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PRELIMINARY RESULTS OF INVESTIGATIONS ON SOME PERIGLACIAL PHENOMENA ON KING GEORGE ISLAND, SOUTH SHETLANDS

Abstract

The paper presents the preliminary results of geomorphological investigations being carried out in 1977/78 on ice-free shores of Admiralty Bay, King George Island. Effects of intensive frost weathering and structures of frost segregation, such as stone polygons, sorted circles, small stone stripes, gelifluction lobes have been observed. Structures of frost segregation are infrequent and weakly developed. Much more frequent and better developed are gelifluction forms occurring as lobes of various size and shape.

Some attention was also paid to slope profiles and slope processes. Almost all slopes show concave or convexo-concave profiles and are modelled by gravitative, gelifluction and washing processes.

Résumé de l'auteur

Dans le travail on a présenté les premiers résultats des études geomorphologiques effectuées en 1977/78 sur les côtes de la Baie d'Admiraly de l'Ile du Roi George. Sur les espaces non occupées par les glaciers on a observé des effets d'une altération de gel intense, les structures de la ségrégation par le gel comme par exemple des polygones de pierres, cercles jamelés, sols striés en miniature, etc. Les formes sont peu distinctes, pas trop nombreuses et pour la plupart mortes. Ce les formes de gélifluxion représentés par des langues de diverses formes et dimensions qui sont beaucoup plus communes et mieux développées.

Beaucoup d'attention l'auteur a consacré aux profils et aux processus de versant, Presque tous les versants se caractérisent par des profils concaves ou convexo-concaves. Il sont formés surtout par les processus de gravité, ceux de gélifluxion et le ruissellement.

INTRODUCTION

As a member of the Polish Antarctic Expedition 1977-78 the present writer had the opportunity to study some periglacial structures and processes on King George Island, South Shetlands. Field studies were mainly carried out on the southern ice-free shores of Admiralty Bay in the nearest terrain of Henryk Arctowski Station (Fig. 1). Because of difficulties in transportation and bad weather conditions the field survey has only sporadically been possible on the opposite side of Admiralty Bay (e. g. Keller Peninsula, Pt. Hennequin) and in the area lying farther of the Station (e. g. Pt. Demay). Thus the results of the investigations from 1977-78 are unsatisfactory and call for further studies. Continuation is especially needed relating to such processes as: frost weathering, downslope movement of waste, frost sorting, wind action, etc. At some sites the bench marks were installed but the results might be available after several seasons of observations.

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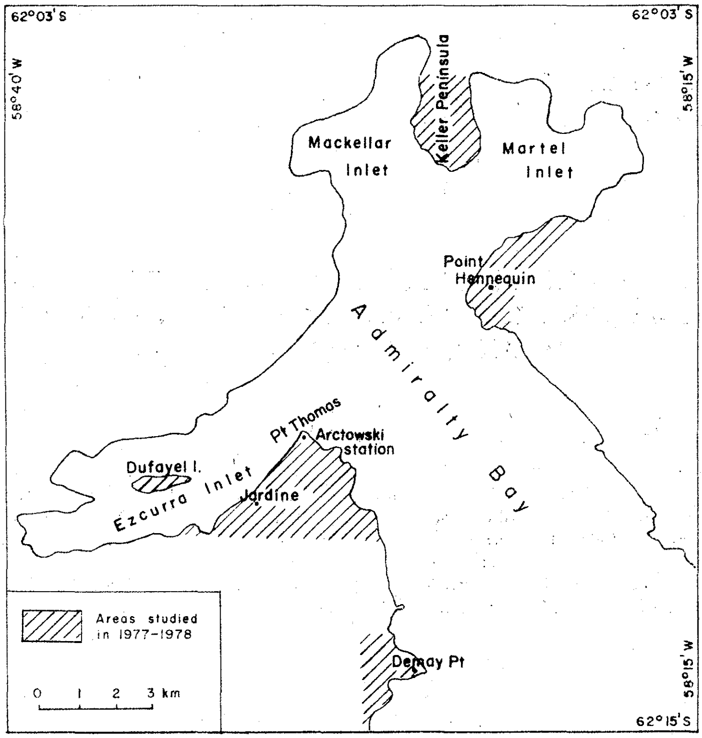

Fig. 1. Location of investigated areas

Climate of King George is cool but not severe. Winters are not very frosty whereas summer temperatures rise only few degrees above 0°C. However, the climate is very characteristic because of strong winds, mean speed of which is ca. 7 m/sec (gusts are even up to 50 m/sec), of high relative air humidity, of frequent rains and showers in summer and abundance of snow in the winter season. Mean annual air temperature is from ca. —1 to —5°C. The difference between summer and winter temperatures is rather low, reaching ca. 10°C (August: —8.1° and February: +2.4°C). Relative air humidity is high, being more than 80% during the whole year. Precipitation from April 1977 to March 1978 measured in the Station was 680 mm. The snow-line is situated relatively low, i. e. about 100—160 m above sea level.

Climatic conditions of South Shetlands are generally favourable for the development of glaciers which, as large caps, cover almost the whole area. Thus, only scarce nunataks and sporadically occurring small ice-free land surfaces along the shoreline are subject to weathering and other land-forming processes. On the exposed surface freeze—thaw is very important and operates intensively during autumn and spring time. In sunny days, just at the winter decline snow- and ice melting occurs on the sun-exposed slopes. During the nights the ground freezes again, whereas on slopes exposed to the sun the near-ground temperatures rose above 10°C (and even up to 20°C), the lee-sides (at the same site) experienced temperatures below 0°C. Hence, the rocks are heated during the day and freeze in the night. These daily freeze-thaw cycles produce intensive rock shattering and — in consequence — large quantity of waste, debris cones and bare cliff-like rock-walls successively re-exposed to weathering.

Land surfaces, near Arctowski Station and around Admiralty Bay, uncovered by glaciers, and also those mantled by ice sheet, are mainly built of volcanic rock units, i. e. tuffs, ashes, andesites, basalts (BIRKENMAJER, 1978) and in minor of slightly diagenesed sedimentary rocks (sandstones, shales, siltstones, conglomerates). Most of the rocks are readily to erosional processes.

Isolated permafrost occurs in the higher areas, about 150-200 m above sea level, generally in places where during winter the snow cover is thin. Thawing of ground (in summer 1977/78) measured on Pt. Hennequin, 250 m above sea level, was 30-50 cm. The depth of permafrost in unknown.

In low-lying terrains the measured winter freezing of ground is different and depends on the topographic location, the nature of the material and thickness of the snow cover. In the final part of the winter, an excavation made in the ridge, 50 m above sea level, showed that under a thin snow cover (snow was blown away) the ground was frozen down to 1.5 m, whereas in site near the shoreline, 3 m a.s.l., under a thick cover of snow the frozen layer of marine gravels and sands was only 15 cm.

Field obserwations of the distribution, the nature and thickness of permafrost and seasonal freezing are too scarce and therefore it is hardly possible to induce any general conclusions. Further studies are necessary.

Gelifluction mass movements, both flows and creep, are the striking phenomena. There are numerous debris- and mud tongues and smoothed slope surfaces with more or less regularly scattered waste material. Intensively shattered blocks disintegrated into fine debris occur commonly, whereas frost-sorted and frost-fissure forms are less frequent. On the shores of Admiralty Bay, several kinds of periglacial structures were found and shortly described below.

SORTED POLYGONS

Sorted polygons occur on surfaces near the Station and on the ridge situated along the glacier Ecology[1] at 100—150 m a.s.l. They are rather indistinct in appearance and composed of stones 10—20 cm in size, arranged in penta- and hexagonal polygons. Most rock fragments are oriented with their long axes parallel to the polygonal furrows, although some stones are set vertically. In polygon centres the rock fragments display no orientation. The polygons are 0.5—1.5 m in diameter though some forms reach 2.5 m in size. They seem to be rather inactive but some polygons still display little evidence of activity. Lichen covered stones in polygonal patterns can be the evidence of their inactive state. Lack and/or

[1] Most of the place-names marked on figure 2 have been proposed by K. BIRKENMAJER.

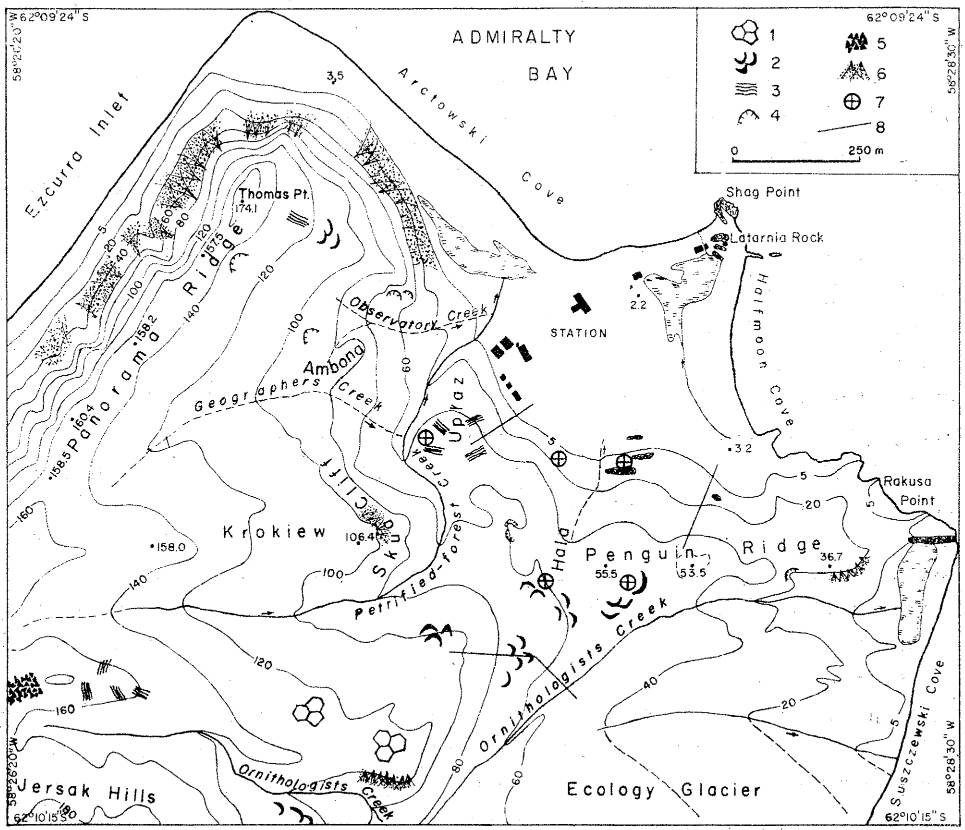

Fig. 2. Some periglacial phenomena occurring near the Polish Antarctic Station H. Arctowski

1. polygonal nets; 2. gelifluction lobes; 3. small stone stripes; 4. semi-active nivation niches; 5. blockfield; 6. debris glacis; 7. sites of detail investigations; 8. lines of hypsometrical slope profiles

weak activity of polygonal forms as well as slightly outlined appearance seem to be an evidence of short-time formation of the polygons and of changes in the climatic conditions.

SORTED CIRCLES

Sorted circles are much more common and occur on flat or slightly sloping surfaces at various heights above sea level. These forms were identified on marine terraces at the foot of Pt. Hennequin and on flat segments of the Pt. Demay slopes (Fig. 3, Pl. 1). The sorted circles have 2—3 m diameter; the borders of stones, surrounding the central parts consisting of fine material, are 50—80 cm wide and 10—15 cm high. Cross-section through these forms indicate that the stone ridges merge under the fine and wet central areas to the depth of ca. 50 cm. Below this depth there is no distinct differentiation into fine- and coarse material (Fig. 4, Pl. 2).

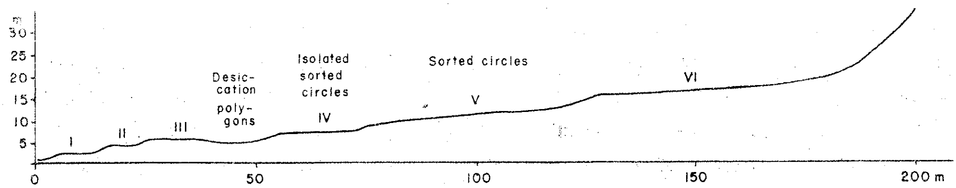

Fig. 3. Hypsometric profile through raised marine terrace at Pt. Hennequin

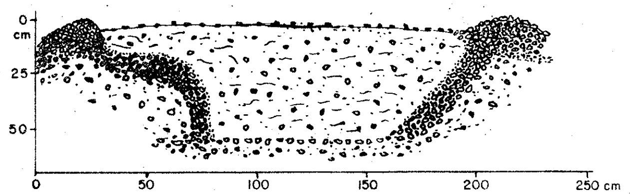

Fig. 4. Cross-section through sorted circle on the VI marine terrace at Pt. Hennequin

Sorted circles are very characteristic of Polar environments with permafrost, as for instance in Spitsbergen (JAHN, 1975). Although best developed where there is permafrost, they are also present in subpolar regions where permafrost is lacking, like e. g. in Iceland (STECHE, 1933) and in South Georgia (CLAYTON, 1977).

On the shores of Admiralty Bay the sorted circles occur most often in groups, although there are also single forms. Apart of large (2—3 m across) and well developed forms showing distinct appearance, one can find also small circles (1 m in size). Some circles are deformed having elipse-like ridges elongated downslope. The majority of circles, mainly of larger sizes, are inactive forms, entirely overgrown by lichens or, in places, show only very little activity as evidenced by new fines which rise to the surface. Small circles are more active forms in places where the ground is wet and contains abundance of fine material. Usually these are large and shallow depressions, sites below longering snow patches and/or at the base of break of slope line. Different stages of the development of sorted circles and dominance of inactive or semi-active forms result probably from climatic conditions althought possible decreasing evolution of the forms may be caused by reaching their maximal sizes (THORN, 1976).

SMALL SORTED STRIPES

Small sorted stripes are patterned ground having appearance due to parallel lines of coarser rock fragments and intervening stripes of finer material oriented downslope (WASHBURN, 1979). Such forms were observed in many sites nearby Arctowski Station, on the slopes of Pt. Thomas (Fig. 2) and Pt. Demay and on the Keller Peninsula. They occur on the surfaces sloping 3—5° and on more inclined surfaces, 10—15°, if only the ground contains enough of silty-sandy particles, and fine debris of 1—2 cm in diameter; coarser debris, of 4—5 cm in size, occur but sporadically. Stripes of fine debris are 3—5 cm wide and in cross--sections they appear to merge down to the depth of 7—10 cm. Beneath there is no visible segregation of material. Intervening stripes of silty-sandy material are 10—15 cm wide and contain only sporadic coarser rock fragments (Fig. 5, Pl. 4).

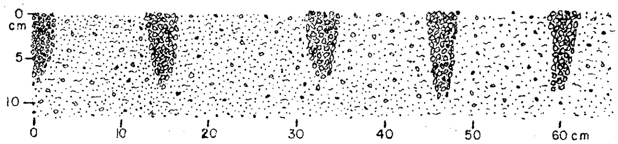

Fig. 5. Cross-section through the small stone stripes

MUD-DEBRIS TONGUES

Gravitative mass-wasting occurs in the all climatic zones. However in various regions it is differentiated and shows various intensity depending on many kinds of agents. It has been long ago observed that downflowing is strongly active under severe climatic conditions, where solifluction is especially characteristic kind of mass-wasting being typical process of periglacial regions and known under the term congelifluction or gelifluction (Andersson, 1906; Dylik, 1967; Jahn, 1975; Washburn, 1979).

Gelifluction is very active on slopes in the vicinity of Arctowski Station and the resultant forms are very common. The forms due to gelifluction were recognized also below the Pt. Demay peak, on the slopes of Jardine, Pt. Thomas, on the Keller Peninsula and in many other sites along the shores of Admiralty Bay. These forms are differentiated as regards their sizes, structure and appearance depending on the degree of inclination of the surface, moisture and grain-sizes of debris material. Some of these forms are arranged in steps.

On the slopes of Pt. Demay, mantled mainly by silty-sandy waste with only small addition of angular debris, the gelifluction lobes of considerable length were observed. They show distinct debris ridges and stripes almost entirely deprived of coarse material. Some lobes are more than 10 m long and only 1—1.5 m wide. The ridges and muddy stripes are parallel to each other what suggests the appearance similar to stone stripes. They are bent according to maximal declivity of the slope which attains here 10—15 °. These lobes, with rather low though distinctly outlined debris fronts end in place where inclination of slope rapidly diminishes. They are active during the period of snow-melting when the ground is very wet, having semi-fluid character and the top of seasonal permafrost still lying near the surface, presents a good sliding plane (Pl. 5).

Shorter lobes are developed at the foot of rock outcrops on Pt. Demay, on gently sloping surface characterized by abundance of angular, 10—20 cm, stones with blocks over 0.5 m across, whereas fine, silty-sandy material is in minority.

On less inclined surfaces, some shorter tongues are formed. These forms display indistinct sorting into silty and debris parts. On the flat surfaces occur characteristic forms, i. e. sorted circles and distinct vertically oriented stones in borders round the centres of fines.

Noteworthy is the fact that almost the whole slopes of Pt. Demay are deprived of vegetation. Vegetation cover composed of various species of lichens appears only in the top part and on the relatively gentle south slope of Pt. Demay. This may be an evidence of vigorous mobility of the waste material due to gelifluction and frost processes (numerous shattered blocks, angular debris, vertical orientation of long axes of stones).

Genetically similar forms, originating also due to gravitative downwasting, but shorter and wider, having almost the same relation of long and cross axes, were observed on the eastern slopes of the peak Jardine. The peak, like its nearest vicinity is built of massive volcanic rocks — basalts and andesites — which, due to weathering, are split into large blocks with very scanty fine fraction. Upper parts of Jardine are free-faces whereas in lower parts there is steep block field with stone steps occurring in the lower part of the block field. Surface inclination is great, more than 35—40°. Many blocks within the rubble field as well as those which participate in lobes are ca. 0.5 m across, and some of them are even more than 1 m in size. They are in general loosely arranged and unstable. Finer material appears just only in the bottom part of the block field and on the flattening of slopes as well as just below the fronts of debris lobes.

Debris lobes in the area near Jardine are characteristic because of their high and steep fronts, up to 1 m, width is about 2—4 m and their length is only a little greater. Worth of noting is considerable washing away of fines from debris-block mantle. Some lobes overlap sometimes each other and form steps and gelifluction terracettes on the slope. The nearer the slope-base the more abundant is fine-sandy waste what results evidently from washing away of fines from the higher and more inclined slope segments and accumulation on lower, concave slope parts. Similar fact has been observed by A. JAHN in Spitsbergen (JAHN, 1979).

Short and wide debris-mud (gelifluction) lobes showing well outlined and high fronts occur anywhere on slopes of considerable degrees and of high content of coarse material.

Dissimilar appearance have lobes on gentler (up to 10°) segments of the structural ridge (Penguin Ridge) situated south of the Station and on the structural flattenings of Pt. Thomas (Fig. 2). These surfaces are covered by fine-grained waste intermixed with stone blocks (sometimes over 1 m in size). Gelifluction lobes in these places display indistinct front- and side ridges of stones. The lobe--forms are marked mainly by greater accumulation of coarse material in the peripheral parts of the structures. Their fronts are scarcely 20—30 cm high and side ridges do not protrude over the surroundings. In these cases gelifluction produces flat tongues, some of which have a width up to 10—15 m with irregularly dispersed numerous blocks.

As results from the preliminary studies made in 1977 and 1978 on the ice-free

SLOPE FORMS

The form and nature of slope evolution were also the task of field observations made on the coast of Admiralty Bay. There is an irresistible impression that almost all the slopes in the area are modelled by free gravitative mass wasting and gelifluction with some efficacy of downwashing in places. This evidently argue for the common occurrence of debris cones joining into vast debris glacis, smoothed slope surfaces overmantled by waste, and numerous more or less distinct gelifluction streams. Almost all the slopes have concave or convexo-concave profiles. However, the most common are concave slopes showing three individual zones. The upper are free faces transiting up usually into a crest or rather narrow and flat top surface. The scree slope lying below the free face is characterized by a mantle of loose openwork debris shifted downslope with some admixture of silty-sandy material depending in amount on the kind of bedrock subject to weathering. And, the lowest one is the gelifluction (waning) slope zone of a very low inclinations with a veneer of fine material accumulated by gelifluction and slopewash. Such a kind of slope forms occurs in the higher terrains not long ago abandoned by glaciers and in the places where the whole slope is not yet covered with waste. Hillslopes of Pt. Thomas, Jardine, Pt. Demay, Pt. Hennequin and on the Keller Peninsula belong chiefly to this category.

Near the Station buildings the low hillslope of concave profile presents all the three characteristic segments of periglacially modelled slope, though free face prevented but partly from being consumed by the debris slope and overlain by waste. The gravity slope is the longest one and inclined at the angle of repose of the debris material which quite evenly mantles the slope. Downslope, this debris slope segment (or constant slope according to WOOD) merges into a low angled waning slope. The junction between these two parts is marked by a distinct break of the slope line. The waning slope is characterized by a high quantity of fines supplied from the upper parts. Coarser rock fragments being transported onto this almost level segment by rock falling or gelifluction are infrequent (Fig. 6).

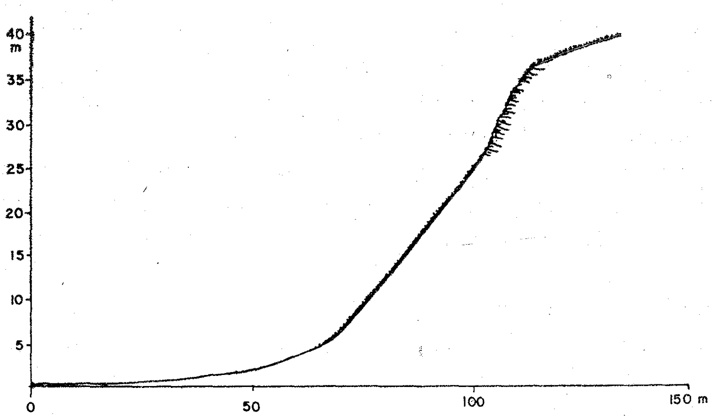

Fig. 6. The free face-, talus- and gelifluction slope near Arctowski Station

bedrock outcrops rising above a smoothed slope surface, abrupt breaks of slope and undercuttings controlled by geological structure. The veneer of waste mantle, composed in majority of sandy-silty material with a great amount of variously-sized debris, has generally inconsiderable thickness; it is often characteristically bedded with alternating layers of fines and coarser particles (Fig. 8). The thickness of slope deposits is as small as 0.5 m in some places but in others it is over 1-1.5 m, especially on the lower slope segments.

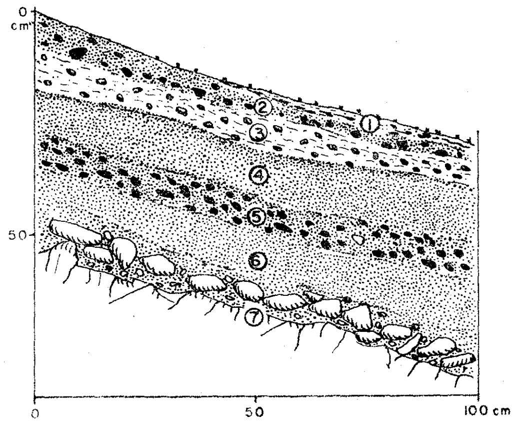

Fig. 8. Slope deposits in the Petrified Forest Valley

1. silty waste with streaks of humus; 2. light-grey fine sand with debris 0,5—2,0 cm in size; 3. brown silty-clayey waste with sporadic debris 5—8 cm in size; 4. light-grey fine sand; 5. fine sand with debris; 6. fine sand; 7. strongly weathered top part of bedrock

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