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PERIGLACIAL PHENOMENA IN THE OASES AND THE MOUNTAINS OF THE ENDERBY LAND AND THE DRONNING MAUD LAND (EAST ANTARCTICA)

Preliminary report

Geological and geomorphological field work in the area of the East-Antarctic crystalline complexes was carried out during the Antarctic summer season, from December 15, 1966 to March 12, 1967. Within the work programme of the geological group 12 SAE, led by M. G. Ravich and D. S. Solovev, investigations were undertaken in the Thala Hills Oasis area (the Soviet Station Molodezhnaya), Ongul Island (the Japanese Station Syowa), the coast of Lützow Holm Bay, the area of the shelf glacier in the surroundings of the Belgian—Dutch Station Roi Baudouin, high mountain areas and nunataks in the moutain ranges Yamato and Sør Rondane, the Wohlthat Massif where the geological camp was pitched, and in the Schirmacher Oasis area.

In addition to the geological mapping of these areas the working programme of the present author was directed above all towards mechanical disintegration of various types of Precambrian rocks in the East-Antarctic crystalline complexes [1] under extremely cool and arid climatic conditions (between the coast of the Southern Ocean and the South Pole glacier Plateau) and, further towards a glaciological and geomorphological investigation, whose main purpose was to contribute to the study of the paleogeographical development of the oases and high mountain areas.

With a view to studying mechanical weathering of crystalline

[1] Comp. E. Picciotto, J. Michot, P. Michot (1959); T. Tatsumi, T. Kikuchi (1959); T. Nakano, K. Kaji, Y. Harada (1960); T. van Autenboer, J. Michot, E. Picciotto (1964); E. N. Kamenev, L. V. Klimov, O. G. Shulyatin (1965); M. G. Ravich, L. V. Klimov, D. S. Solovev (1965); T. van Autenboer, W. Loy (1966); M. G. Ravich, D. S. Solovev (1966).

rocks, in addition to extensive field documentation (written evidence, photographs, sections, maps, sketches, etc.) many samples were collected which will serve in the lithologic-genetical-stratigraphic evaluation of the Quaternary geology of the areas investigated. More than 700 samples were taken from 224 documented localities. Materials were provided for the compilation of synoptic geomorphological and detailed covered geological maps.

This report presents the preliminary results of field investigation devoted especially to cryogeological problems.

From the cryogeological point of view the regions of oases and mountains under consideration in the Enderby Land and the Dronning Maud Land represent an ideal area where in various zones and various types of relief, cryogenic forms and processes (occurring in an extremely cold and arid nival climate) can be studied [2]. In mountain regions the temperature averages 8—10°C lower than that in the oases. The maximum temperature range of rock surfaces in the mountains at „warm" NW exposures is higher, for instance 20—30°C in the Insel area at 1500 m above sea-level.

The depth of the regelation zone of permafrost is very small: in the Thala Hills oases up to 0.8 m; in the Schirmacher oasis as much as 0.6 m; in the Insel area less than 0.4 m; in the mountains 2000—2600 m above sea-level it is 0.25—0.15 m; and on the nunataks of the border of the South Pole Plateau as low as 0.05—0.00 m.

Snow melting and depergelation of permafrost in weathered rocks and sediments were observed by the present author up to altitudes of about 2,500 m. Intensive sublimation occurs everywhere and that is why wetting of covering rocks is here but slight. Maximum vertical shifting of particles in the regelation zone at altitudes of about 2,000 m was recorded to attain up to 8 cm.

Within the framework of the investigation of gelivation processes, especially movements of material, various types of ice were recorded in addition to ice in glacier bodies (P. A. Shumskij, 1957; C. W. M. Swithinbank, 1959; V. Schytt, 1961; W. de Breuck, 1961; T. Van Autenboer, K. V. Blacklock, 1966; V. I. Bardin, 1966). These are:

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[2] G. A. Avsyuk, K. K. Markov, Shumskij (1956); T. Yoshikawa, H. Toya (1957); N. F. Grigoriev (1960); K. K. Markov (1960); A. Cailleux (1957); T. van Autenboer (1964); T. L. Péwé (1966) and others.

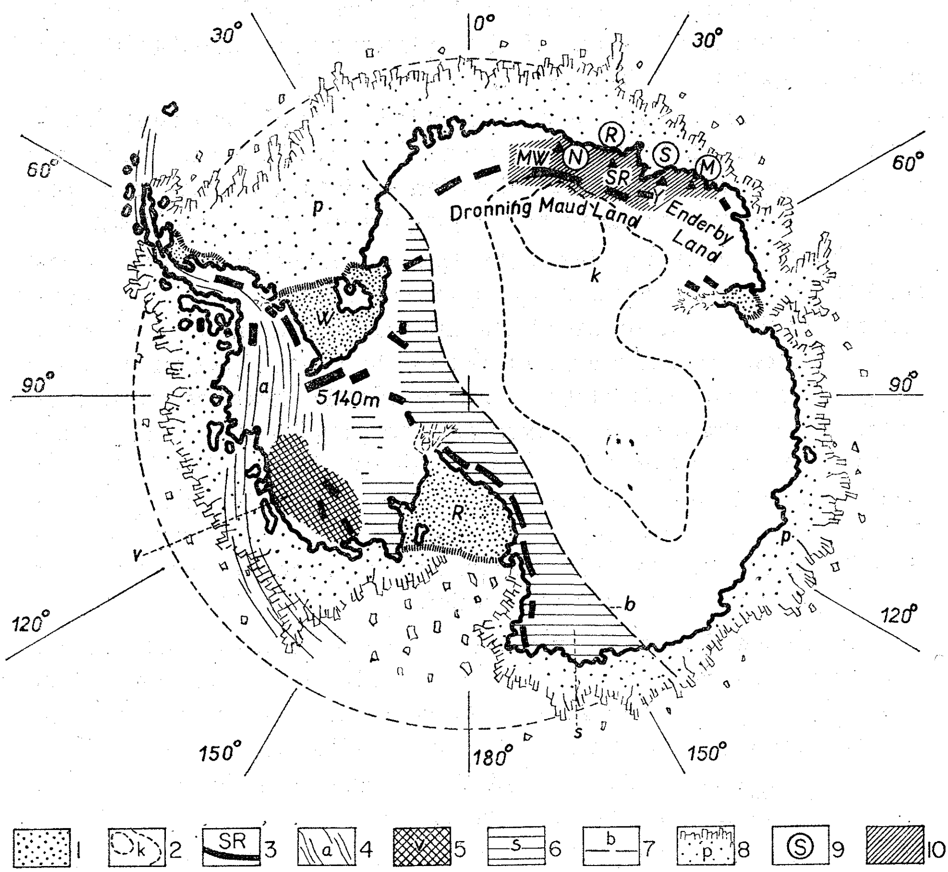

Fig. 1. Synoptic map of Antarctica

1. Weddel (W) and Ross (R) shelf glaciers; 2. top part of the Antarctic continental glacier; 3. mountain ranges: SR — Sør Rondane, Y — Yamato, MW — Wohlthat Massif; 4. young West-Antarctic mountain ranges (Antarctic Andes); 5. volcanic mountain ranges; 6. sedimentary platforms; 7. assumed western boundary of the East-Antarctic crystalline complex; 8. fast ice („pripai"); 9. stations visited by the author: S — Syowa (Japan), M — Molodezhnaya (USSR), R — Roi Baudouin (Belgium—the Netherlands), N — Novolazarēvskaya (USSR); 10. sphere of interest of geological group of the XIIth Soviet Antarctic Expedition (visited by the author)

(1) Cementation (homogeneous) ice, mostly in congelifraction deluvia, (heterogeneous "ground ice" affected mainly by migration of water in mollisol);

(2) Segregation ice occurring frequently in polygenic structures (note: "pipkrake" was not established anywhere because of extremely arid climate mainly due to wind action and intensive insolation);

(3) Sublimation ice (in skeletal development found at depths at a maximum of 0.1 m on deflation platforms and detritus, mostly at the peripheries of firn fields);

(4) Ice filled cracks (only in insolated parts of the oases; short--term occurrence). In mountain areas this type of ice in crevasses, passes — due to intensive sublimation — into a homogeneous cementation fissure ice up to non-homogeneous ice (permafrost).

Gelivation generally takes the form of congelifraction; the resultant forms are crevasses up to several tens of meters in width (especially in crest areas of mountains — comp. J. Sekyra, 1966), cracks, crashed down blocks up to congelifraction deluvia. In granitic rocks, especially porphyroblastic granosyenites, medium-grained granites, gabrosyenites, anorthosites etc. the structure of the rock is responsible for macrodesquamation; the latter, as well as some forms of the relief of a "trogschulter" type, weathering crusts and honeycomb relief are usually important morphological features referred to in the estimation of the paleogeographical development of the extraglacial relief.

Microgelivation was studied together with eolization on honeycomb forms. The development and distribution of honeycomb relief is of great importance in these areas, as it can be used in genetico-stratigraphic estimates of the sediments, the weathered rock mantle, and in the study of the paleogeographic development of the erosional (denudational) relief.

Honeycomb reliefs were found in rock exposures, on eluvia and sediments at various altitudes, and at various distances from the Antarctic coast. From the lithological point of view, the most typical forms as to shape and size were found in granitic rocks and migmatites (granites, porphyroblastic granosyenites, anorthosites, migmatitic gneisses, granulites, metadiabases, leucocratic gneisses with layers of amphibole etc.) i.e. mainly in rocks showing conspicous disintegration along vertical, oblique or horizontal joints. The maximum size of honeycomb cavities (aeroxysts) is of some 3 m. On the other hand, miniature forms occur on deflation reliefs in rocks showing gneissose structure (mostly crystalline biotite--amphibole schists, amphibole-pyroxene gneisses etc.). The frequency of occurrence of honeycomb reliefs and the degree of eolization (including accumulation of silicates on the surface of weathering crust) is directly proportional to the age of the relief on which they were formed. Very interesting complex observations which are

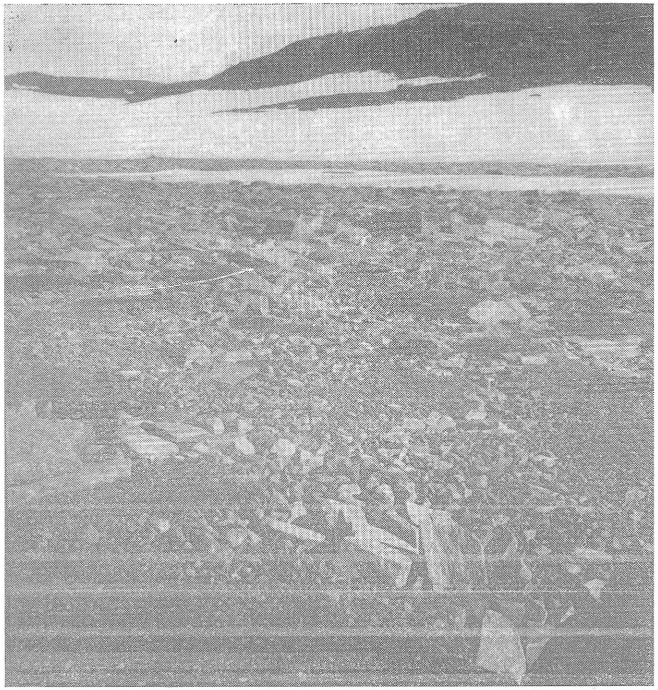

Photo by J. Sekyra, Feb. 10, 1967

Pl. 1. Polygonal structures. Central part of the Schirmacher Oasis

Sorting takes place during the Antarctic summer season in temporary wetted glacigenic deluvial material at the periphery of periodical lakes

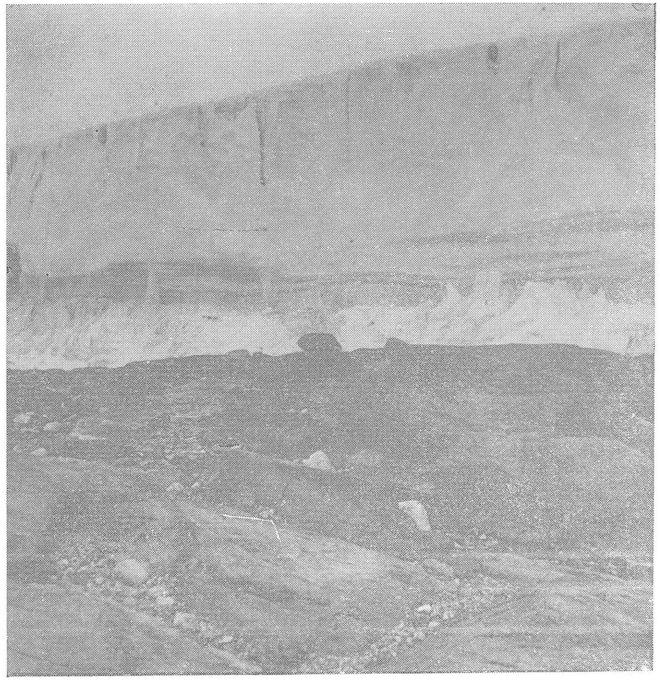

Photo by J. Sekyra, Feb. 10, 1967

Pl. 2. Snout of subcontinental glacier at the southern border of the Schirmacher Oasis

On a detersion-glacial relief old honeycomb forms are preserved, filled with glacigenic material from the last retreat

Photo by J. Sekyra, Jan. 25, 1967

Pl. 3. Southern part of Petermann's crests in the Wohlthat Massif — altitude of the shields is of about 3000 m

At the horizon of the plateau of the continental glacier from which glacier tongues more than 1 km thick with lateral and central moraines, move downwards to the north between shields and crests of mountains

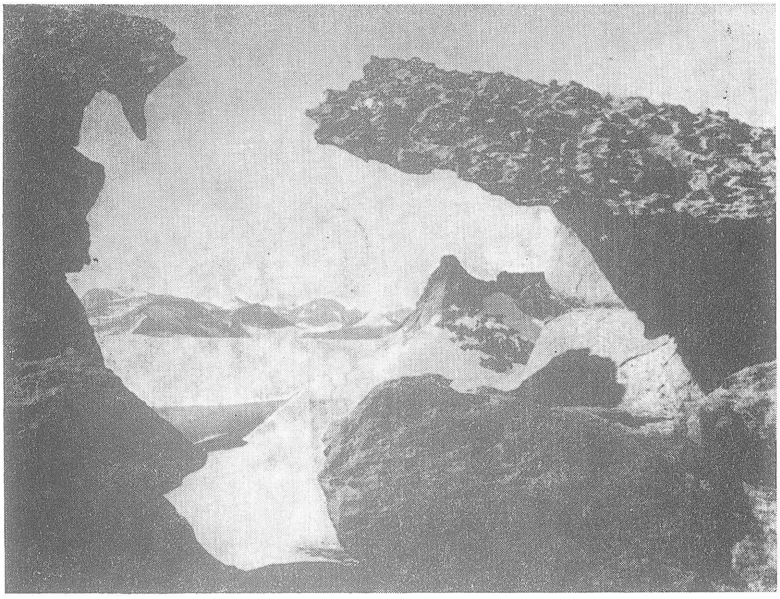

Photo by J. Sekyra, Jan. 25, 1967

Pl. 4. View through a huge honeycomb form (macro-aeroxyst), 5 m in diameter, in migmatites. Southern part of the Insel Massif in the Humboldt mountain range

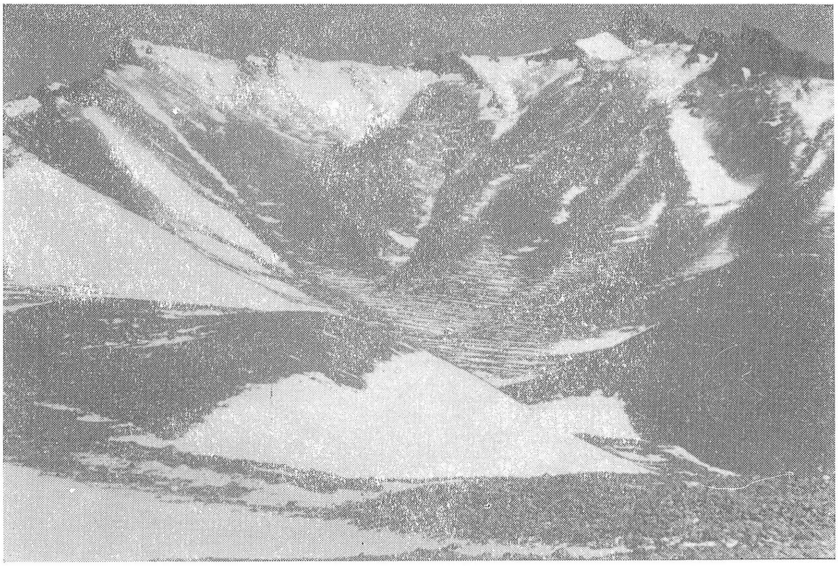

Photo by J. Sekyra, Jan. 2, 1967

Pl. 5. North-eastern slopes of the Wideröfjellet Massif (3180 m) in the Sør Rondane mountain range covered with deluvial and morainic detritus

In the background of the cirque debris avalanche accumulation, marked solifluction terraces; in the foreground lateral and central moraines from the last stage of mountain glaciation (Q_{R-1})

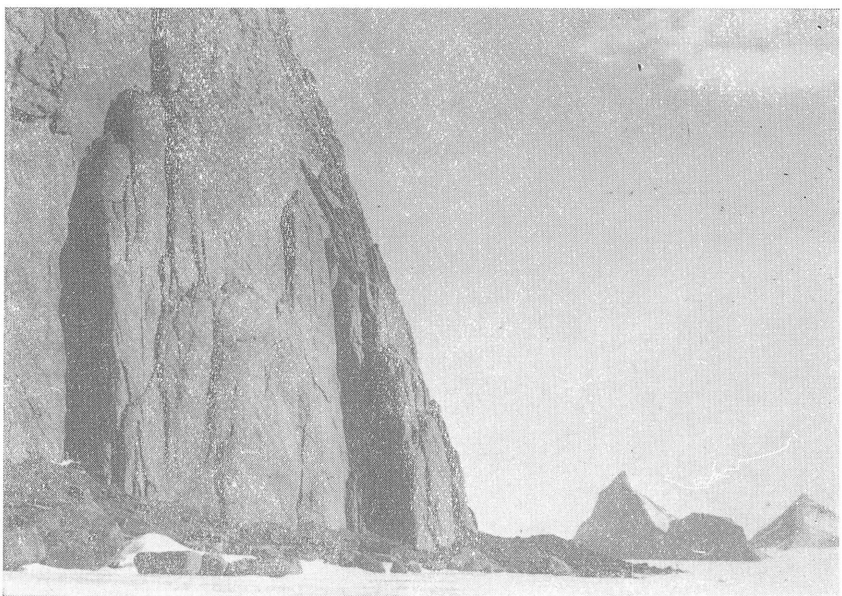

Photo by J. Sekyra, Jan. 17, 1967

Pl. 6. Trough walls built of „charnockites" in the upper portions with conspicious honeycomb relief. North-eastern part of the Petermann crests in the Wohlthat Massif

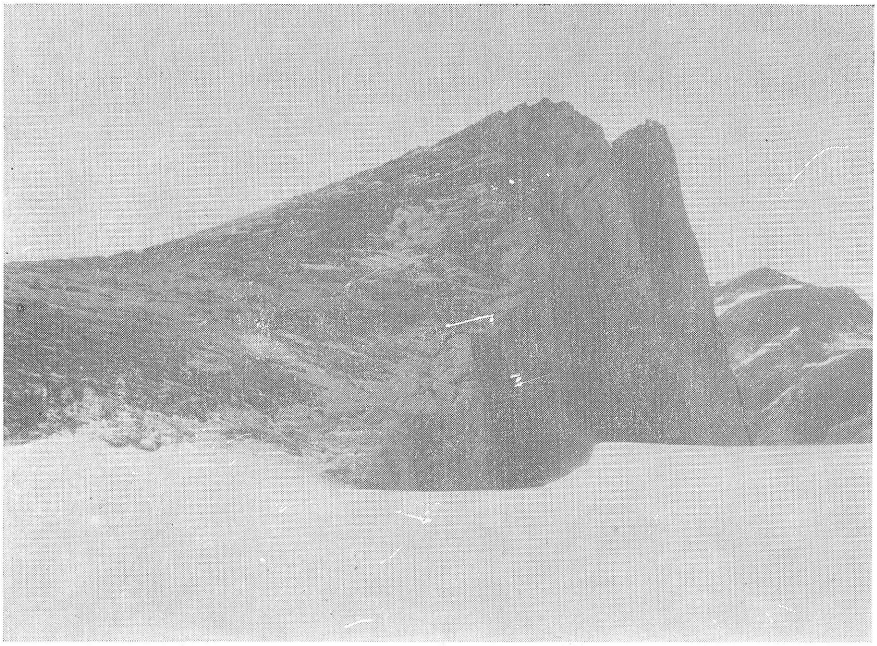

Photo by J. Sekyra, Jan. 2, 1967

Pl. 7. Northern part of granitic Pinguinane nunatak (1910 m) with relics of exfoliation plates above trough walls. Sør Rondane mountain range

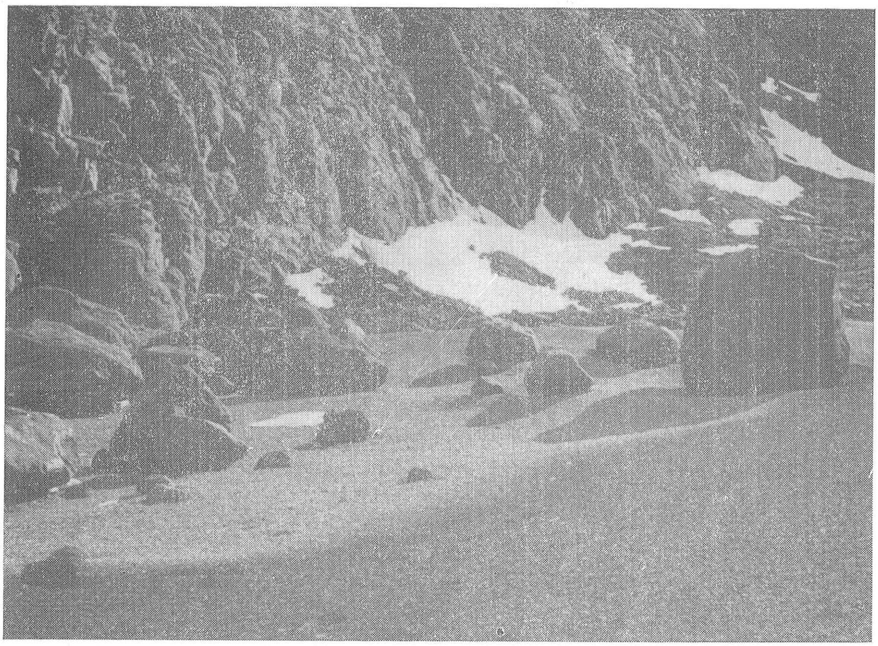

Photo by J. Sekyra, Jan. 15, 1967

Pl. 8. Deluvial debris of microgelivation origin redeposited by wind at the foot of a trough wall. Eastern part of the Curie Massif in the Wohlthat Massif

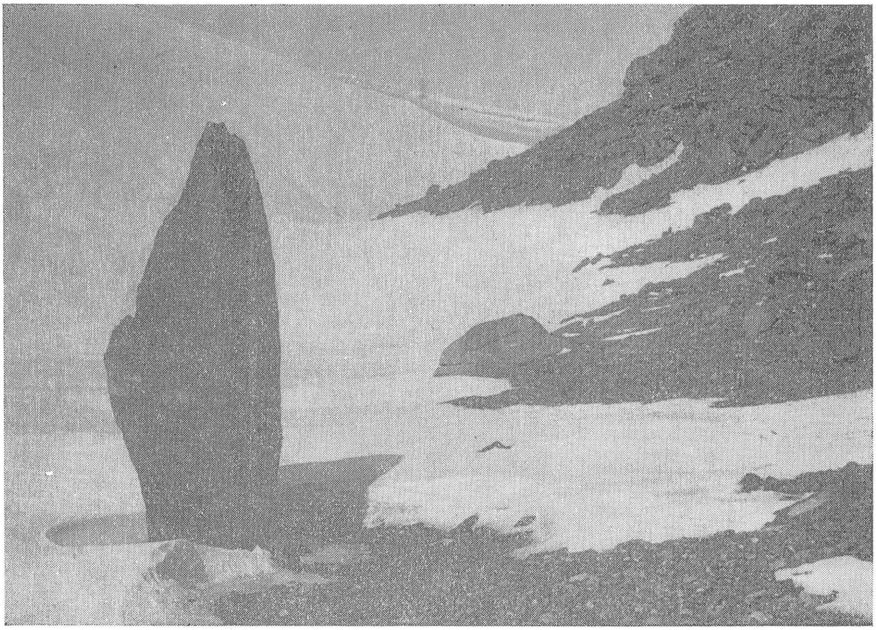

Photo by J. Sekyra, Jan. 15, 1967

Pl. 9. Syenite block oriented vertically by regelation (height 3.5 m) located in temporarily wetted morainic material between a border glacier wall and a trough wall in the northern part of the Wohlthat Massif at about 1300 m above sea level

Photo by J. Sekyra, Feb. 16, 1967

Pl. 10. Remnant of basal moraine on a detersion relief at the northern border of the Schirmacher Oasis (block of migmatite 4.5 m in diameter)

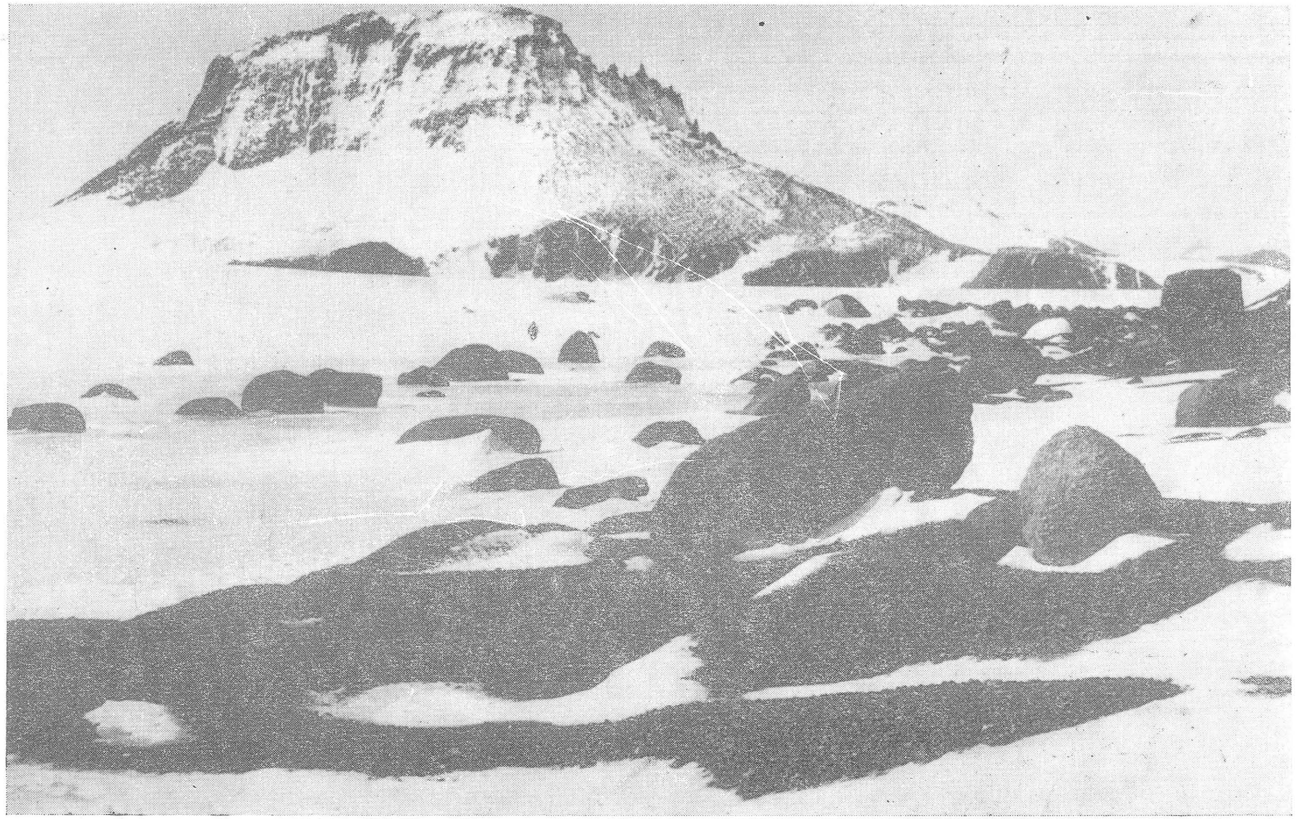

Photo by J. Sekyra, Jan. 15, 1967

Pl. 11. Microgelivation of charnockite boulders (up to 6 m in diameter) mostly subangular to rounded. Northern part of the Wohlthat Massif; in the background shields at Point 2170 m

Genesis — distintegrated desquamation plates and gravitational transport at the border of a valley glacier. Microgelivation debris accumulates around the blocks; it is partly redeposited by wind into drifts sometimes more than 1 m thick

Photo by J. Sekyra, Jan. 16, 1967

Pl. 12. Eastern foot of the central Petermann crest below Point 2530, built by a charnockite series and showing typical glacigenic modelling

In an old trough wall ($Q_{R\text{-}1}-Q_{R\text{-}2}$) a layer of dark amphibol differentiates occurs between light-grey syenites. In the foreground redeposited subangular disintegrated exfoliation plates

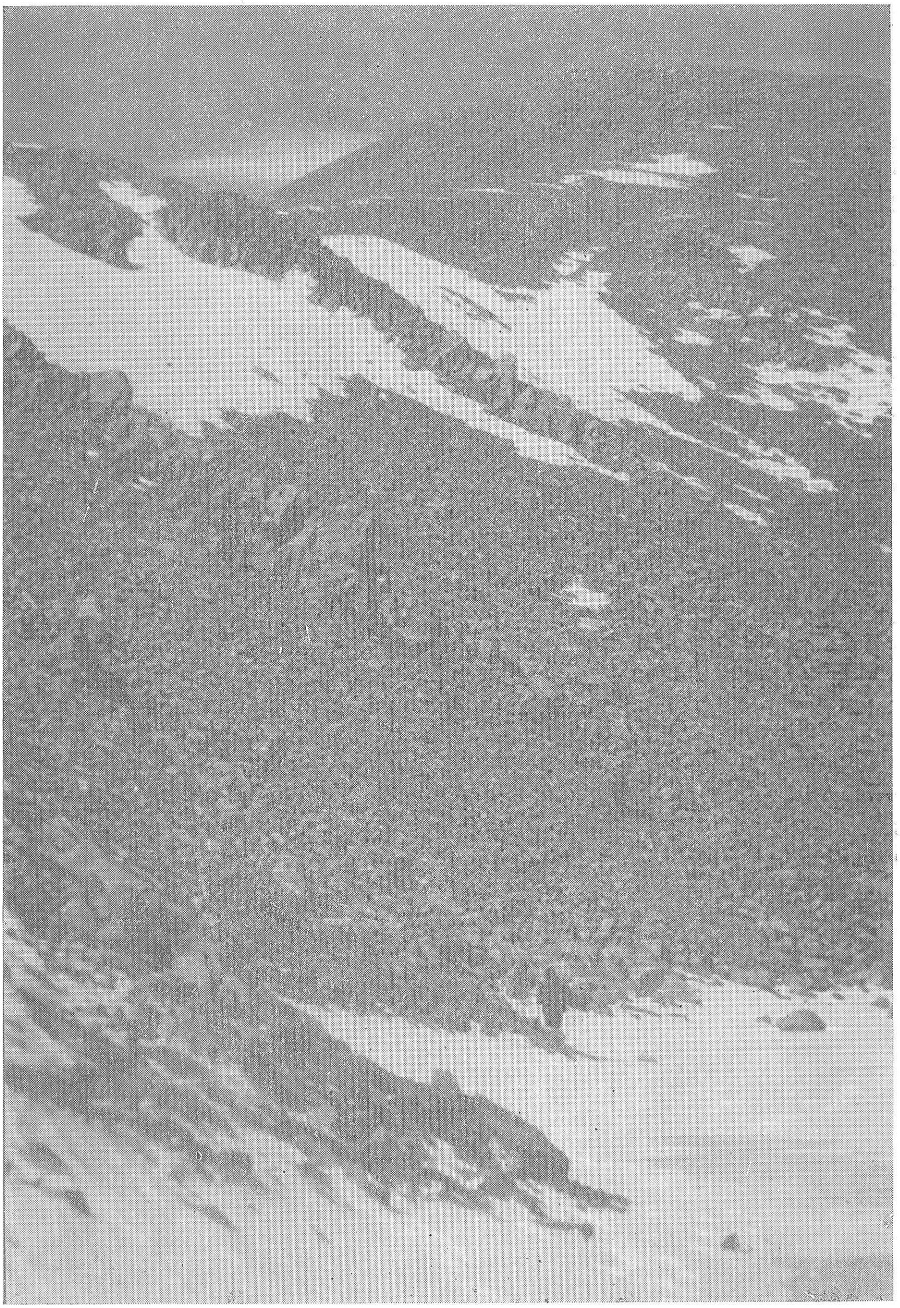

Photo by J. Sekyra, Jan. 2, 1967

Pl. 13. Selective mechanical destruction of amphibole gneisses in the Watnumfjellet Massif. Central part of the Sør Rondane mountain range

Sorting by gravity of the stony and gravelly material prevails of great importance for the stratigraphic identification of the relief, were made on *roches moutonnées* with honeycomb reliefs and striae. In addition to honeycomb reliefs conspicuous dish- and kettle--like forms were observed mostly on the horizontal surfaces of crags of granitic rocks. These forms and the above mentioned honeycomb reliefs are dependant on rock structure, humidity conditions, micro-gelivation processes and eolization (comp. M. A. Glazovskaya, 1958; P. Calkin and A. Cailleux, 1962; V. I. Bardin, 1966).

Contraction fissures were found primarily in deluvio-eolian up to glacio-eolian or micro-glacio-solifluction sediments of fairly remarkable thickness, mostly in depressions. These fissures often form squares 3—13 m in diameter; the material at their margins is poorly sorted. The maximum temperature range at the surface of sediments usually reaches up to 35°C. There are no favourable conditions for a perfect sorting; this is consistent with Romanovsky's equation (*l.c.* J. Sekyra, 1960).

Cryogenic segregation — structural forms. In the areas under consideration practically all the known segregation forms were found from micro- to macroforms (even of more than 10 m in diameter). Their size and shape have primarily been affected by the thickness of sediments and the depth of the regelation zone, and consequently also by the thickness of permafrost or the thickness of the underlying compact rock. Frequent facies gradations into clinotropic forms were observed.

The relative stratigraphic assignment of segregation structures was investigated on morainic accumulations Q_R—Q_{R-2}.

Vertical segregation and its resultant forms, i.e. "stone paved surfaces" were established in many depressions, usually at the margin of firn fields or in the surroundings of periodical lakes (in the oases).

Solifluction was observed on sediments ranging from rather fine-grained deluvial up to deluvio-eolian (see various resultant forms: solifluction terraces, garland structures, blocks shifted by solifluction etc.). From the ratio of solifluction sediments and deluvio-eolian accumulations it follows that the maximum solifluction phase of Q_R—Q_{R-1} age, corresponds, therefore, to a relatively warmer or more humid phase. The present-day climatic conditions, which are very arid, are not suitable for solifluction processes, in the high mountain areas of Central Asia (J. Sekyra, 1964).

Eolian erosion and accumulation. Eolian erosion (corrosion) does not only markedly affect sedimentation but also influences the final form of the microrelief (in: A. Cailleux, 1957). Conspicuous eolian corrosion (wind troughs, mushroom-like forms, honeycomb relief of various shape and re-modelled by wind) were found mainly in the areas of oases and on the deflation platforms of old Pleistocene morainic accumulations in mountain areas. Eolization processes closely connected with microgelivation have produced many typical forms of eologlyptoliths, especially in homogeneous compact rocks (quartzites, aplites, fine-grained granites, microdolerites, metabasites, etc.). Abundant eologlyptoliths and boulders at the level of a high morainal terrace Q_{R-2} and at older levels show considerable accumulations of Fe and Mn hydroxides and SiO_2 accumulations ("silicicrusts"). Both are significant in paleogeographic estimates; they were established only at older levels in mountain regions, mostly at altitudes of more than 80 m above the present-day glacier tongues; only in isolated cases they were redeposited at lower levels.

The thicknesses and the frequent occurrence of "silicicrust" are strikingly impressive in the southern parts of the mountain range at the border of the South Pole Plateau. The intensity of eolization and SiO_2 accumulation depends on the abrasion by crystals of the glacier, which at temperatures below —15°C show hardness of 6 on Mohs scale (C. Teichert, 1939), and also on the intensive sublimation of snow.

Accumulations of blown sands fairly considerable in thickness were established only in the lee of blocks at old levels of exposures, mainly at the margins of morainal fields. The maximum thickness of fine up to coarse blown sand (grain-sizes 0.1—1.5 mm) is usually of about 3/4 m; these accumulations were established on an outside of a glacial deflation relief at 80—100 m above the present-day glacier tongues. Eolian material is poorly sorted; opaque grains occur in coarse fraction only. Lithologically, the material agrees with the morainic material affected by gelivation (A. Monbeig, A. Cailleux, 1962). Transport of blown sands over fairly large distances was also observed. For instance, on the South Pole glacier Plateau on the slope of a continental glacier (area of the temporary aerodrome SE of Lützow Holm Bay), in depressions of a dish-like microrelief a sand-size particles of 0.1—0.4 mm was detected (the nearest nunataks were more than 25 km away).

In the Thala Hills Oasis region accumulations ranging from coarse-grained sand up to debris of eolian origin were found on relics of glacigenic (C. A. Z n a c h k o-Y a v o r s k i j, 1964) gravel or glacier gravel material redeposited by the sea in the depressions (furrows) of polygonal structures near Cape Granat. Eolian fillings of the depressions (T. L. P é w é, 1959) account here for absolute stagnation or consolidation of cryogenic segregation forms (centers 1.3—2.8 mm in diameter).

Accumulations of the coarsest eolian material were encountered in many localities in the Thala Hills Oasis (mostly eolian redeposited gelivation debris of microcline in the proximity of pegmatite dykes — fraction from 0.5 to 2.5 cm), further, in the mountains of the Wohlthat Massif accumulations of small gravel were found — fractions 1—3 cm composed of vein quartzs up to rock crystals with an admixture of pebbles of microdolerites and magnetite. This reveals a genesis by eolian redeposition of glacio-deluvial material in the lee of blocks and rock walls.

D e l u v i o - e o l i a n s e d i m e n t a t i o n with signs of stratification occurs at some localities in enclosed depressions between morainal walls Q_{R-1} (to Q_{R-2}?) in the area of the "Insel" group of mountains. In depressions as much as 50 m in diameter, accumulations of eolian and deluvial origin (mostly microsolifluction accumulations) lie at the bottom or on the gently grading slopes (up to 8°). These sediments are rhythmically bedded and show facies grading into fluvio-deluvial accumulations forming flat dejection cones.

From the m o r p h o g e n e t i c point of view, cryogeological processes, in addition to the glacigenic ones, can be counted among the most important agencies which played and still play to a considerable extent a role in the modelling of the relief. They have largely influenced the final development of the relief of the East-Antarctic crystalline complexes, which attained various degrees of galcigenic detersion (exaration).

Cryogenic processes may be said to have exerted a decisive influence upon a special type of selective denudation which was predisposed by the main geological structures (faults and dips) not only in oases and nunataks but also in mountain ridges.

The best marked differences can be observed in two types of rocks:

(1) m a s s i v e gabbro-granitic intrusive complexes showing distintegration into blocks, which appear in the terrain in the form of elevations, walls, castle- and tower-shaped forms, in the crest portions, cirques and trough valleys, macrodesquamation forms, most intensive honeycomb weathering, etc.;

(2) c o m p l e x e s of crystalline schists and gneisses (especially biotitic and biotite-amphibole gneisses) showing well-developed schistosity responsible for the production of tabular up to shard-like disintegration, whose resultant weathering forms are depressions (saddle depressions), predisposed parts of trough valleys, crevices), conspicuous segregation structure, gravitational sediments, gentler slopes, weathered rocks with a higher degree of chemical decomposition, small-scale forms of honeycomb relief, etc.

Between these two main groups there are many transitional forms which cannot be designated as rocks playing any important part in selective modelling.

In connection with the investigation of cryogeny, eolization and other periglacial processes and forms, some morphogenic elements significant for the paleogeographical development of the relief (between the coast of the Southern Ocean and the South Pole Plateau) were preliminarily established in various types of compact, as well as clastic rocks and on the eluvial mantle. Relics of detersion- and cryoplanation reliefs including striking glacigenic accumulations proved to be particularly relevant for the reconstruction of a comprehensive scheme of profiles (sections). In this scheme the material from the Wohlthat Massif area was primarily estimated (V. I. B a r d i n, 1966) with regard to the high mountain areas of Sør Rondane (T. van A u t e n b o e r, 1964) and the Yamato mountain range (Y. Y o s h i d a, 1961; Y. Y o s h i d a, K. F u j i w a r a, 1963). Some localities in foothill areas, especially in oases, after having been plotted on the sketch map showed some dependences which may be of importance for a paleogeographical knowledge of the coastal areas of East Antarctica.

During initial cryogeologic investigation the present author estimated morphographic significance of clinotropic processes, forms, sediments and the striking levelling over the slopes of crests, cir-

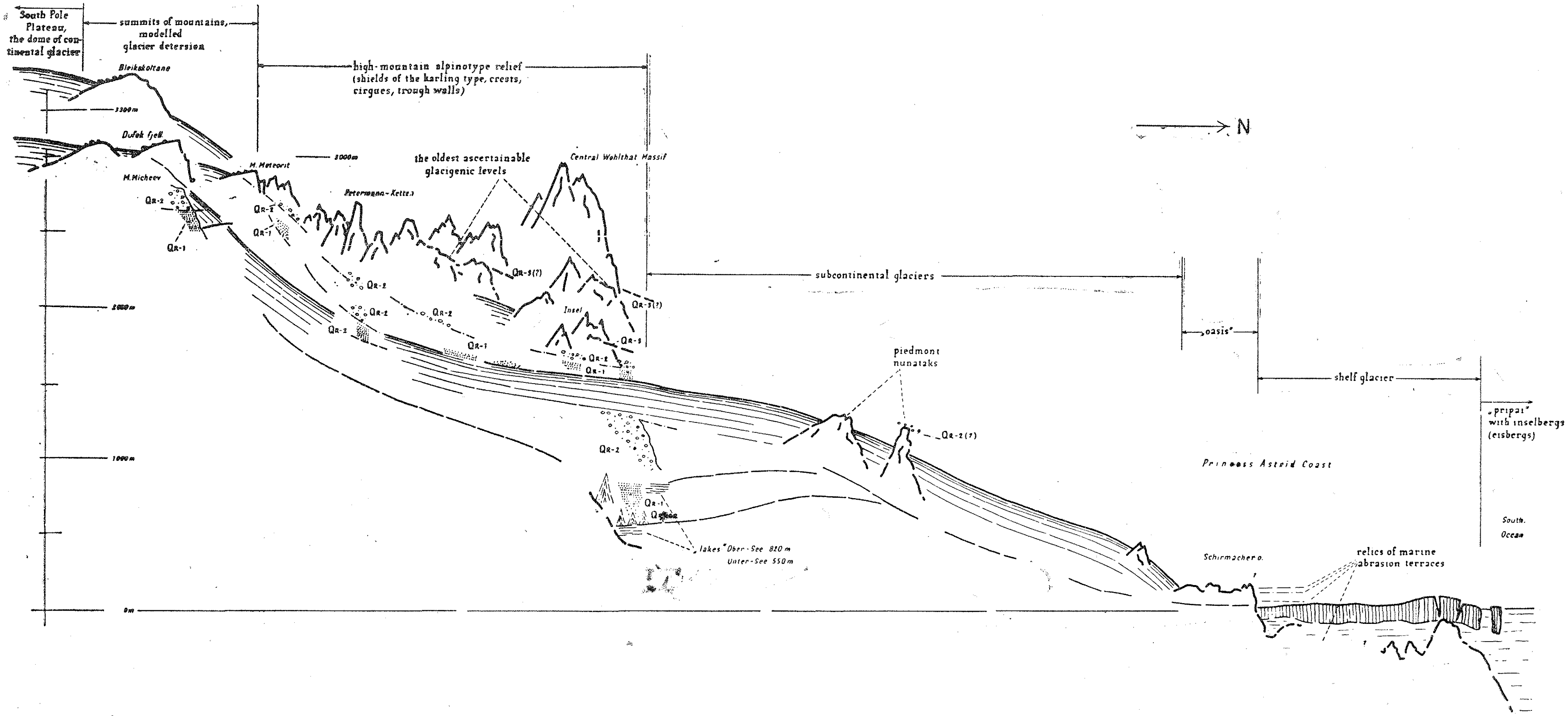

Fig. 2. Schematic section through the Sør Rondane mountain range and the Wohlthat Massif, Dronning Maud Land, East Antarctica

Section (300 km long) constructed from N—S sections drawn across characteristic areas of the northern border of the South Pole Plateau to the coast of the Southern Ocean ques, depression reliefs and in the top parts of nunataks, as well as in valley levels and saddle depressions. After plotting these levels on a map, it turned out that these relics are parallel above the level of the present-day glacier tongues (comp. the section in fig. 2) and that there are great contrasts in the weathering degree of rocks, especially in their cryogenic and eolized forms.

Soft forms of a glacigenic detersion character at altitudes of 2,200—2,500 m show polycyclic or polygenic development of the present-day relief (Q_R—Q_{R-2}, Q_{R-3} not being excluded). The development of the northernmost isolated groups of mountains is asymmetrical — the northern part usually has an alpine type in which several remodellations of the earlier relief can be traced (A. Ritscher, 1939, 1942). In these massifs cirque enclosures are concealed by moraines Q_{R-1}—Q_{R-2} (as high as 200 m above the present-day glacier tongues). From the position of these sediments it can be inferred that walls of cirques and troughs, glaciated in the last Q_{R-1}, were „showered" with sediments. This suggests that it occurred under a markedly warmer climate than that of the present time.

Similar morainal accumulations (R. K. Souchez, 1965) are also found in the central parts of high mountain regions (compare the moraines below Schwarze Hörner, Schlüssel etc.). In the area under consideration the shields have a clearly Matterhorn character, which is only partly affected by the presence of granitoid rocks. Glacier tongues in valleys have strongly re-modelled the alpine type relief in which, in addition to transfluence depressions of Q_{R-1}(to Q_{R-2}?) age two stages of glaciation can be distinguished (according to the forms analyzed, *Trogschulter*, walls of troughs, relics of moraines, weathered mantle, hanging secondary enclosures of cirques etc.). The most conspicuous relics of earlier reliefs are found again on granitoid rocks which are least destroyed by ice (eastern slopes of the Krasovski and Curie ridges). The levels with relics at the north-eastern border of the high mountain massifs link up with the levels Q_{R-2} in the valley system (at an altitude of more than 50 m above the present-day glacier tongues).

On nunataks in the piedmont part of the continental glacier no well-marked horizons were encountered; their development is mostly polycyclic (Q_{R-1}—Q_{R-2}).

The oases, coastal as, for instance, that of Thala Hills, or island-shaped (Ongul) or oases lying between the shelf and the snout of a continental glacier show striking features of marine abrasion. Especially in the Schirmacher Oasis, relics have been established showing a marked level at 105—110 m extending practically over the whole area of the oasis. From the morphological analysis of the whole oasis, carried out by means of the section method as well as from detailed measurements it follows that the last retreat of the glacier (Q_{R-1}) exposed the denudation relief, slightly re-modelled by ice. The greatest influence upon the re-modelling of the relief may be attributed to glacifluvial action (during maximum thaw) and cryoplanation process (origin of frost-riven cliffs, cryoplanation terraces, steep slopes, bounding-valley depressions, etc.). In the relief of the oasis two conspicuous re-modellings of depressions, serving as drainage channels, can be observed. Great steep scarps defining the oasis in the north, represent a typical cliff relief, partly due to geological structure or tectonic conditions. According to the geophysical measurements made so far between the Schirmacher Oasis and the northern border of the shelf glacier, a conspicuous level extends 200 m under the present-day sea level. In this area (and even on the coast of Enderby Land) intensive oscillations of the sea level cannot be ruled out; they may fall within the Quaternary.

After complete elaboration of the field material all the resultant forms and the Quaternary sediments will be compared with the results of the work done in the other coastal areas of eastern Antarctica (R. von Klebelsberg, 1942; S. Różycki, 1961; P. A. Shumskij, P. S. Voronov, 1960; T. Yoshikawa, H. Toya, 1960, 1961) and western Antarctica (R. L. Nichols, 1960; O. Holtedahl, 1929; T. L. Péwé, 1960).

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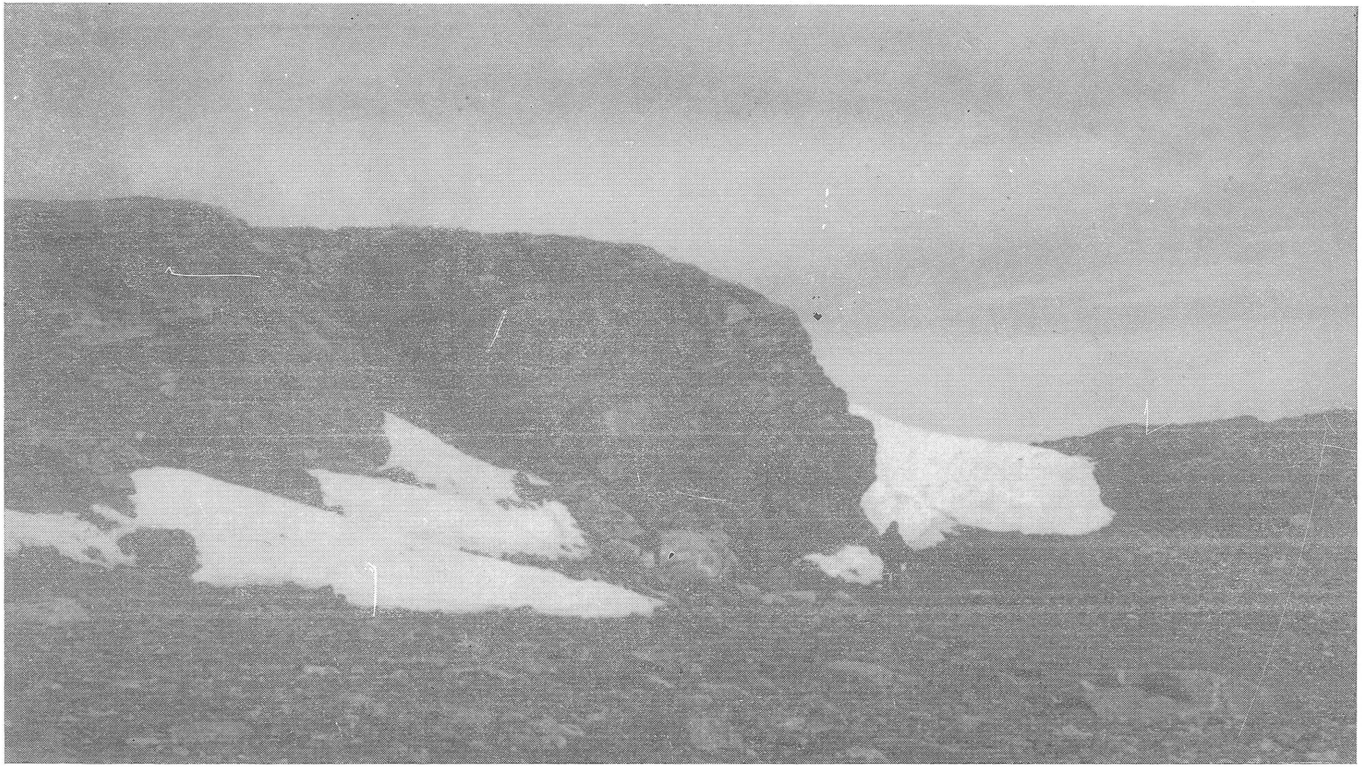

Photo by J. Sekyra, Feb. 10, 1967

Pl. 14. Frost-riven cliff, 5—8 m high, bounding the cryoplanation platform (110 m above sea-level) in the eastern part of the Schirmacher Oasis

Photo by J. Sekyra, Dec. 15, 1966

Pl. 15. Honeycomb weathering on granitic gneisses. Northern part of the Thalla Hills Oasis (Enderby Land), in the top part of a detersion relief of "roches moutonnées" character (25 m above sea-level)

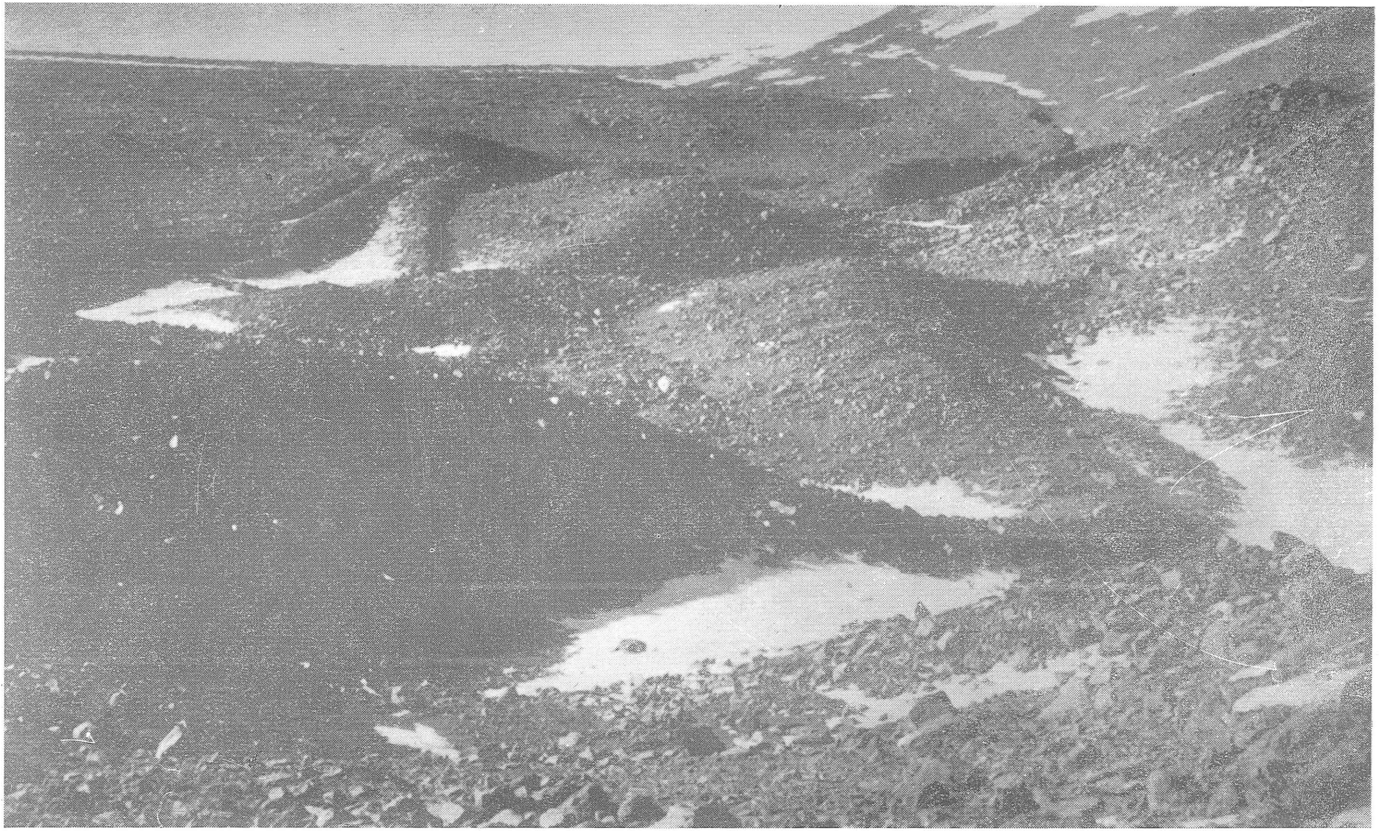

Photo by J. Sekyra, Jan. 26, 1967

Pl. 16. Morainal walls subrecent up to Q_{R-1} in the central part of the "Insel" mountain group (1980 m) in the Humboldt moutain range. Morainal material is mostly composed of migmatites

Photo by J. Sekyra, Jan. 17, 1967

Pl. 17. Blocks of porphyroblastic granite at the border of lateral moraine in the eastern part of the central Peterman crest in the Wohlthat Massif

In the background, northern part of the eastern Petermann crest (Point 2170) with a marked cirque exposed north-westwards

Photo by J. Sekyra, Jan. 25, 1967

Pl. 18. Castle-like anorthosite outcrop (about 10 m high) at the eastern foot of the Sinicina Mt. at 2400 m above sea-level with a typical system of cracks (fissures, joints, crevasses)

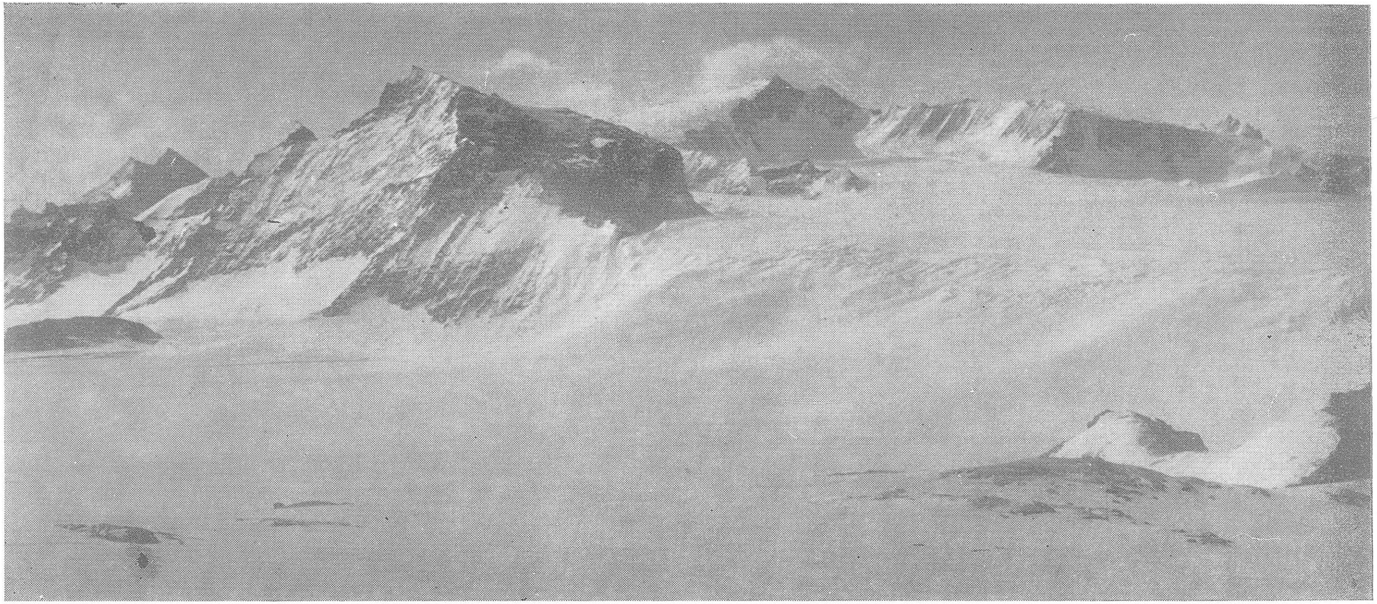

Photo by J. Sekyra, Jan. 25, 1967

Pl. 19. View of an alpine type high-mountain relief of the greatest known anorthosite massif (central) Wohlthat Massif with the Ritscher Mt. (3010 m) in the middle); view from the west, from the Sinicina Mountains

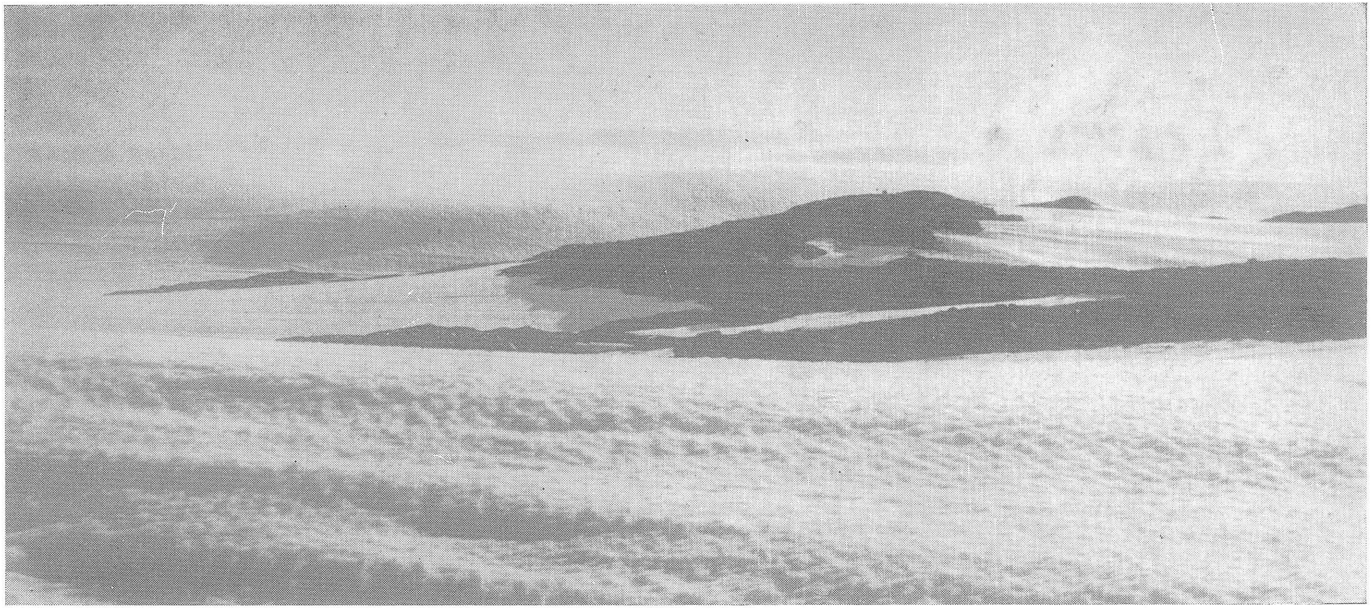

Photo by J. Sekyra, Feb. 14, 1967

Pl. 20. Eastern part of the Schirmacher Oasis in the vicinity of Novolazarevskaya station, attaining here altitudes of some 110 m (view from north)

In the foreground pitted sublimation microrelief of a blown glacier; in the background, slope of a subcontinental piedmont glacier

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