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PERIGLACIAL COVERS IN THE BESKID WYSPOWY (CARPATHIANS)

Abstract

From the analysis of periglacial formations and deposits observed in three regions of the Beskid Wyspowy, Carpathians (Gruszowiec, Dobra and Lipowe near Limanowa) the writer concludes to the simultaneous occurrence of slope and river transportation during the last glacial period. Slope and valley processes are believed to have been alternatively predominant during the Baltic glaciation and the occurrence of periodical intervals in solifluction transportation has been established. These intervals, the writer correlates with the interstadials. On the slopes of the Beskid Wyspowy three successive morphogenetic zones were recognized (from the top downward): a. ruble fields and corrasional gullies, b. denudation by solifluction and down-wash, c. solifluo-fluvial accumulation. The temperate Holocene morphogeny differs from the periglacial one by a more appreciable activity of linear erosion and tendency to strip the solifluction covers off the slopes.

Covers of periglacial accumulation from the last glaciation are those that are best preserved in the Flysch Carpathians. They consist of fluvial sands, gravels and clays, solifluction formations either more detrital or more loamy and loessy clays (Dylik 1955; Klimaszewski 1948). The age of the solifluction and fluvial covers, as well as the conditions under which they were formed are best known from the profiles at Krościenko (Klimaszewski et al. 1950), Maniowe (Stupnicka, Szumański 1957), Dobra (Klimaszewski 1958) and some other exposures. As established by Klimaszewski, the series of periglacial slope deposits reveals the existence of alternate increase and decrease of solifluction transportation and—at the bottom of valleys—an alternate predominance of downslope and fluvial accumulation. The differentation and coalescence of the deposits are supposed to reflect climatic fluctuations occurring whithin one glacial period (Klimaszewski 1958), falling into several stadials separated by interstadials (Szafer 1952; Woldstedt 1956). Apart from this, some vegetal fossils the Aurignacian interstadial found in several exposures in the Dunajec valley (Stupnicka, Szumański 1957; Środoń 1952) and probably also in that of the Raba, afford evidence of a bi-partition in the Carpathians of the terrace cover the Baltic glaciation. Halicki (1955) does not agree with the interpretation of Klimaszewski who accepts a simultaneity of processes but contemplates the possibility of 3 successive phases of periglacial accumulation: a fluvial, a solifluction and a loessy one.

During the years 1956—57 the present writer conducted geomorphic investigations in the area of the Beskid Wyspowy, in which the known exposure at Dobra is located. The object of research was particularly to determine the relation of Holocene covers to periglacial covers and formations. The present paper on the periglacial covers of the Beskid Wyspowy [1] was written in connection with the preparations made for the excursion of the participants of the Symposium of the Commission on Periglacial Morphology of IGU and also as a result of discussions during this excursion. The Beskid Wyspowy affords excellent possibilities of studying periglacial morphogeny, the slopes being here mature, long convex-concave and thus facilitating a good preservation of the deposits. Out of the several areas known to the writer, only three are described in detail in the present paper: Gruszowiec, Dobra (studied by Klimaszewski 1958 a) and Lipowe near Limanowa. A joint investigation of these three exposures enables a recognition of the relations between processes operating on slopes and those operating in valley-bottoms and confirms Klimaszewski's concept of the simultaneity of these processes and of their varying intensity during the last glacial period.

THE DEPRESSION IN GRUSZOWIEC

The latitudinal depression of Gruszowiec (600—700 m above sea level) whose eastern portion is drained by a tributary of the Łososina river, has asymmetrical slopes. The south-facing slope of the Śnieżnica (1005 m above sea level) 1—1,5 km in length is convex, cut by deep valleys. In its upper and middle portions inclined 25—30° it is built up of debris covers. These are to-day „extinct", either residual or somewhat displaced covers overlying Magura sandstones and overgrown by woods. Outside large valleys the slopes are diversified by occasional troughs of corrasional type, frequently unrejuvenated in the Holocene. Below, extends a zone of slope planations composed of sandy-detrital solifluction covers. The opposite slope of the Cwilin (1060 m above sea level) is longer and convex-concave in profile (pl. 1). It may be divided into three well-defined portions just the same as the slope of the Łopień described by Klimaszewski (1958 a). The upper portion, convex and abrupt (30—35°) built up of debris covers overlying a complex of Magura sandstones is diversified by corrasional gullies and a few steeper zones at the outcrops of more resistant sand-banks. Below, extends a stretch of predominantly shale sub-Magura layers inclined 10—20°. Some secondary thresholds

[1] The present paper was presented at session of the Laboratory of Geomorphology and Hydrography of the Geographical Institute of the Polish Academy of Science in Cracow.

occur here on the sandstone banks. This portion is veneered with a thin solifluction cover and shows thus the character of a „glacis" (Klimaszewski 1958 a; Mensching 1958). At the base of the upper rubble fields occur here and there some screes inclined 20—25°. The largest, cover-mantled portion merges gradually into the bottom of the depression. In the middle and downslope portion the arrangement of the zones is frequently disturbed by downslides owing to which the solid rock is laid bare and the initial form destroyed.

The lower part of the depression is covered with periglacial formations up to 8 m in thickness, overlying the uneven, older erosional relief. These covers form three heterogenous morphological elements of the depression which are older than the Holocene cuts and thin covers, namely: flats of solifluction accumulation and alluvial fans (fig. 1, pl. 2). The flats of solifluction accumulation inclined 4—11° are widest near the watershed pass where they are not overlain with alluvials. At the foot of the Śnieżnica the covers are composed of rough blocks bedded in a sandy mass, and on the slope of the Cwilin — of clays containing some sandstone fragments generally derived from the sub-Magura series. The plains of river terraces averaging 5—8 m in height above the present-day river-bed are built up of roughly rounded debris material (the edges alone are usually rounded). They either overlie a rocky pedestal or a solifluction cover, or dip beneath the river bed. Not everywhere do these plains merge into plains of solifluction accumulation. At places they are separated from them by an edge that may be indicative of subsequent remodelling by running water. The plains of alluvial fans inclined 8—11° lying at the outlets of the deep incised valleys of the Śnieżnica are convex ,frequently separated from the plains of solifluction accumulation by the channels of old river-beds. On the opposite slope the fans are flat, more gently inclined, incrusted into the solifluction slopes. In these exposures the bi-partition of the deposits is plainly visible. Solifluction covers, up to 4 m in thickness are overlain with a 2—3 m thick cover of coarse alluvials, predominantly blocks 0,1—0,5 m in diameter. For example, in the exposure located near the school-building in Gruszowiec the 5 m high wall exhibits from the top downward:

0,0—2,5 m (sometimes up to 3 m) a gravelly-detrital material thrust in sandy clay. Material almost exclusively magurian, whose longer axis frequently exceeds 1,1 m in length, usually roughly, but sometimes very well rounded. The stones are either oriented vertically or inclined south- and south-westward. These deposits have been transported by water during periods of sudden overpouring of the funnels of source valleys;

3,0—5,0 red and grayish-green striated clays with unrounded sandstone fragments. At the base, hard rock is likely to emerge: banks of spotted shales with incrusted sandstones.

Considering the relation between fluvial and solifluction deposits as well as between forms and deposits, the writer believes that 3 phases are recorded in the depression of Gruszowiec:

1. A phase of periglacial climate that came to an end in the Older Dryas and was characterized by solifluction transport on the woodless slopes that were seasonally thawing in summer, and water transport along the axes of larger recipient valleys. These deposits may be coalescing.

2. A phase of climatic transition (decline of periglacial) coinciding with the close of glacial period — vigourous weathering and downcreep of debris in the upper slope portions. Extinction of solifluction processes in the downward slope portions, which became overgrown with woods (Szafer 1952; Środoń 1952). Retreat of permafrost and increasing amount of precipitation induced vigourous sweeping which indicates that the bare source funnels were unprotected by vegetation and the gravelly-detrital covers were deposited in this depression on top of the covers of the first phase. At the same time, lateral erosion progressed along the axis of the depression (undercutting of the solifluction flats).

3. A phase of temperate climate comprising the Holocene. Cutting through the late-glacial fans and flats of solifluction accumulation. Coating of the eroded bottom of the depression with covers of fluvial deposits, overstrewing of periglacial covers only at outlets of smal valleys intersecting the mountain sides.

EXPOSURE AT DOBRA

In the valley of the Łososina, in the downward slope portion of the Łopień which shows a similar three-zonal profile, Klimaszewski (1958 a) recognized some periglacial covers, exceeding 13 m in thickness. Judging by their character, by the tundra vegetation which they were found to contain and by their relation to younger Holocene terraces and small valleys, he attributed them to the last glacial period. The profile — described in detail — exhibits under a 10,5 thick solifluction cover, a 1,8 m thick layer of well-rounded gravels mixed with angular ones, overlying 0,5 m of plastic clay containing sandstone fragments and at the river level, another gravel layer. Other profiles in the valley axis show fluvial gravels alone, building up the 6—8 m high terrace and in the wells on the slope there is only a series of solifluction deposits. Comparison

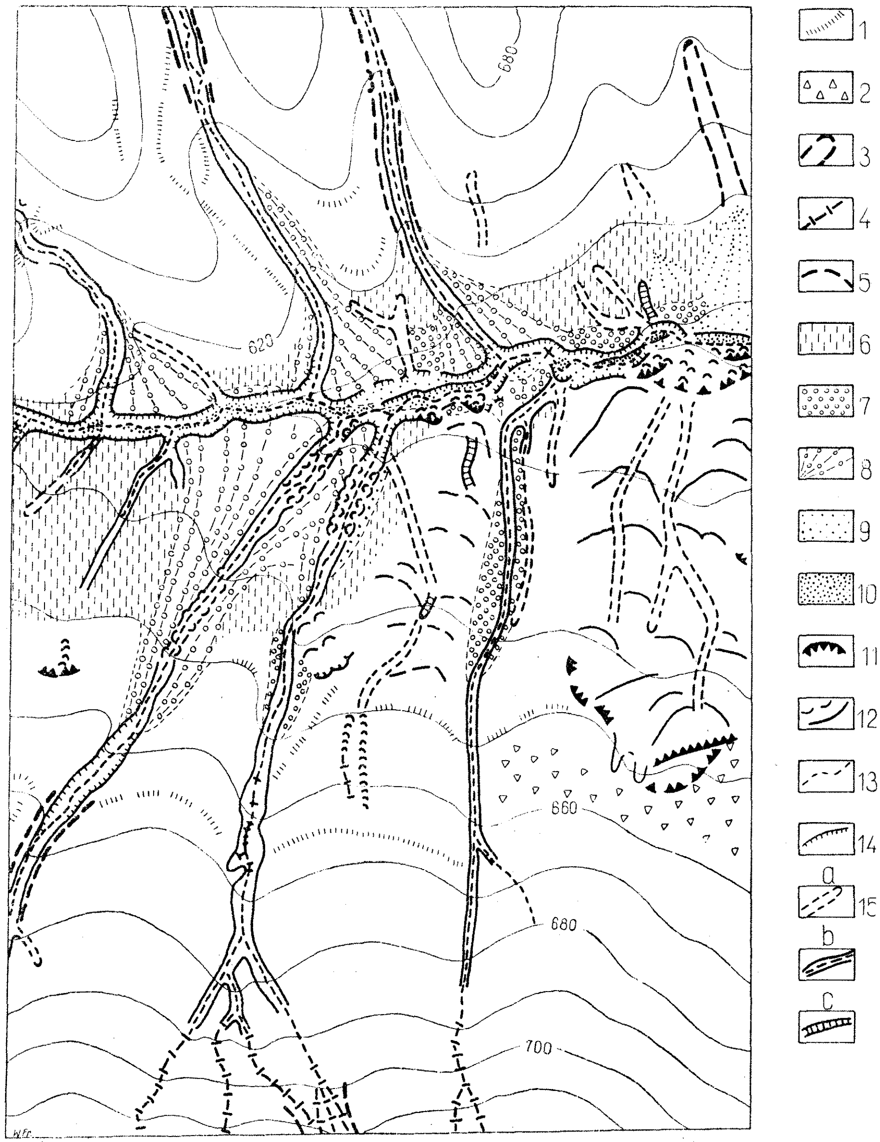

Fig. 1. Morphology of part of the Gruszowiec depression

1. old denudational edges; 2. ruble fields (overgrown); 3. through-like periglacial small valleys; 4. drained stone gullies; 5. old landslide ramparts; 6. solifluction covers; 7. terraces from last glacial period; 8. late-glacial alluvial fans; 9. higher Holocene terraces; 10. lower Holocene terraces; 11. landslide niches; 12. landslide tongues; 13. stream beds; 14. Holocene edges; 15. Holocene small valleys: a. troughs, b. incised, c. flat-floored

of these prosiles suggested the conclusion that in the periglacial cover, fluvial and solifluction deposits are overlapping. Solifluction and fluvial transport progressed simultaneously and the gravel horizons of the basic exposure, representing the zone of contact are regarded as evidence of alternate phases of predominance of either solifluction or fluvial processes. Klimaszewski (et al. 1950) under reference to the Krościenko profile attributes these phases to climatic fluctuations during the last glacial period.

As pointed out during the excursion of the participants of the Symposium, the gravel „incrustations" can be only accounted for by alterations of the periglacial river bed. During the period of solifluction, however, the river is likely to have been rather steadily pushed westward by material provided by the west-facing slope of the Łopień which is approximately twice as long and elevated as the opposite bank of the Łososina. The period of gravel accumulation beyond the axis of the periglacial valley must have been a phase of lateral erosion during which the solifluction covers became immobilised.

During the excursion, dr. A. Środoń presented the first report relating to the horizon newly discovered in the profile in question and containing vegetal fossils. As a result of the summer-flood in 1958 a band of silts emerged from beneath the overlying gravels; this band contains sylvan vegetation which analysis showed to be very similar to that of the Aurignacian interstadial (Stupnicka, Szumański 1957), thus confirming the Baltic age of the cover. In view of the fact that vegetal fossils of such age were found in the Carpathians as high up as 700 m above sea level; one must accept that during the Aurignacian interestadial the slopes were — at least in their donward portions — overgrown with woods (Stupnicka, Szumański 1957). The occurrence of solifluction during this period seems rather unlikely. The Łososina receding under the pressure of fans from her left-side tributaries was undercutting the slope of the Łopień. Also the upper gravel layers overlying the erosional sufface cut out in the solifluction covers of the Dobra profile must have been deposited at that time. In the undercuts, slope material was sliding down into the river bed — hence the presence of angular material in the gravels.

Thus the cover from the last glaciation records climatic changes (Klimaszewski 1958 a). However the fact that fluvial and solifluction deposits are coalescing i. e. occur jointly and interlaced with each other in the vertical profile is not only an expression of the alternate predominance of each of these processes. The periglacial cycle was moreover at least once interrupted during the last glaciation and was characterized by fluvial, eroding and accumulative processes.

PROFILE IN LIPOWE NEAR LIMANOWA

Covers of periglacial accumulation 6—8 m in thickness occur in the valley of a tributary of the Sowlina. At about 1,2 km distance of the debouchure, near the twist of the valley, the writer investigated in detail the covers composing the terraces and slope bases[2]. In this part the stream meanders and undercuts a whole complex of terraces. The highest terrace, 6—8 m is also the most extensive one and merges gently into slopes rising 100—170 m above valley (pl. 3). In its basal portions, it is, like that of the Łososina valley, built of solifluction covers and in the valley axis — of fluvial deposits frequently plunging beneath bank-level. The steeper right-side bank consits of two well-defined portions: the upper one icnlined 15—20°, built of Inoceramic layers and the lower one inclined less than 10° and coated with solifluction covers.

On the left-side valley-slope some fluvial gravels and sands from the axis zone occur in the undercut of the 7 m terrace. Most of them are only roughly but some are well-rounded, angular ones constituting only a small percentage. Their arragnement is frequently tile-like. In the top-layer, nearly 1 m thick the writer found some vertically set stones and small involutions. A 3,5—4 m high terrace, cut out in this cover exhibits the

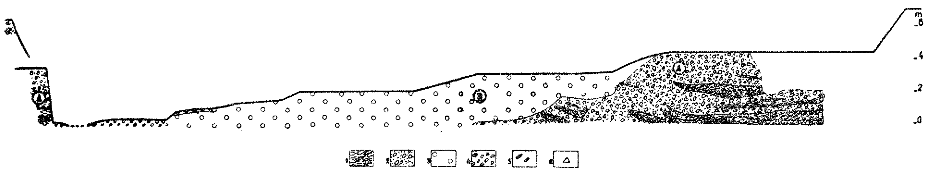

Fig. 2. Profiles of terraces from last glacial and postglacial periods in Lipowe, near Limanowa

1. clayey-waste solifluction covers; 2. periglacial gravels coalescing with solifluction covers; 3. fluvial gravels with incrusted sand (Holocene); 4. stone banks accumulated during the last inundation; 5. large rock boulders; 6. exposure with Dryas vegetation

most perfect exposures (fig. 2). In the left-side bank the profile is as follows (from the top downward):

0—1,8 m of gravels rounded from angular to well-rounded ones and varying in diameter; they are bedded in clay-sandy till;

1,8—3,5 m gray, vaguely striated clays containing a few small unrounded pebbles. It is a solifluction slope deposit. In this clay, some slightly undulating thin bands (a few cm in thickness) of well-rounded gravels 1—3 cm in diameter occur at

[2] The field-mapping of the deposits building the terrace were made with the aid of Mrs. Karaś-Brzozowska to whom the writer expresses his indebtedness.

0,3 m, 0,5 m and 1,0 m above stream bed. They afford evidence of periodical activity of running water and of downflow of the clays from slopes onto the valley floor.

On the opposite slope an incised meander exposes the transversal profiles of several terraces, the highest of which has as much as 4,5 m in height. The wall shows two readily recognizable series: A — the older one that builts up the uppermost terrace and B — an inset series forming the border of the lower terraces. A well-marked bi-partition of the series is visible in the profile of the 4—5 m terrace:

0—2,0 m gravel

2,0—4,5 m (water level) gravel coalescing with solifluction tongues.

The downward portion of this series, 2,5 m in thickness above water level consists of coarse fluvial deposits intersected by downwashed slope material. In thus shows a well-defined rhythm. The horizons of fluvial debris are composed of either angular, roughly rounded or exceptionally well-rounded pebbles, having frequently up to about 30 cm in diameter; at places they are bedded in a sandy (rarely clayey) mass. The pebble horizons are grayish-yellow in color. The pebbles are oriented in various directions but single stones are generally inclined southward, frequently at an angle of 20° which is characteristic of vigorous fluvial sedimentation. Near-slope, some gravel layers grow thinner and even wedge. The writer regards these gravels as a river deposit. They show a striking similarity with those composing the stone banks deposited during the present-year inundation [3]. This pebble-banks consist of gravel of various diameter amid which sandstones occur together with rounded shale pebbles either red or gray-greenish in color. In degree of roundness they vary widely, angular pebbles lying beside well-rounded gravels that are not always derived from less resistant rocks. Their arrangement also varies, being generally tile-like although some gravels with longer axes are set either vertically or horizontally. Therefore the writer sees no essential differences between the deposit in the exposure of the terrace edge and the one freshly accumulated. Also the considerable amount of clayey components forming irregular agglomerations within the periglacial cover may be explained by observations relative to the zone of the present-day river bed. Shale pebbles weather easily and fill the voids between the generally angular sandstone gravels which thereby become displaced. As a result, the distinctive features by which such a deposit differs from the clayey-detrital solifluction cover become obliterated.

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[3] During the excursion the writer attracted attention to it when the fluvial character of the deposits was questioned.

The debris horizons of series A are interbedded with bands of slope material clearly differing from them in stucture, color and petrographic composition. They are composed of variously colored, distinctly stratified clays containing isolated angular sandstone fragments up to 20 cm in diameter. These solifluction bands whose shape is that of sharp tongues are despite their varying thickness and local undulation generally inclined at an angle of several degrees and grow thinner in their westward portion. Some of the tongues terminate at the same line. Farther, extends a compact series of gravels. Downflow of clay from the eastern bank is also evidenced by the presence in one of the thinnest near-slope bands of angular material and — farther westward — of the rounded gravels. Some single layers have a thickness of 0,5 m. The solifluction deposits show two kinds of arrangement. Single thin laminae some less than 1 cm in thickness may be frequently observed within such layers. Multicolored striae: gray, green, red and purple occurring here beside each other, are often sharply delimitated. Red striae generally initiate and close the sedimental „cycle". The color of the particular layers remains unaltered along a stretch of several meters. Their arrangement is parallel and their thickness is usually equal for a considerable distance. This is clearly a deposit of fluidal structure of the type of stratified unbound solifluction (Dylik 1955, 1956).

At places however the stratified clays exhibit packets of fragments lying horizontally or nearly horizontally i. e. in a different direction than in the gravel series. They afford evidence of periodical downslope creep of ground patches bound by vegetation. This shows that at times bound solifluction also occurred on the same slope.

Compressed tuft remnants of tundra vegetation occur amid the stones of the solifluction bands. Dr A. Środoń kindly offered to analyse 2 samples with tundra vegetation. Among other components he found leaves, buds and capsules of alpine dwarf-willows, *Carex* nuts, seeds of *Comarum palustre*, traces of *Potentilla* and *Armeria* and numerous mosses.

The texture of these clays and the tundra vegetation indicate the solifluction character of the deposit. The simultaneous occurrence of slope processes and fluvial transportation is evidenced by the alternating fluvial and solifluction faciae and their mutual interpenetration. These sediments were deposited in the bed of the periglacial „river". Clayey material was downwashed in the summer spreading in a thin layer at the bottom and — sometimes presumably during periods of more rapid movements — advancing as far as the opposite bank. Such an explanation may account for the strangely flat arrangement of the sediments and the rather sudden curling up of the layers in their westward portion. Thin bands, usually homogenous in their color derived from that of the clay shales laid bare on the slope (red, green) are frequently spotted or show intermingled colors resulting from the downflow of various clay shales. The gravel overlies solifluction clays without disturbing their rather regular stratification. Traces of eluviation are also lacking in the clay. This shows that fluvial accumulation must have occurred either late in the spring or early in the summer over a frozen substratum, or perhaps also over a thin ice-cover in the stream bed. It is difficult to say at present at what rate the process of accumulation progressed and whether the particular horizons of the gravel and of the overlying clays may represent an annual period. However, it seems certain that the intensity of solifluction and fluvial transport varied widely over the years. The river debris is presumably due to the years when the clayey material was outwashed leaving behind the coarser material that became displaced at short distance during local melt-floods, whereas the clay bands are due to more dry years when only thin mantles of downwashed material littered the dead stream bed. Similar differences in grain-size were observed by the writer in the valley of the Werra, in slope cover exposures coalescing with the fans of lateral valleys (Mensching 1958).

In the same exposure and at a similar level only somewhat farther westward the gravel exhibits some packets of clay that are not related to the stream-bed series mentioned above (pl. 4). Their shape is that of blocks or lenses, either arcuate or inclined eastward, and their material is identical with the one described above: striated, multicolored, with sandstone fragments. Preponderance of eastward inclination (up to 35°) would suggest downflow from the left-side bank, were not this bank built up of grayish-green clays alone. Hence, these are solifluction deposits derived from the right-side bank but dislodged from their former situation. They are perhaps blocks of upfrozen solifluction clays detached from the slopes. A large sandstone block about 85 cm in lenght that does not seem likely to have been transported by running water, and the rather sudden break off at the same vertical line of several solifluction bands characteristic of the western part of the exposure also argue in favour of this assumption. Some of them are perhaps remnants of subsequently truncated erosional involuttion structures. The top portion of cover A composing the 4 m terrace consists almost exclusively of gravels containing some more sandy horizons. Clay fraction is nearly entirely absent, the pebbles usually roughly rounded, some having up to about 40 cm in diameter. Their arrangement is generally tile-like, the axes of some pebbles are inclined over 50°. The top of the periglacial cover, raised 6—7 m above stream-bed level is here stripped off (cut-in terrace). The deposit suggests increased participation of running water that eluviated the material supplied by slopes. During the subsequent phases of the glacial period the solifluction covers of the Inoceramic sandstones composing the upward portion of the right-side bank may have perhaps coated the clay shales and finally reached the stream bed. This would account for the change in the mechanical composition of sediments within the valley axis. Also the top of the 7 m terrace in the undercut of the left-side bank has a sand-waste character. Furthermore may outwash have played a certain role at the close of the glacial period. However the negligible declivity of the bottom and the reduced size of the basin argue against the late-glacial age of this series (vid. Gruszowiec).

The periglacial A series composing the 4 m terrace is interbedded with sediments of the lower terraces (B). They are sandy-detrital, loose, thouroughly eluviated, the material shows better sorting, some horizons consist of sands, others of pure gravels. Their arrangement and usually higher degree of roundness than that of the older gravels are indicative of fluvial transportation and deposition by permanently flowing waters, that were at times overloaded with coarse material. In the lower terraces, the material was accumulated on the concave slope of the meander that was continually shifted and deepened. These deposits are the younger to modern ones inclusively — the lower and nearer the present-day river bed is their situation. As a whole they presumably represent different stages of the Holocene. In some places the boundary separating the periglacial series (A) and the post-glacial one (B) is difficult to trace. It is delimitated by the spread of solifluction clay-lenses and of the accompanying large stones set tile-like, a conspicuous difference in grain-size in the horizontal profile and a thin ferruginous layer occurring here and there on the erosional surface separating gravels of various arrangement.

The profile in Lipowe affords convincing evidence of the simultaneous occurrence of solifluction slope processes and fluvial transport that was reduced to eluviation of fines from slope covers and near-by dislocation of coarse material. The rather wide valley bottom was periodically filled with solifluction covers. The sharp contact of solifluction clays and fluvial gravels in the left-side bank and the detached clay-packets in the right--side bank exposure are indicative of the existence also in such small valleys of interstadial phases of erosion. The predominantly clayey fraction at the base of the sediments is due to the initial supply of material from the down-slope (shaly) portions whereas the sandy-detrital one in the top-portion is due to the subsequent supply of material from the upward portion of the right-side bank that is built up of sandstone. During the transitional phase, probably towards the close of the glacial period when supply from slopes became reduced, occurred the undercut of the future 4 m terrace, that was still further dissected during the Holocene.

CONCLUSIONS

1. In the area of the Beskid Wyspowy, some storeyed zones, evidenced by periglacial forms and covers were developed during the last glaciation on the slopes of island-elevations. They are dictinctly recognizable in the slope profile (Klimaszewski 1958 a):

a. a zone of rubble fields and corrasional gullies, involving the up--slope portions of the Śnieżnica, the Cwilin and the Łopień inclined 25—40°, built up of resistant sandstones. Also rock slides and benches are here numerous;

b. a zone of denudation through solifluction and downwash involving the mid-slope portions of isle-hills (Gruszowiec, Dobra) and the up-slope portions of the Carpathian Foreland inclined 10—25° (Lipowe);

c. a zone of solifluction and fluvial accumulation inclined 0—12°, involving down-slope portions that merge into the valley floor.

These zones, reminiscent of those distinguished by Różycki (1957) in the Land of Torell are clearly due to the geologic composition and the character of the slopes. According to Mensching (1958) a predisposition to slope planations during the Pliocene played a considerable role in the periglacial modelling of numerous mountain slopes. Zones **a** and **b** were during the major part of the glaciation an area of predominant denudation. The rubble field debris from zone **a** sliding down the frozen substratum and displaced by needle-ice, was subsequently flowing and creeping downward together with the thawing layer of clay shales of zone **b**. In the lowest down-slope zone, periglacial sediments accumulated which constitute a record of the type, the intensity and the sequence of processes.

2. Evidence afforded by the exposures in Dobra (Klimaszewski 1958 a), Lipowe and Gruszowiec enables a reconstruction of the synthetic vertical profile of periglacial covers in the valley depressions of the Beskid Wyspowy (fig. 3). Slope deposits are coalescing with fluvial ones and form a common surface. All the three exposures supplement one another. Confirmation of the simultaneous occurrence of downslope and fluvial transport is also afforded by exposures in one of the valleys in the Beskid Mały and in a tributary valley of the San at Smolnik, near Lutowiska. This phenomenon occurs in other regions too, as reported a few years ago by Dylik (1955) from Jabłonów in the Łódź Upland and recently by Gilewska (1958) from the Przemsza valley near Będzin. Numerous

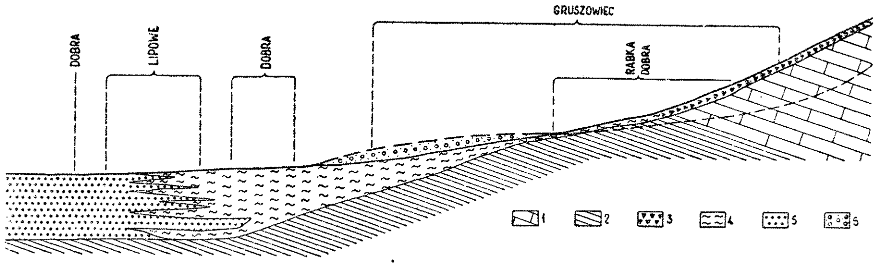

Fig. 3. Diagrammatic profile of periglacial covers in valley depression in the Beskid Wyspowy

1. series of Magura sandstones; 2 series of sub-Magura beds; 3. detrital covers (rubble fields); 4. soli fluction covers; 5. covers of fluvial accumulation from last glacial period; 6. covers of fluvial accumulation from the late-glacial phase

workers (Woldstedt 1951; Klimaszewski 1958 a; Sawicki 1952) accept and demonstrate the existence of phases characterized by predominance of either fluvial, solifluction, or eolian processes dependent on the rhythm of climatic fluctuations. In view of such facts, however, it is difficult to agree with the concept of only two glacial phases: the anaglacial and the kataglacial one (Büdel 1951; Halicki 1955; Jahn 1956; Różycki 1957). Furthermore the profile at Dobra indicates that more or less intensive periglacial morphogeny did not last uninterruptedly during the whole glacial period. In the Aurignacian interstadial the climate grew so warm that solifluction was inhibited, the valley floors became widened, probably also deepened and overstrewn with fluvial gravels. In the late Pleistocene alluvial torrential fans were superimposed at the outlets of the deep incised valleys as recently reported by Klimaszewski (1958 b) from the Tatras [4].

In smaller valleys (Lipowe) and in such parts of larger valleys as were situated in the wood-covered storey and had lesser gradients, erosion was operating already in the late Pleistocene (Poser 1950). In the Holocene, the dominant phenomenon was dissection and removal of periglacial covers. In larger velleys dissection began earlier, as most clearly indicated by the profiles in the Foreland portions of the valleys of the Wisłoka and the San.

3. In proportions and extent there is a well-marked contrast between present day and periglacial accumulation in the Beskid Wyspowy. The area of periglacial accumulation involves not only the cover-filled broad valley floors but also the adjacent downslope portions to 1/3 of slope lenght. To-day, compact accumulation in valleys is either reduced to the stream-

[4] Of the same age are probably also the terraces and fans 6—12 m in height occurring south of Dobra, which J. Gołąb recognized and identified as post-glacial. Also W. Pożaryski (1953) admits the existence of a late-glacial phase of accumulation in the gorge of the Vistula through the Southern Uplands.

-bed and the lowest terrace (Dobra, Rabka) or is almost completely absent (erosional incision).

The area of Holocene accumulation involves the Foreland of the Carpathians, where Holocene covers overlie rather thin covers from the last glacial period (Klimaszewski 1948; Starkel 1958). The fact that erosion occurs in upslope portions and accumulation in downslopes ones is now increasingly gaining confirmation (Starkel 1958; Unger 1956; Woldstedt 1951). Periodically flowing periglacial rivers were not capable to carry the coarse material supplied from abrupt slopes, the more so as the maximum water-flow preceded the development of the summer solifluction processes, as evidenced by the profile in Lipowe. This is the reason why the inclination of valley floor of periglacial accumulation exceeds that of the Holocene ones. Periglacial morphogeny in the Beskid Wyspowy promoted retreat of slopes and gradual overstrewing with covers of valley floors and of the slopes themselves whereas Holocene morphogeny tended to strip them off.

Translation by T. Dmochowska

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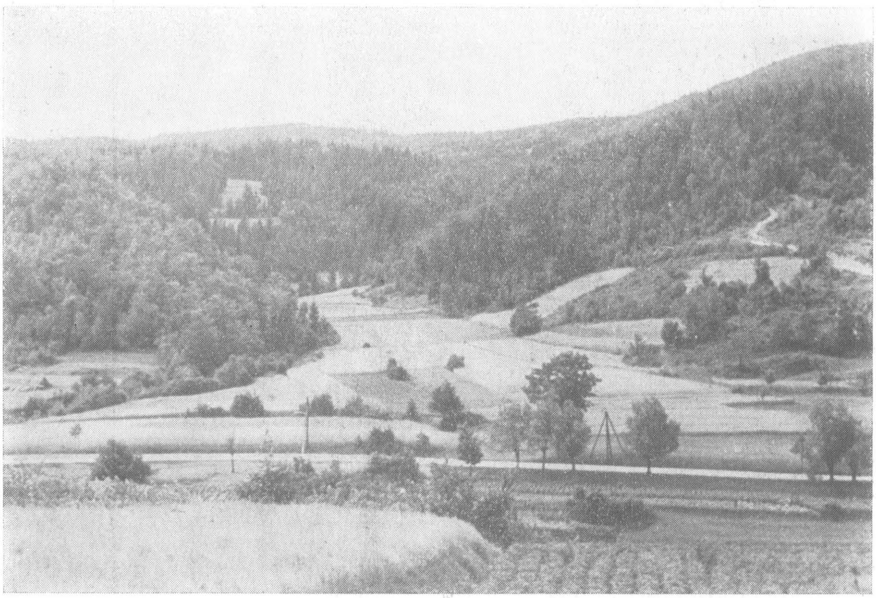
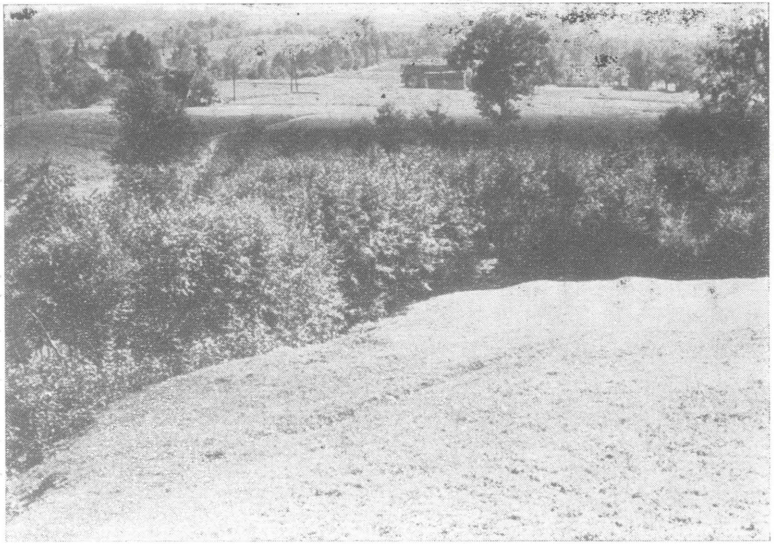
Pl. 1. North-facing, three zonal slope of the Ćwilin

In the foreground, fragment of slope base of the Śnieżnica coated with solifluction covers and intersected by Holocene valley (right-hand side)

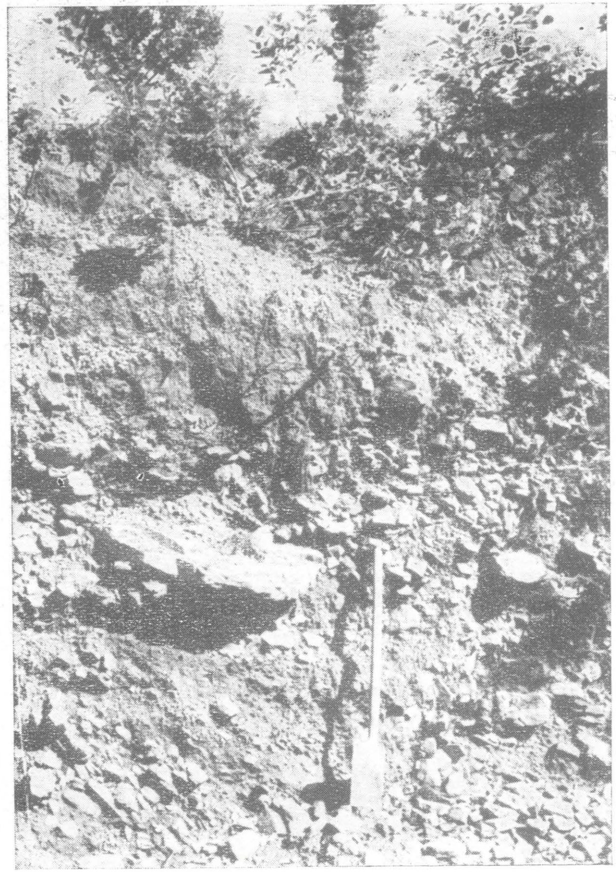


Pl. 2. Alluvial fan at the outlet of a valley in the south-facing slope of the Śnieżnica

At the base of convex slopes narrow accumulational planations. Parallel to the road — axis of the Gruszowiec depression



Pl. 3. Lipowe. Vast plain of solifluo-fluvial accumulation, cut 6—7 m during the Holocene



Pl. 4. Lipowe. Fragment of exposure (vid. fig. 2)

Profile of 3 m terrace. Below postglacial series — periglacial fluvial covers. Below sandstone block — lense of solifluction clays