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Łódź

RHYTHMICALLY STRATIFIED SLOPE WASTE DEPOSITS

Abstract

Preliminary investigations of formations of the type *grèzes litées* or *éboulis ordonnés* was conducted in Klemencice near Jędrzejów and in Parkoszowice near Miechów. Comparison of these sediments with similar deposits known from France revealed certain differences. The thickness of the formations in question is inferior to that of the French deposits. The particular layers and bands of these sediments are also much thinner and their corresponding frequencies of recurrence much higher than in France. As a whole, the formations investigated show some striking differences in grain-size of material and in alternate succession of layers. These differences between deposits of that kind in France and in Poland are probably due to geologic and climatic conditions. Glacial accumulation that did not take place in France, supplied the fines abundantly occurring in the Polish *grèzes litées*. These contrasts are also in part attributable to the more continental climatic conditions pravailing in Poland.

The writer assumes that the formations in question may represent a particular variety of a more general category of rhythmically stratified slope deposits for which the terms *grèzes litées* or *éboulis ordonnés* do not seem to be adequate.

In the exposures investigated, stratified slope debris occurs in a series of generations separeted by weathering zones and fossil soils. At least four generations of these formations correspond to four cold periods.

The importance of the formations called *éboulis ordonnés* or *grèzes litées* has been emphasized in the Program of the Commission on Periglacial Geomorphology (Dylik, Raynal 1958). Such formations have long been known only from France (Guillien 1951, 1954; Cailleux 1948; Tricart 1950; Guilcher and Tricart 1951; Beaujeu-Garnier 1953). Later, they were reported also from Morocco (Raynal 1956; Wiche 1955; Mensching 1953, 1955), Greenland (Malaurie and Guillien 1953; Malaurie 1949) and Iceland (Bout 1953).

As it seemed rather unlikely that such deposits should be confined to France alone and further doubts were suggested by the somewhat surprising fact that in all the areas mentioned above *grèzes litées* were recognized by French workers, the Commission thought it desirable to point out the necessity of investigations aiming at a recognition of similar deposits in other countries.

For the first time was the occurrence of such formations reported from Poland a few years ago (Dylik 1956) on the basis of reconnaissance investigations conducted in the Carpathians near Dukla, the slopes of the Turbacz, the Babia Góra and the Basin of Żywiec. Similar deposits were also recognized in the region of Racławice, Miechów and Jędrzejów. But not until 1958 were these peculiar formations studied in detail at Klemen-

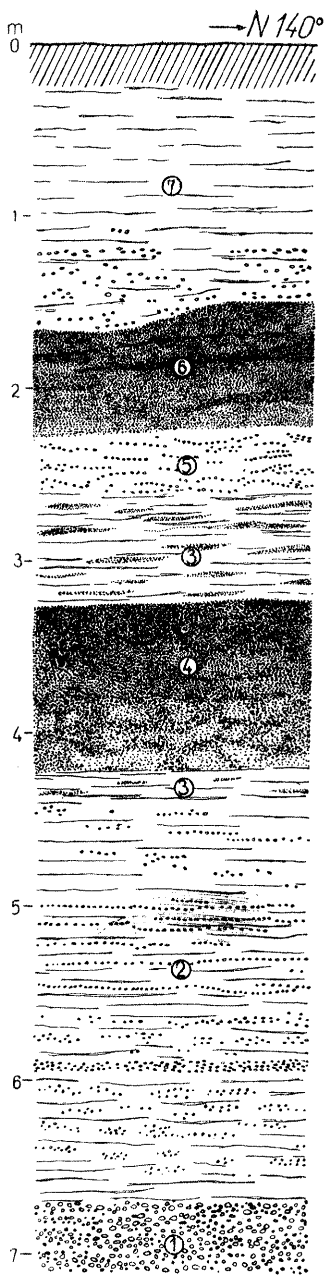

Fig. 2. Exposure at Parkoszowice

1. lower slope debris; 2. loess with bands of slope debris; 3. loess with striae of displaced humus; 4. fossil soil with well-developed subsoil; 5. loess with bands of severely weathered debris; 6. fossil soil; 7. loess with striae of weathered debris at the base

cice and Parkoszowice. Both these exposures, prepared for research work, as well as the one in Racławice were visited by the participants of the Periglacial Symposium.

Deposits of the *grèzes litées* type were recognized at Klemencice as far back as 1952, in an abandoned quarry of the south-facing slope of the dry valley where the village is situated. The wall, laid bare from the valley-edge down to the solid rock shows the profile described below (fig. 1; pl. 1).

Fresh Senonian marl is here directly overlain by slope debris composed of marl fragments with admixture of loessy material (fig. 1, series 1; pl. 2, 4). The local debris mass contains a few rounded or angular particles of crystalline and alien sedimental rocks, some of which are of Scandinavian origin. Such a material is also most frequently encountered in the analogous basal layer at Parkoszowice (fig. 2, pl. 3).

Both these series of slope debris are, in textural as well as structural features strikingly reminiscent of the French *grèzes litées*. In fraction the debris is usually not over 5 cm, the values most frequently encountered ranging from 1 to 2 cm. Grain-size curves, though less abrupt and more spread show a pattern similar to those from Charente (fig. 3). Stratification of slope debris consists of rhythmically alternating coarser and finer material.

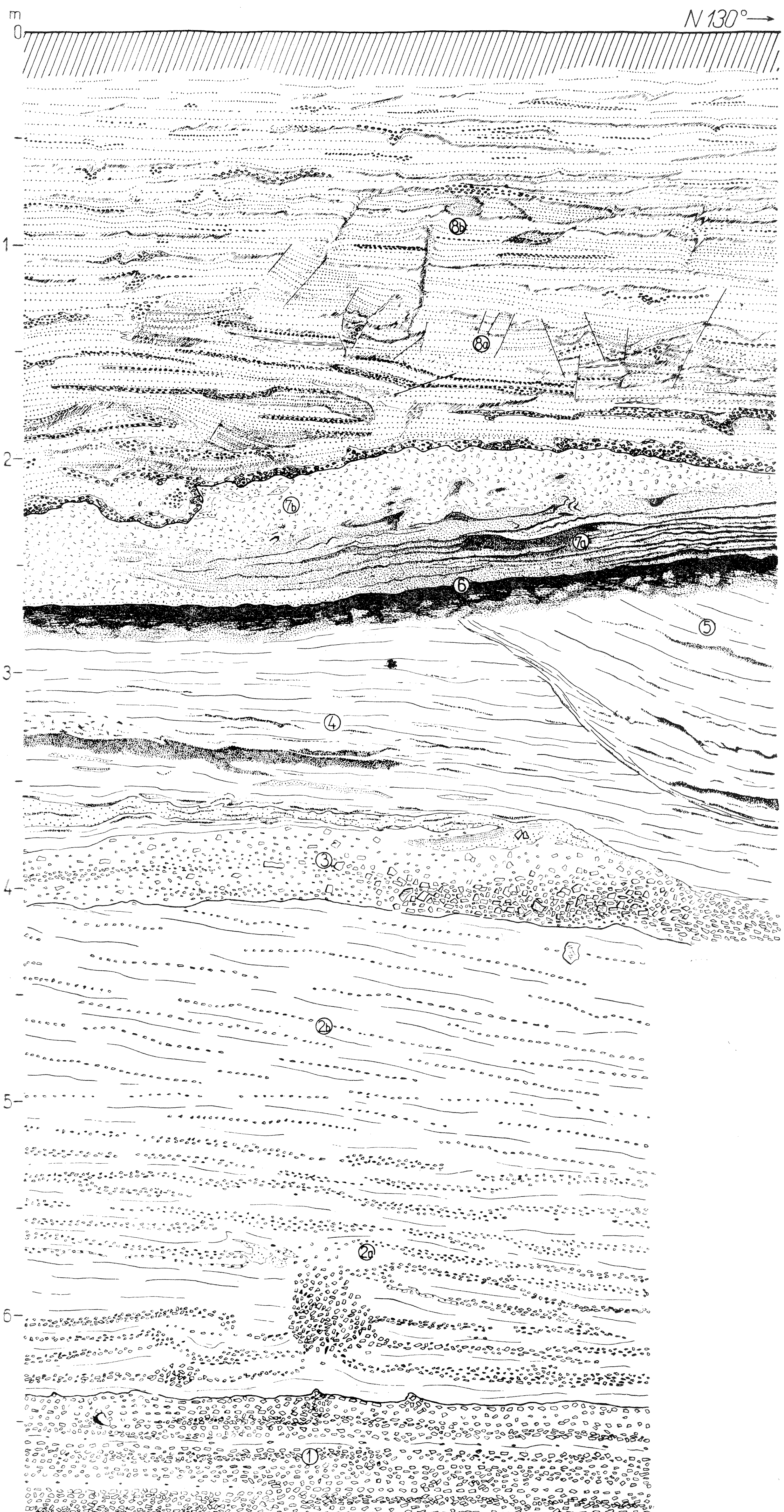

Fig. 1. Exposure at Klemencice

legend in text

Above the debris appears a most peculiar formation (2) 2,5 m thick. Its main bulk consists of loess containing thin bands of waste. At the base of the deposit (2a) loess is predominant (pl. 5) but higher upward (2b) the bands of waste become so frequent as to make the number of rock fragments more or less equal and the alternation of loess- and waste-bands regularly rhythmical throughout the entire cross-section. Marl fragments are severely weathered, though weathering is more advanced in the downward part of the sediment (fig. 4).

The surface of series 2 is visibly truncated and overlain by a layer (3) of coarse marl debris (pl. 6). The rock particles 5—8 cm in diameter are angular and nearly unaffected by weathering.

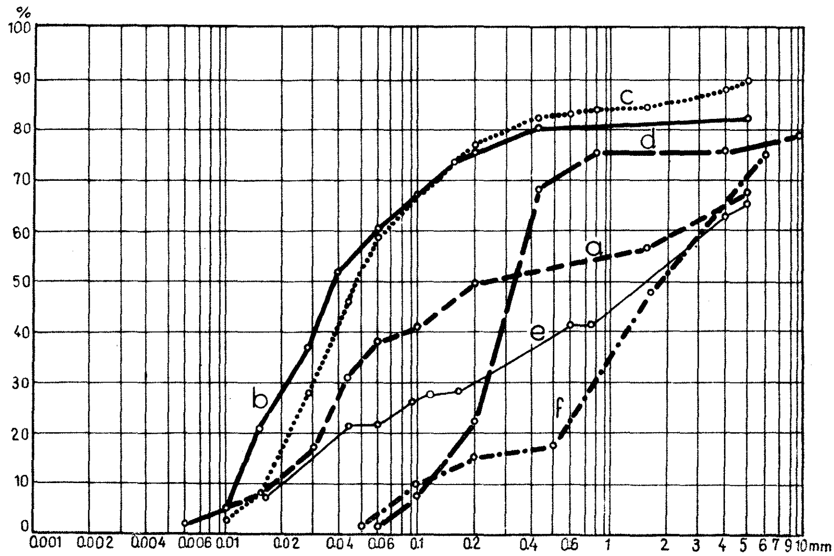

Fig. 3. Grain-size curves of stratified waste deposits

a. Klemencice, series 1; b. Klemencice, series 2a; c. Klemencice, series 2b; d. Klemencice, series 8a; e. Parkoszowice; f. Charente

A stone layer is overlain by dark-gray loessy material (4), indistinctly stratified though containing bands and striae of dark tinted loess and brighter sandy material (pl. 7). This slope formation became displaced chiefly by congelifluxion and tinted with humus derived from a now inexistant horizon of fossil soil, that corresponds perhaps to the lower soil layer at Parkoszowice.

On the right-hand side of the exposure, the series in question is dissected and shows, lower downwards, some material reminiscent of the one marked 4 and — higher upwards — some bright striated loess (fig. 1, series 5). This is, no doubt, part of a fossil gully filled at the bottom with congelifluxion deposits and higher upwards with downwash material.

Still higher upward, in the top portion of the deposits filling the gully and on the left-hand side, above the surface of series 4 that is regarded as a congelifluxion deposit, fossil soil occurs *in situ* together with a thin humus horizon and well-developed sub-soil (fig. 1, series 6; pl. 8, 9).

The humus horizon became probably diminished as a result of the increased activity of slope processes after a period of stagnation during which the soil originated. This interpretation is supported by evidence derived from series 7a where an autochtonous humus layer is overlain with stratified, bright sands alternating with dark ones which clearly contain humus (pl. 8). Higher upwards the layers are disturbed and bend into folds. Obviously, downwash must have been here gradually replaced by congelifluxion which became finally the sole formative agent of series 7b that is composed of loessy material with admixture of marl fragments. The top portion of this formation exhibits traces of chemical weathering, evidenced by the reddish-brown color of the loessy material and extreme decalcification of the debris, exceeding by far the one noted in the uppermost series (fig. 4).

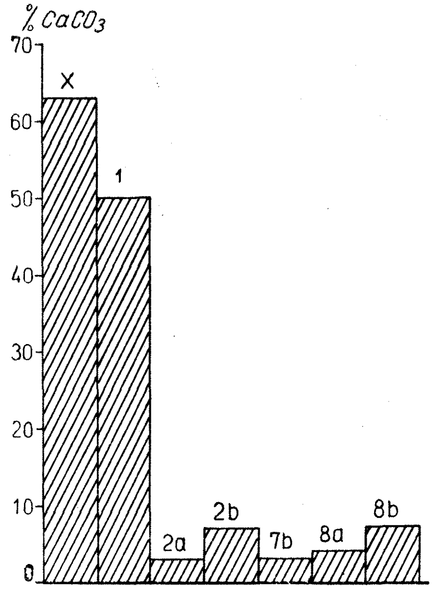

Fig. 4. $CaCO_3$ contents of stratified slope debris at Klemencice
the figures correspond to the legend in fig. 1; x — bedrock (Senonian marls)

The phase of stagnation of slope processes, recorded by the weathering zone mentioned above was followed by one of increased activity of slope formative agents. Deposits reflecting the operations of these new morphogenetic events are found in series 8 which discordantly overlies the forms previously described.

A layer of comparatively coarse debris (5 cm) initiates the downward portion of the series (8a) and is overlain by layers of sand, fine gravel, silt and debris. Intervals between the single debris bands are considerable as compared to those in the upward portion of the same series (pl. 10). The arrangement of the bands is here largely disturbed.

In the upward portion (8b) debris bands are much more frequent and intersected with bands of fine sand and pulverulent material ranging 4 to 16 cm in thickness. Here also, the bands are contorted and broken by fissures and tiny veins occurring in both portions of the series and sometimes penetrating from one into the other. The rock fragments are weathered, though less decalcified than in the downward portion (fig. 4).

As results from the above description, the formations occurring at Klemencice and Parkoszowice unquestionably bear a resemblance to the French *grèzes litées* or *éboulis ordonnés*. They are slope deposits showing a distinctly rhythmical stratification in which bands of coarse material alternate with layers of fines. The layers dip concordantly with the line of slope.

No less typical are the textural features. The material of the coarse-grained bands consists mainly of fragments of Senonian marl up to about 5 cm in size, though it contains also sandstones, flints and Nordic rocks in the shape of either rounded or angular pebbles. In the layers of fines calcareous and quartz sands are predominant.

In both the exposures at Klemencice and Parkoszowice, the deposits in question occur in several horizons, which are differentiated by the structural and textural features of the formations. Bands of coarse material usually thin towards the top of the exposure. Characteristics of openwork texture also disappear in the same direction. In the layers of fines there is an increasingly growing predominance of fine quartz sand containing grains of feldspar and even an appreciable quantity of loess. Thus, the base series alone which rests directly on the weathered bedrock actually resembles the French *grèzes litées*.

However, even these deposits, although best-developed clearly differ from similar formations in France. The French *grèzes litées* have a thickness up to 40 m whereas in the exposures hitherto investigated in Poland thickness has never more than a few meters. In Poland, the layers dip only about 15° while in the French deposits they dip almost 40°. All the component bands, whether containing coarser or finer material are much thinner and correspondingly alternate more frequently than in the French deposits. Petrographic differentiation is also much greater in the Polish deposits than in the homogenous *grèzes litées*, that are almost exclusively composed of limestone fragments.

All this shows that the most striking feature of the Polish stratified waste deposits is in the contrasting character of both stratification pattern and petrographic composition. The French *grèzes litées* exhibit monotonous arrangement and homogenous material. Thus, this contrasting character is to be regarded as the most emphatic expression of the differences between the French and the Polish deposits.

What may have been the cause of that contrasting character of the Polish waste deposits and how are the dissimilarities between them and the French *grèzes litées* to be accounted for?

The most essential dissimilarity is in the quality of the material and the peculiar pattern of stratification. This clearly shows that the different character of the French and the Polish deposits is mainly due to differences in geologic and climatic conditions.

France lies, as well known, outside the limit of the Pleistocene continental glaciations. Periglacial formations are here therefore directly overlying the old pre-Pleistocene bedrock and consist exclusively of autochtonous rocks. In Poland, owing to the glacial accumulation which deposited masses of alien, Scandinavian as well as autochtonous, far-transported material, the sediments are much more diversified and complex. This explains the heterogenous character of the Polish waste deposits.

The present-day climate of Middle Europe is more continental than that of the Western countries. Numerous paleogeographic indications prove that a similar climatic difference prevailed also in the Pleistocene. A more continental climate is characterized by a lesser amount of precipitation, greater aridity, frequent and well-marked contrasts. The Polish variety of *grèzes litées* with their numerous contrasts in pattern of stratification clearly reflect all these characteristics of a more continental climate. Even in Poland they represent in comparison with other periglacial deposits a more oceanic variety which probably corresponds to some more humid phase of a cold period. But in comparison with similar deposits occurring in the West of Europe, they display unmistakably continental features. This accounts further for the lesser thickness of the Polish stratified debris deposits which did not find in our country such favourable conditions of development as those prevailing in France during the Pleistocene.

Analysis of the sedimentological characteristics also suggests conclusions regarding the dynamics of the processes involved. The series of recurrent bands deposited by running water affords convincing evidence of the preponderant role of downwash in the genesis of these formations. Downwash was here the most essential agent. Its operations were not reduced to mere eluviation of limestone fragments since, apart from fine calcareous sands that can be regarded as a product of eluviation, also non-calcareous, alien, fine-grained material, that was undoubtedly deposited by downwash occurs and even predominates in these sediments. All these facts tend to confirm Guillien's theory which is further supported by such additional evidence unknown in France as the peculiar character, especially the heterogenous material of the Polish deposits.

Two essential features determine the nature of the *grèzes litées*, namely: sorted products of gelivation and rhythmical arrangement of layers. On account of the latter, formations of that type can be regarded as a special instance of rhythmically stratified slope deposits. But, apart from the *grèzes litées* which represent the most striking example of that kind, also other formations such as „varved sands" and other sandy-silty or silty slope deposits should be placed in this category. Such deposits as those called niveo-fluvial and niveo-eolian i. e., such deposits as are dynamically associated with slope processes, especially with downwash and congelifluxion probably also belong to this class.

Such interpretation of the slope deposits and formations called *grèzes litées* raises certain problems relative to terminology. Deposits of that type cannot possibly be reffered to as *éboulis ordonnés* since their character is not that of deposits due to rock-slides. Nor do all the formations of that type occurring in France display such features as to justify a designation implying rock-slide. Considering the situation of the deposits that were shown to the present writer by prof. Guilcher at St. Mihiel in Lorraine, they certainly are not attributable to rock-slides. They mantle here the upward part of a small, trough-like denudational valley and the layers dip scarcely a few degrees.

The term *grèzes litées* although expressing the characteristics of the formation is entirely deprived of dynamical connotation which is an advantage in so far as it thus does not argue in favour of any of the current theories, but is a disadvantage as it deos not imply the most obvious and fundamental dynamical characteristic of such deposits namely the fact that they are slope deposits.

If both these French terms seem unsatisfactory even when strictly applied to the formations for which they were introduced, they are clearly inapt to define the general category of rhythmically stratified slope waste deposits. *Rhythmically stratified slope waste* or simply *stratified slope waste* would be, it seems, a more appropriate designation for such particular varieties of this category as the deposits in question. As to the term *grèzes litées* it may be advantagously suplemented by the addition of *de versant*.

The exposures at Klemencice and Parkoszowice are highly interesting from the morphological view-point, the deposits found in these formations being correlates of morphogenetic events of exceptional importance. Most conspicuous are certainly the traces of the denudation that destroyed the old glacial cover and attacked the bare Senonian bedrock. Several debris horizons testify to the occurrence in the past of a number of phases of intensive slope development accompanied by parallel slope retreat. This also affords evidence of the importance of periglacial morphogeny which, in several recurrent phases removed the old glacial cover laying bare the solid rock and stripping off the ancient pre-Pleistocene forms of denudational relief.

All the French stratified slope waste deposits are of the same age and originated during the last cold period corresponding to the Würm glaciation. Although they attain an enormous thickness, all the series of such formations are uniform and attributable to one and the same period, the climatic conditions of which favoured the formation of such sediments. In Poland, the pattern of arrangement is entirely different and much more complex. Both the exposures investigated were found to contain four series of debris deposits alternating with loess layers and zones of chemical weathering.

Such an arrangement reveals the extreme importance of these recently discovered formations for paleogeography in general but in particular for paleoclimatology and morphogeny. The four horizons of stratified slope debris afford direct evidence of four cold periods that promoted intense mechanical weathering due to gelivation and vigorous activity of slope processes. The zones separating the debris bands correspond to periods when slope processes were inoperative, whereas the debris layers must be regarded as the result of intensive gelivation, downwash and congelifluxion. Consequently they are due to cold periods, while the zones of decalcified debris generally overlain by fossil soils are indicative of warmer periods during which slope processes were inoperative and became replaced by increased activity of chemical weathering and soil formative biochemical agents.

Detailed sedimentologic analysis showed that the particular sedimentary units are symptomatic of climatic conditions varying in time. Analysis of the deposits themselves enabled a reconstruction of the morphogenetic events and thereby also a determination of the morphogenetic environment. Climate being the most important element of this environment, the succesive deposits allowed to establish not only the sequence of morphogenetic events but also that of climatic periods. All this provides a basis for speculations regarding chronology. At present, however, an exact determination of the age of these formations is not yet possible. Investigations are not yet completed and a number of solutions required for a sound determination of the chronological sequence are still lacking. Until now, only the number of cold and warm periods and their mode of succession have been ascertained. But their length of duration is still unknown and it is impossible to say which of them correspond to either glacials or stadials, interglacials or interstadials. Nor has any of the periods distinguished been identified on the ground of its identity with any one of the constituents of the stratigraphic scheme, chiefly because of our present insufficient knowledge of fossil soils and horizons of chemical weathering.

Nevertheless, the presumable chronological sequence can be inferred from the investigatory results hitherto obtained. In both exposures at Klemencice and Parkoszowice, the total mass of the lowest base series of waste deposits is composed of the congelifractate of Senonian marls. In both the exposures, however, this series contains a certain, though very small quantity of Nordic material. Klemencice and Parkoszowice are situated outside the maximum extension of the Riss glaciation. If this area was not invaded by any earlier glaciation than the Mindel, the Nordic material occurring within the basal debris of both these exposures must be obviously derived from the accumulational cover of the Mindel glaciation. This material is not, however, lying in its initial position, since it occurs in periglacial slope deposits that were undoubtedly formed during the next cold period. The base series of slope debris would be thus attributable to the Ris glaciation. If this were actually the case, they would be indicative of an ascending, humid, anaperiglacial phase (J. Alexandre 1958, p. M 319) of the Riss. The subsequent series whose single bands are inbedded in a mass of loess, corresponds most probably to the maximum phase of this glaciation. According to mode of succession, would consequently the huge weathered zone containing severly decalcified debris and the lowest fossil soil in Parkoszowice be attributable to the interglacial, while the upper soil layer in Parkoszowice, the surface of truncation and the fossil soil in Klemencice would correspond to the Aurignacian interstadial. Finally, the debris deposits overlying this soil would have to be ascribed to at least two later stages of the last glaciation.

These tentative suggestions regarding chronology are offered as it were on the margin of the main discussion and the chief object of the present paper which is essentially designed to present — for the first time in Poland — certain deposits, strikingly reminiscent of the French *grèzes litées* or *éboulis ordonnés* and to attract attention to the important paleogeographic significance of the deposits called here *stratified slope waste*.

The recognition of such deposits in Poland tends to confirm the opinion of the present writer who postulated the existence of that type of formations outside France, Morocco, Greenland and Iceland. The correctness of this assumption is further supported by the fact that in a number of recent publications the occurrence of similar formations has been reported from Belgium (Macar and Alexandre 1958), Thuringia (Unger 1958) and Roumania (Mihailescu 1957).

The paleogeographic importance of stratified slope debris is well-known from the numerous publications dealing with the formations occurring in France and Morocco. It seems, however, that as concerns the paleogeography of the Pleistocene, the role of the formations occurring in Poland and perhaps also in other countries of Middle Europe, is much greater. Like the French *grèzes litées* so is the stratified slope waste indicative of a climate that was at the same time cold and humid. It thus belongs to the formations that developed during the initial, ascending or anaperiglacial phase of a cold period. Recognition of that type of formations provides, therefore, new possibilities of a more exact differentiation of the Pleistocene climatic phases. The series of generations of stratified waste deposits affords a new and reliable basis for both paleogeographic and chronological reconstructions.

In both the exposures at Klemencice and Parkoszowice loess is found to occur between the slope layers and bands. A similar sequence of formations was also observed elsewhere e. g. at Racławice. This close sedimentologic relationship is, no doubt, due to morphogenetic events during which combined processes induced almost simultaneous accumulation of debris and loess. Although this problem is not yet quite clear it can be hoped that the sedimentologic relationship now recognized may eventually throw some light on the conditions of loess accumulation.

Translation by T. Dmochowska

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Photo by J. Dylik, 1959

Pl. 1. Exposure at Klemencice, general view

Photo by J. Dylik, 1959

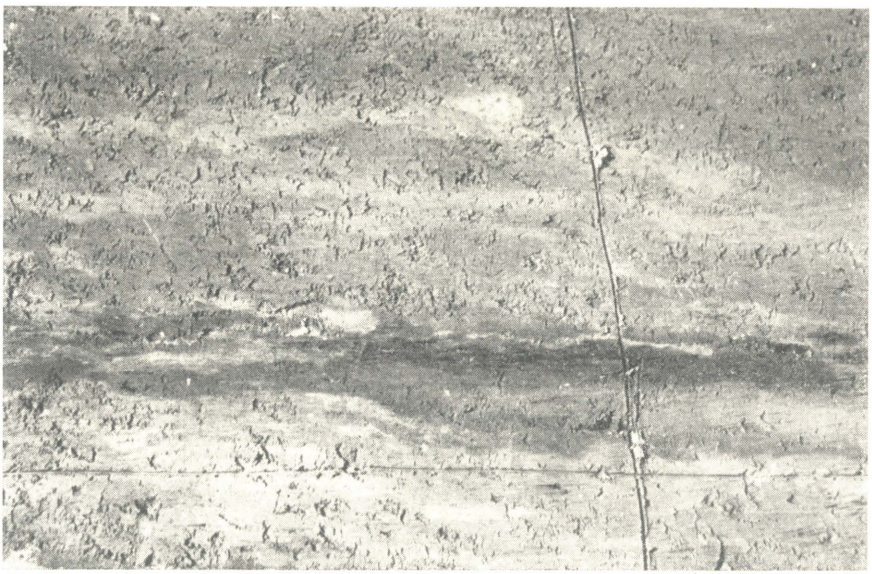
Pl. 4. Klemencice. Fragment of base series of slope debris (fig. 1, series 1)

Photo by L. Dutkiewicz, 1959

Pl. 5. Klemencice. Top of base series of slope debris (1) and lower part of loess series with bands of debris (2 a)

Photo by L. Dutkiewicz, 1959

Pl. 6. Klemencice. Coarse debris (fig. 1, series 3)



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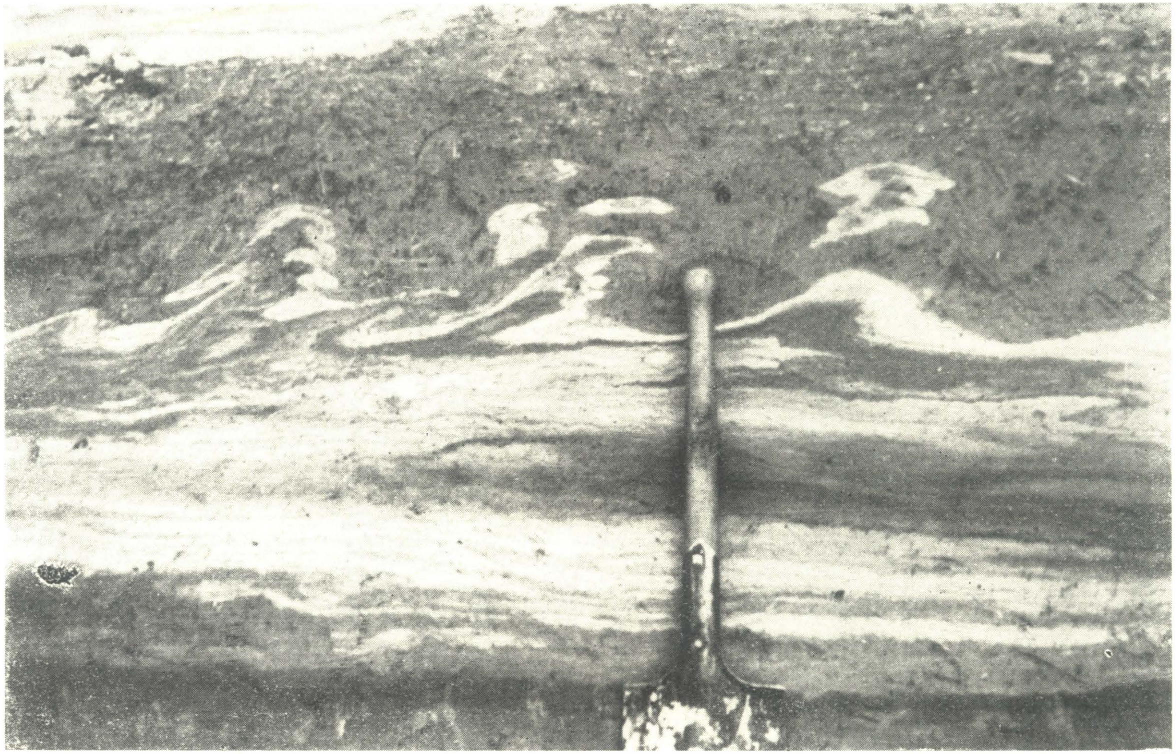
Pl. 7. Klemencice. Dark loessy formation with admixture of humus, visible bright sand striae of displaced fossil soil (fig. 1, series 4)



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Pl. 8. Klemencice. Downwash deposits (7 a) overlying fossil soil (6). Higher upward involutions and congeliflux-ion deposits (7 b)

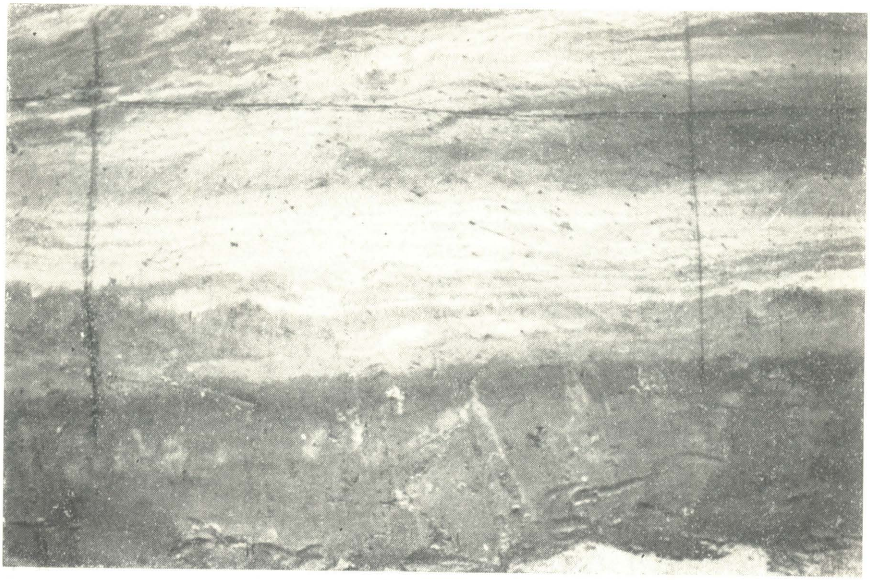

Photo by Ł. Dutkiewiczowa, 1958

Pl. 9. Klemencice. In the middle — soil horizon *in situ* (fig. 1, series 6)

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Pl. 10. Klemencice. Upper series of slope debris (fig. 1, series 8 b)