and leeward slopes by glaciated effect.

(4) Weichselian glaciated age and its hypothetical ice cap axis suggested by B.S. John[1] should be further verified.

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