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MORAINE-LIKE DEPOSITS IN THE PERIGLACIAL ZONE

In summer 1969 the members of the Symposium on Periglacial Phenomena and Paleogeography of the Pleistocene took part in an excursion in the region of Rostov Yaroslavskij where they were shown some profiles characteristic of the periglacial zone of the Valdai glaciation. The main profile in the depression of the lake Nero was presented by professor MARKOV. Much interest has been aroused by the dubious deposits overlying a series of the Mikulino (Mgin) interglacial. The determination of the origin of these deposits — whether morainal or not — has a crucial stratigraphical and paleogeographical meaning because according to this statement the limits of the last in this area (Valdai) glaciation should be traced. The question has not been resolved yet in spite of numerous valuable papers on these profiles (MOSKVITIN, 1950, 1967; NOVSKIJ, 1961; SUKAČEV, GORLOVA, *et al.*, 1965; TUREMNOVA, VINOGRADOV, 1952; ČEBOTAREVA, 1949, 1969; ČIŽIKOV, 1938; archival materials). MOSKVITIN, NOVSKIJ and others regard the silts with pebbles overlying the Mikulino series as corresponding with the moraine of the Kalinin glaciation and the area itself they include into the Valdai glaciation. MARKOV (1940, 1961) marks the limit of the Valdai glaciation more north-westwards. This opinion is also shared by GRIČUK, ČEBOTAREVA, ŠIK and other authors.

The glacial deposits can be useful for stratigraphical and paleogeographical purposes provided that morianic deposits be distinguished from the moraine-like ones of various origin. The main obstacle is a striking resemblance between the both groups of deposits. Unfortunately, so far this question has not been paid enough attention. The authors of the recently published papers (ŠVARCBAKH, 1968; KROUELL, 1968; KHEJZEN and KHOLLISTER, 1968) have been concerned with the formation of the pseudomorainic sediments. KROUELL has discussed some processes leading to the formation of tillites.

Of special importance are the studies of the complex of lithological criteria that permit to reconstruct dynamics of the environment in which the deposits have come into being. KHEJZEN and KHOLLISTER have made such an attempt as regards

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the marine moraine-like deposits, but any criteria providing facilities for the recognition of pseudomorainic terrigenous deposits have not been worked on yet.

One of the reasons for the lack of the criteria that would permit to distinguish glacial deposits from non-glacial (moraine-like) ones lies in the insufficient knowledge of processes of glacial and glacifluvial accumulation in the areas covered with the Pleistocene ice-sheet. This problem has been discussed many a time by ŠANCER who together with LAVRUŠIN have outlined the key method on the basis of the investigations in the present-day glaciated areas for the resolution of this problem. The other cause hampering the identification of pseudomorainic deposits is insuffcient recognition of the structure and texture of glacial deposits.

The present authors have attempted a presentation of the most typical moraine-like deposits occurring both in the periglacial zone and in the glaciated areas and to compare their structure, mineral composition and conditions of their occurrence with the deposits indisputably glacial.

The first example is taken from the area of Yaroslavl, i.e. from the Valdai periglacial zone. In the well-known profiles situated along the Čeremošnik gully, on the Sara and near the Levina Gora village there are exposed: a moraine of the Moscow glaciation, the late Moscovian loess-like silts, the Mikulino interglacial deposits, complex of the loessy silts, with and without pebbles, of the Valdai and late-Valdai periods.

The examination of the Pleistocene deposits performed by the methods defining the mineral-, petrologic-, chemical, and grain-size composition as well as physical properties, has afforded the basis for the comparison of pseudomorainic deposits. The analyses have been made according to the generally accepted rules. However, it should be mentioned that some additional examination has been introduced into the grain-size analyses and complex methods applied in the studies on rock particles as well as a special way of presenting the results obtained.

The grain-size analysis has been made by means of complex methods. The quantity of grains larger than 10 mm was obtained by sieving from the sample of 25,000 cm^3 (40—60 kg); first the volume was determined and then the weight calculated (ŠEKO, 1968). Gravel-and sandy fraction was obtained by means of ordinary sieves, while the aleurite- and clayey ones — by KAČYNSKIJ's pipette method. The total sum of individual fractions in the full granulometric analysis is up to 100%.

The mean size of the sample was determined by the mean weighted diameter $d = \frac{\Sigma_n \cdot P_n}{100\%}$, where n = the middle of fraction, P_n = contents of fraction in %.

The complex analysis of rock fragments consists of the examination of petrologic composition, degree of weathering, morphology and orientation. Special studies permit to state that the most representative size for the purposes of the complex method falls within 50—40 mm, and 80 is a sufficient quantity of rock fragments. There has been introduced the index of weathering of the petrologic spectrum:

$$\frac{1\cdot 0+2\cdot I+3\cdot II}{\Sigma_{0,I,II}}\cdot 25\,\%$$

where 0 represents the rock particles difficult to be split with a hammer, 1 — easily split along fissures, 2 — at a stroke split into a shapeless mass.

The following morphological characteristics of the rock debris have been determined: roundness coefficient Cr (KHABAKOV, 1933), elongation b/a, flattening c/b. The orientation of rock patricles in the deposit was measured along the longer axes and along the maximum flat debris surface; the dip values have also been taken into account. There has been calculated the coefficient of degree of the unidirectionally oriented pebbles Cu

$$Cu=\frac{n_i}{\Sigma_n}$$

where n_i means the number of pebbles oriented along direction i (in the whole 16), Σ_n — total quantity of rock fragments examined.

Mineral analysis has been made for grain sizes 0.1—0.25 mm. To present the data in figures there have been introduced the indexes of gravity (Cg), of mineralogical composition (SUDAKOVA, 1967), and of weathering (Cw) of hornblende, the leading mineral in glacial deposits of the Russian Plain:

$$Cg=\frac{\Sigma m_1\,\%}{\Sigma m_2\,\%}$$ m_1 = mineral with the specific gravity > 3.4 g/cm³, m_2 = mineral with the specific gravity $\leqslant 3.4$ g/cm³;

$$Cw=\frac{\Sigma n_1}{\Sigma n_2}$$

n_1 = weathered grains of hornblende, n_2 = unweathered grains of hornblende.

In the vicinity of Rostov Yaroslavskij two very distinct moraine-like deposits occur: (a) changed water-basin sediments (sections 214, 217, 235, 236), and (b) solifluxion deposits (sections 230, 231).

The influence exerted by periglacial processes on deposits resulted in disturbances of stratification, frost deformations, changes in texture of the deposits, characteristic contact-lines with the over- and underlying deposits as well as in other features which give them a moraine-like look.

The moraine-like water-basin sediments overlie the sandy-clayey deposits horizontally stratified; the succession is associated with the last gradual facial changes.

In the exposure 214 at Levina Gora (Fig. 1) the pseudomorainic deposits consisting of sandy-clayey material, in places with an admixture of debris, have signs of primary horizontal stratification. The upper 40 cm layer is the most clayey, though in the horizontal section it is visible that in some places it contains a high admixture of sands. Downwards there occur lenses and large pockets of loose coarse sands with pebbles, irregularly penetrating into the sandy-clayey material. Loose sands have various ochreous shades, while the cemented deposits are grey-blue; the outlines of lenses and pockets are irregular. The top line of the layer is uneven and dissected by numerous small fissures and wedges (7—10 cm) with ochreous ferruginous incrustations. However, there occur larger ground-wedges: one of them is 110 × 36 cm in size. It is filled with porous loess-like silts from the overlying horizon. The layers in the adjoining deposits are slightly bent upwards. The lower limit between the pseudomorainic and underlying deposits is distinct both in colour and grain-size composition.

The pseudomorainic coarse-grained deposit occurring in small lenses stretches down the river some 10 meters till the mouth of the old gully. Up and down the river this series passes into horizontally stratified lacustrine sediments with small admixture of gravels.

The whole moraine-like series displays a poor sorting of the material and frost-caused deformations. It is amazing that some scientists (Novskij, Breslav — discussion during the Symposium 1969) regard these deposits as a moraine. Their characteristics can only testify to severe climatic conditions and to a variability of sedimentation, and permit to regard the deposits as the ones of water-basin type.

Table I

Facial features of lacustrine sediments
in Levina Gora

No. of layer	Thickness	Facial features of deposits (from older to younger)	Tendency of water level changes of the lake Nero
4	1.5 m	Moss-grassy peat of Mikulino (Mgin) age	Low water level, transformation of the lake into peat-bog
5a	2.0 m	Horizontally stratified sand with sporadic pebbles, interbedded with organic matter	Ingressive phase
5b	2.8 m	Deep-water deposits: rhythmically stratified silts and clays	High water level
5c	2.0 m	Littoral deposits: well sorted sands with some pebbles	Progressive shoalling of the lake
5d	1.5 m	Moraine-like sandy-clayey material containing numerous gravels in some places, poorly sorted, stratification partly disturbed	Unstable water regime, seasonal drying

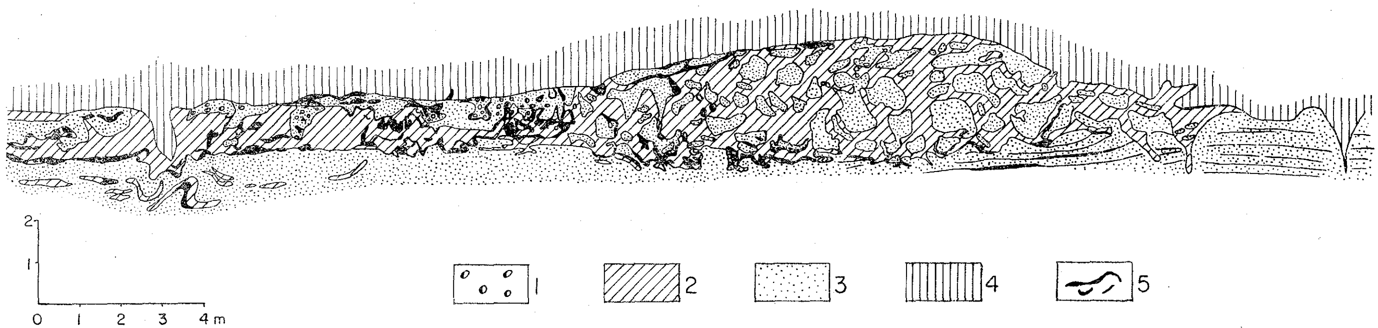

Fig. 1. Cross-section through the sandy-gravelly moraine-like deposits overlying lacustrine sediments of the IInd terrace, Levina Gora

1. gravels; 2. stratified silts; 3. sands; 4. unstratified silts; 5. strong ferruginisation

This horizon is a facial succession of layers connected with the underlying lacustrine series, in which the change of facial conditions can be readily noticed: from the abyssal in the bottom to the coastal at the top (Table I). Wedges and frost fissures in the top of this series undoubtedly originated when the lake became shallower and due to the unstable water-table under severe climatic conditions of the periglacial zone.

The characteristics of the deposits, e.g. low density (1.48 g/cm^3), high porosity (44%), contents of rock fragments bear witness to the aqueous origin of this series. In the gravel pit at Debolovskoe (sections 235, 236; Figs 2, 3) the pseudomorainic deposits display similar occurrence, i.e. they are underlain (like in section 214) with horizontally stratified sandy-clayey lacustrine deposits that are overlain with a series of stratified silts passing upwards into the diagonally stratified sands and gravels of the stream origin.

The pseudomorainic series itself (2.5—3 m) consits of fine and cemented sands, dark-brown silty sands, grey cemented silts and of medium-grained light-brown sands with gravels and pebbles. Larger stones occur sporadically mainly in the

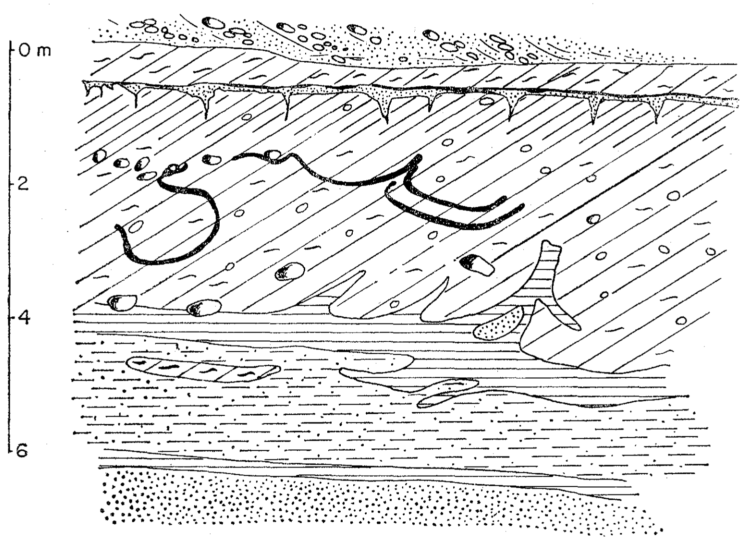

Fig. 2. A detail of cross-section at Debolovskoe

top part of the series. It should be mentioned that the distinct stratification and alternating variously-grained layers occur chiefly in the upper part of the pseudomorainic series. Below, the initial stratification is disturbed. The intercalations have curved contours and in places the separate lenses are surrounded with the material completely different in grain size. In the lower part there can be often seen lenses of greenish-grey silt from the layer underlying the gravelly-stone horizon. The structure of the deposits clearly indicates their significant transformation under periglacial conditions.

The attention should be called to the fact that in the upper 1.5 m thick part, the signs of hypergenesis can be noticed. The top is dissected with a net of fissures filled with dusty whitish sand due to the pedogenetic processes. The lenses and incrustations of loose sand form the soil horizon, which can be traced in the eastern and western walls of the quarry. The cccurrence of the hypergenesis zone bear evidence to a time interval in the accumulation. Due to washing away of the soil horizon the grey, horizontally stratified silts lie in places directly on the unweathered pseudomorainic deposits.

Table II

Mean grain-size gradation coefficients of moraine and moraine-like deposits in the Yaroslavl area

No.	Type of deposits	Percentage content of particles					Average weighted diameter α (mm)	Mean diameter Mα (mm)	Coefficient of sorting Cs
		> 100 mm	> 2.0 mm	0.1−0.01 mm	0.05−0.01 mm	< 0.001 mm			
1	Ablational moraine (sections 204, 205)	36.78	65.83	12.00	4.96	6.69	46.09	58.50	6.85
2	Proper moraine (sections 202, 205, 207)	1.65	23.56	41.00	13.56	5.84	5.58	0.096	4.78
3	Diagonally stratified gravels and pebbles of aqueous origin (sections 235, 236)	—	32.92	20.57	8.12	3.60	2.00	0.68	4.88
4	Moraine-like deposits (sections 214, 217, 235, 236)	—	25.38	10.16	4.03	4.24	2.14	0.42	3.46

The grain-size composition of moraine-like deposits is similar to the moraine material (Table II). However, unlike the typical moraine the pseudomorainic deposits of the lacustrine origin at Levina Gora and in the gravel pit at Debolovskoe diplay an increased content of sand (69%), less clay (on the average 2.5%), and are therefore better sorted (Cs = 3.85). The cummulative curves of pseudomorainic deposits are of concave—convex shape, while those of the typical and of ablational moraines are convex. The pseudomorainic deposits both at Levina Gora and at Debolovskoe are analogous as to the grain-size gradation. Upwards, the two series show the increasing amount of sand while the number of pebbles and of gravels decreases. In the typical moraine the distribution of the sand, pebble and gravel grains is irregular.

The mineralogical composition of deposits in the sites investigated is similar to that of the proper moraine (Figs. 3, 4) because the parent material for all the Upper-Pleistocene deposits were the deposits of the Moscow glaciation. But the facial diversity in the accumulational conditions could not be unmarked. By means of the coefficient of gravity (Cg) there has been stated a tendency to the increase of the quantity of minerals with the specific gravity smaller than 3.4 g/cm^3 in the pseudomorainic deposits of aqueous origin at Levina Góra. Due to that, the coefficient Cg is relatively small — 0.65 (in the moraine: 1.2—1.8). The order of the leading minerals according to the sorting of minerals as regards their specific gravity is — in comparison with the morainic spectrum — somewhat different: hornblende, garnet, epidote, ilmenite. The quantity of hornblende increases upwards and is higher than that of other minerals (29%, while in the moraine — 13—19%). The degree of weathering of hornblende — which is the most susceptible mineral to weathering — is remarkably higher in the pseudomorainic deposits at Levina Gora than in the parent material (0.91 and 0.30—0.50 respectively; Table IV). It testifies to a great transformation of the sandy-pebble pseudomorainic deposits in comparison with the proper moraine.

It is also worth emphasizing that the pseudomorainic deposits of aqueous origin contain a greater amount of humus than those of the proper moraine (0.7—0.5 and 0.2 respectively). The pseudomorainic deposits display remarkably smaller contents of carbonates than the moraine deposits (0.4—1.4 and 6.0—8.0 respectively).

Petrologically, the rock particles in pseudomorainic deposits accumulated in a water-basin show a big share (ca 60%) of rocks derived from the Baltic Shield. In the proper moraine the erratics are ca 45% and in the ablational moraine they reach almost 80%. Differentiation of petrologic contents of rock particles in the proper and ablational moraines can depend on the distribution of detritus in the glacier during its movement and melting, whereas in another genetical types of deposits it is conditioned on various causes, among others on the nature of parent material, on dynamics of the accumulational environment, and on the later processes. The high content of quartz, garnet quartzites (34—40%) in the pseudomorainic deposits at Levina Gora seems to indicate the differentiation of rock fragments in current water.

Good roundness of the rock fragments in the pseudomorainic deposits (Cr = 58% at Levina Góra; 40—43% in the morainic deposits) confirms the water activity. The coefficient of roundness has been specially determined for the carbonate rocks in the moraine and in pseudomorainic deposits; these rocks as the most susceptible to mechanic working display even more striking differences: for the moraine Cr = 36—43%, for the pseudomorainic deposits Cr = 67.8%.

The degree of weathering of stones defined by means of the weathering index (Cw) has shown the dependence of this coefficient upon the kind of deposit (Tables III, IV). The coefficient of weathering for pseudomorainic deposits is 15%, for

Table III

Complex analysis of rock particles in glacial, glaciofluvial and moraine-like deposits in the Yaroslavl area

Type of deposits	Elongation b/a	Flattening c/b	Orientation of axis a		Orientation of flattened face a x b		Coefficient of weathering Cw	Coefficient of roundness Cr
			Angle of dip	Degree of unidirectionally oriented axes	Angle of dip	Degree of unidirectionally oriented stone faces		
Albational moraine	0.70	0.60	19	0.120	32	0.120	18.0	41.2
Proper moraine	0.66	0.58	18	0.148	25	0.130	12.0	43.2
Glaciofluvial deposits	0.68	0.48	36	0.216	58	0.142	8.0	50.0
Solifluxion deposits	0.62	0.54	23	0.212	42	0.138	27.0	48.0
Silts of ice-dammed lakes	0.64	0.53	44	0.082	60	0.088	15.0	58.0

the proper moraine — 12%, and for the ablational moraine — 18%. Probably all the differences are due to the fact that the Cw has been calculated for the petrologically differentiated deposits and that selective weathering affected the variously resistant rocks. The degree of weathering of the morainic and lacustrine deposits does not show too large a divergence (3%), but this question requires thorough investigations.

The shape of rock particles: elongation b/a and flattening c/b as well as roundness can afford some information about the environment in which they were reworked. It has been stated that in the sandy-gravelly deposits at Levina Gora there prevail the elongated, flattened and well rounded pebbles. These data suggest that the modelling of rock fragments took place in the aqueous environment. The stones from the moraine are isometric and poorly rounded.

The analyses of orientation of big stones in the pseudomorainic water-basin deposits have not revealed any processes responsible for the development of deposits. The stones have higher angles of dips than those in the moraine and a wide dispersion of orientation of longer axes. These permit to assume that the deposits were accumulated in quite waters of the lake type. Distinct roundness and distribution of stones dependent on their resistance were most probably conditioned by the former fluvial channel processes. The material could have been transported to the lake shores from gullies and ravines.

In the solifluxion deposits 88% of rock fragments come from the Baltic Shield (Fig. 5). This number is much higher than in the moraine and 8% higher than in

Table IV

Comparison of some coefficients of characteristics of moraine-like and proper moraine deposits in the Yaroslavl area

Coefficients		Moraine-like deposits			Moraine deposits	
		Deposits of ice-dammed lakes		Soliflu-xion deposits	Proper moraine	Ablational moraine
		Levina Gora	Debolovskoe	Čeremošnik		
Grain-size composition	Average weighted diameter, d (mm)	3.23	1.58	—	6.62	46.1
	size 0.01–0.05 mm	5.81	1.44	—	12.5	4.96
	size > 2 mm	18.6	23.23	—	23.5	65.8
Physical properties	Volume weight γ g/cm^3	1.48	—	2.0	1.96	—
	Porosity, n %	44	—	2.3	23.0	—
Chemical composition	Carbonates (acc. to CO_2)	1.44	0.44	—	8.09	6.86
	Humus, in %	0.72	0.52	—	0.21	0.21
Mineral composition of grain sizes 0.1-0.25 mm	Coefficient of gravity Cg	0.65	—	—	1.21	1.86
	Hornblende, in %	29.0	15.0	—	19.0	13.7
	Weathering coefficient of hornblende, Cw	0.91	—	—	0.29	0.49
Characteristics of particles > 10 mm	Mean dips of long axes of rock particles	44°	—	23°	19°	19°
	Degree of unidirectionally oriented long axes	0.082	—	0.212	0.148	0.120
	Mean value of dips of the flattened faces	60°	—	42°	25°	32°
	Degree of undirectionally oriented flattened faces	0.088	—	0.138	0.130	0.080
	Coefficient of weathering	58	50	48	43	41.2

Physical properties of rock particles — A. I. VVEDENSKIJ
Analyses of chemical composition — N. N. GLUŠANKOVA

the ablational moraine. A high degree of weathering (Cw = 27%) as well as the kind of petrologic spectrum indicate that stones derived from moraine and later they underwent further reworking as the pebble roundness is higher (48%) than in the moraine (41—43%), and their shape resembles that of pebbles from the water-basin deposits at Levina Gora.

Distribution of oriented rock particles in the pseudomorainic deposits indicates the nature of additional processes affecting the debris. Degree of the unidirectionally

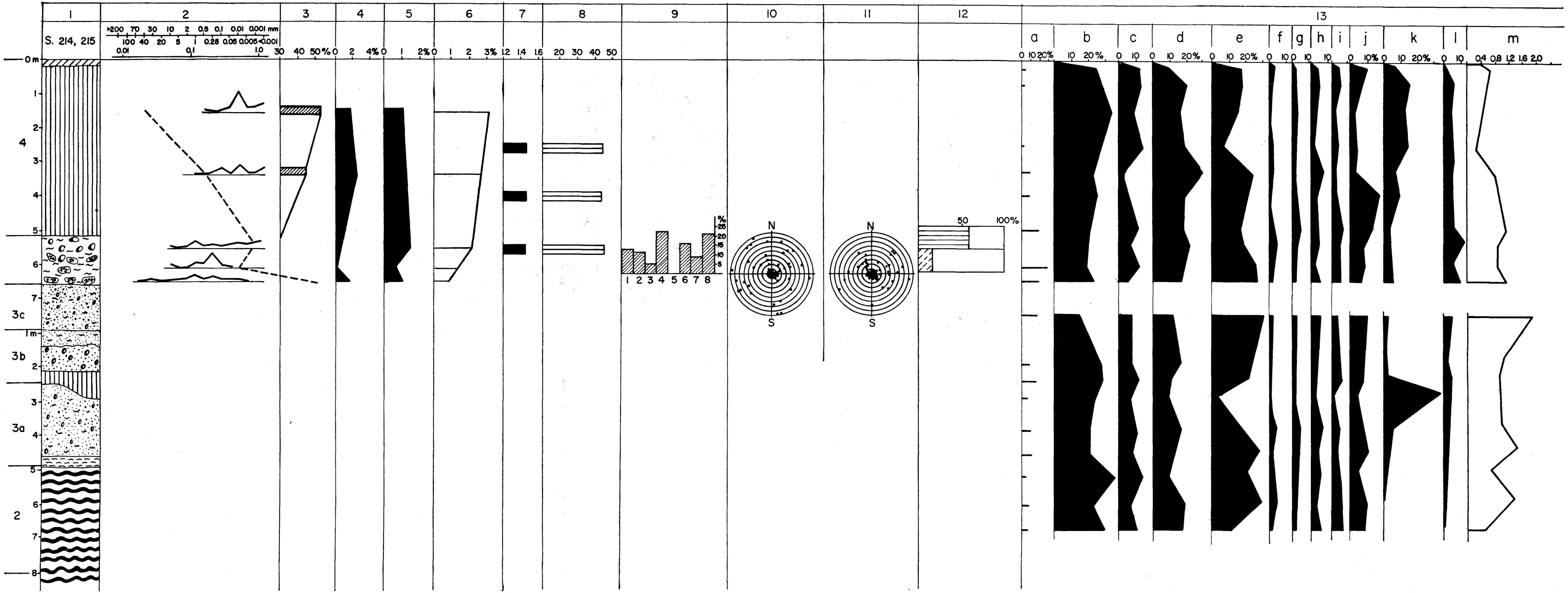

Fig. 3. Diagram of Pleistocene deposits. Levina Gora

Explanations of columns: 1. geological section; 2-3. grainsize distribution: average diameter, d mm (2) and coefficient of monofraction (3); 4-5. chemical composition: CO_2 (4) and content of humus (5); 6-8. physical properties: soil moisture (6), specific gravity (7), and porosity (8); 9-12. petrologic characteristics: petrologic composition (9), orientation and dips of long axes (10) and of flattened pebbles (11), and coefficients of roundness (upper), and of weathering (lower); 13. mineralogical composition: heavy particles (a), hornblende (b), other amphiboles (c), epidote (d), garnet (e), tourmaline (f), kyanite (g), sillimanite (h), staurolite (i), ilmenite (j), limonite (k), rock fragments (l); coefficient of resistance (m)

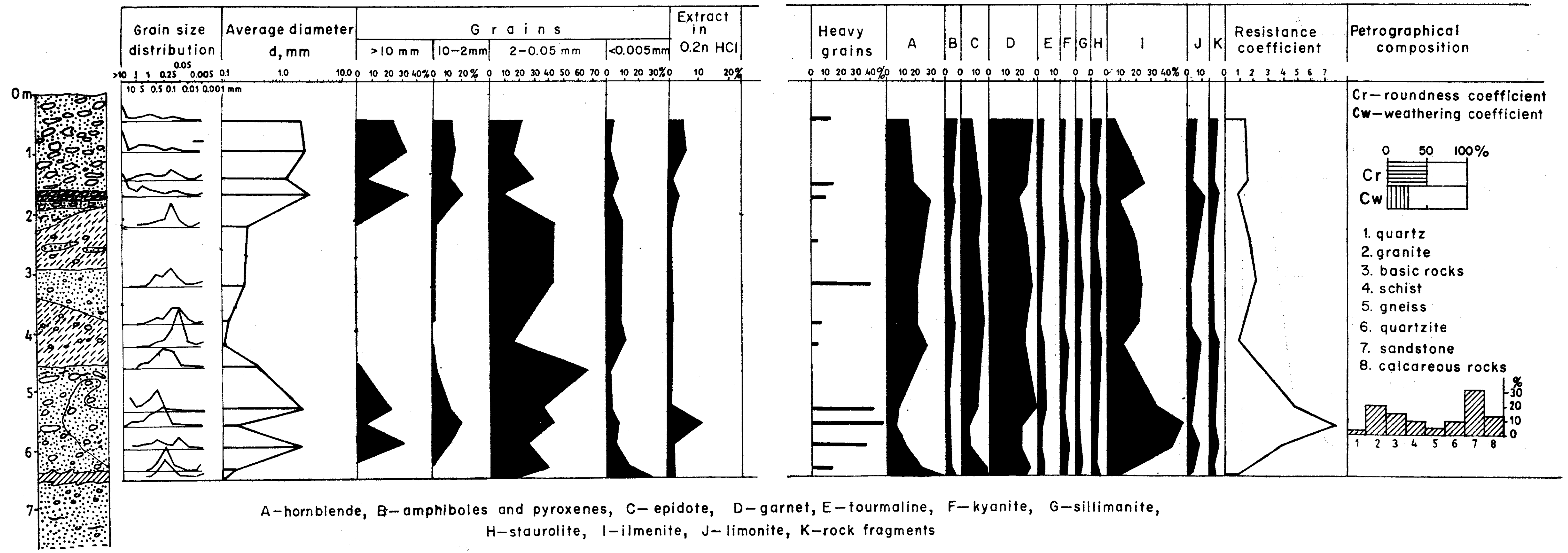

Fig. 4. Diagram of Pleistocene deposits. Debolovskoe

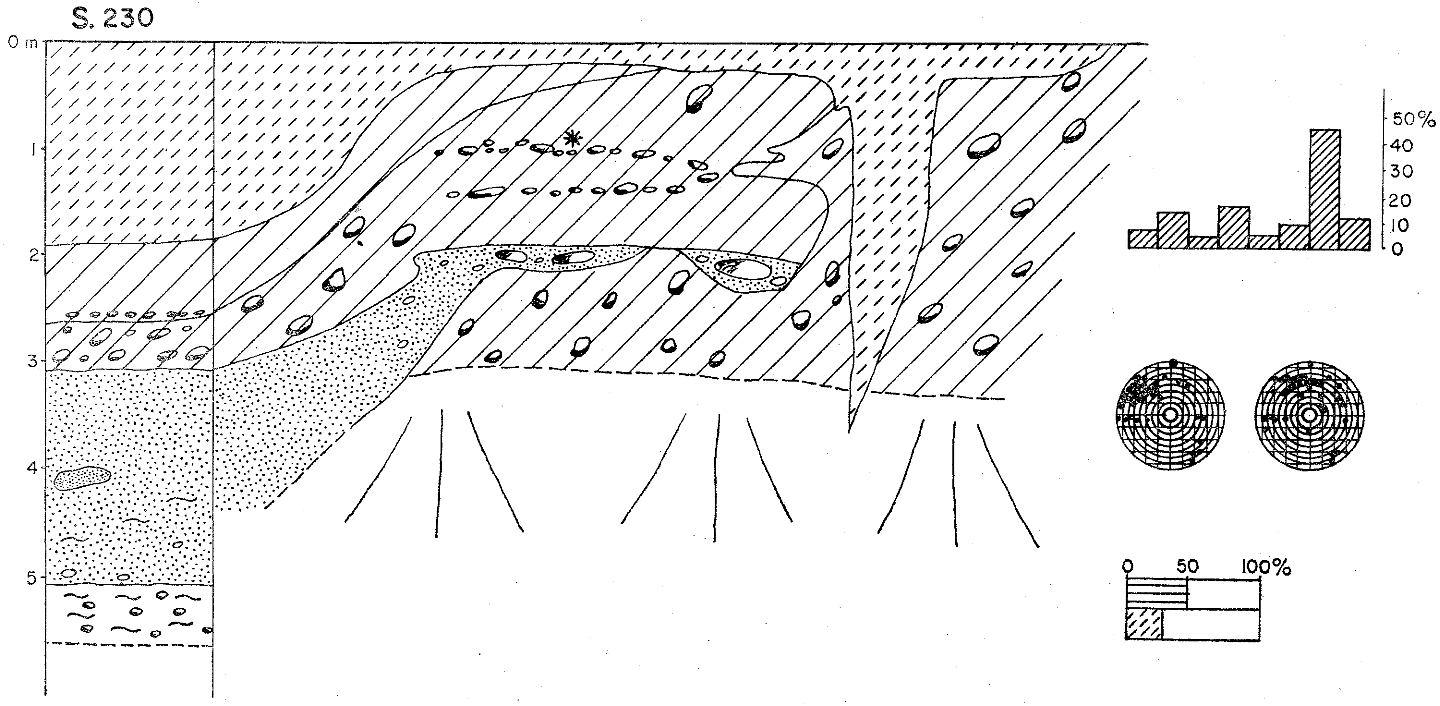

Fig. 5. Moraine-like solifluxion deposits in the gully of Čeremošnik

oriented fragments is here the highest: Cu = 0.212 (for the moraine: 0.120—0.148). The dips of longer axes (23°) and of maximum plains of stones (42%), which are larger here than in the moraine, as well as the degree of unidirectional orientation testify to the action of processes giving the distribution of the particles of morainal material displaced down the slope. The orientation of stones in the solifluxional deposits also differs from that of pebbles in the water-basin deposits. The characteristics of rock fragments in the solifluxion deposits show clearly that stones were shaped by slope processes.

The comparative analysis of some indexes of properties of moraine-like and moraine deposits has shown that there are both similar and quite different features. The differences permit to distinguish more or less assuredly the pseudomorainic deposits from those of proper moraine.

The similarity of larger stone fragments from the both deposits is manifested chiefly by poor sorting and by coarse fraction. In our case, these features are true both of pseudomorainic- and solifluxion deposits. Deposits can acquire these features in consequence of the activity of various glacial and non-glacial processes operating during the accumulation and therefore they cannot serve as criteria for defining the origin of deposits. However, some properties, such as: physical and textural patterns, degree of orientation of bigger particles are characteristic only of some kind of moraine-like deposits, i.e. of solifluxion sediments.

The characteristics differing the morainic deposits from pseudomorainic ones can be divided into two groups. To the first group the following features typical of all kinds of pseudomorainic deposits are included: roundness, angles of dips of longer axes of stones, content of organic matters. All the types of pseudomorainic deposits were characterized by a better roundness of pebbles (Tables III, IV), stronger weathering of hornblende, greater angles of dips of longer axes and maximum flattenings, and by a greater amount of organic matter. On the contrary, the moraine material displayed a poorer roundness of stones and pebbles, smaller degree of weathering of the more susceptible minerals, lower angles of dips of longer and flattened particles and an insignificant quantity of humus.

The second group presents the features characteristic of the pseudomorainic deposits of sedimentation type only. It embraces: degree of orientation of longer axes and flattened planes of debris, physical properties, differentiation of spectrum of minerals according to their specific gravity, granulometric differentiation of deposit in the vertical profile.

Unlike the moraine-like solifluxion deposits, the pseudomorainic sediments of the lacustrine origin at Levina Gora and at Debolovskoe display a differentiation of minerals according to their specific gravity (the minimum value of Cg is 0.65; low density — 1.48 g/cm^3), tendency to the upwards decrease of the size of particles, high porosity (44%), lack of orientation of longer axes of pebbles. These are characteristics of the deposits originated in water basins.

The properties of pseudomorainic solifluxion deposits and of those of the proper moraine are very similar. There can be observed a distinct orientation of stones, low porosity and remarkable density of material (Fig. 5). However, a high coefficient of roundness, presence of humus and other features permit to distinguish these deposits from the moraine. Very characteristic is the structure of solifluxion deposits. Unlike the weakly marked bedding in the moraine, here it is distinct due to differences in grain-size gradation. The greater stones are oriented along the layer dips. Sometimes there appear a rhythmical sequence of layers which somehow corresponds with the seasonal changes of deposition. It can also be noticed a dependence of the inclination of layers upon the nature of land-relief. The influence of physical and geographical factors on the pseudomorainic deposits originated in periglacial zone was probably so important that sometimes facial features of deposits underwent strong deformations changing partly or totally the properties of deposits that were acquired during their primary accumulation. It concerns the primary lacustrine deposits at Levina Gora and at Debolovskoe. It is clear that the facial properties of pseudomorainic deposits can be rightly explained only when the landscape and geographical conditions of the formation of deposits and of their later transformation are taken into consideration.

The evidence of severe periglacial conditions under which the formation of pseudomorainic deposits took place in the region of Rostov Yaroslavskij can be found in numerous frost disturbances, deformation of the initial stratification, sorting of larger stones, ground-vein nets in the top of pseudomorainic deposits. In the exposure at Debolovskoe there have been found traces of fossil soil of the podzol type in the top of the clayey-gravelly series, which testifies to the existence of an interval in the deposition and of the hypergenetic processes. The detailed studies (Guide-book of the excursion Moscow—the upper Volga, 1969) have revealed that in the Upper Pleistocene, i.e. when the pseudomorainic deposits came into being at Levina Gora and in the gully of Čeremošnik, the tundra—steppe biocenosis prevailed in this region. In the woodless landscape the fauna was represented by lemmings; mammoth and hairy rhinoceros were the only representatives of the big mammals.

The above described lithological properties of pseudomorainic deposits and of paleontological remnants permit to state decidedly that they originated in the near-glacial zone of a severely continental climate. The tundra—steppe landscape was favourable to the intensive operation of periglacial processes, which caused the changes in grain-size composition, partly in chemical properties and in structure of the deposits. Periglacial conditions were also favourable to displacements of the material due to the activity of slope processes (mainly solifluxion). In that case there has been preserved spatial connection of the newly originated slope deposits, often resembling a moraine, with the underlying proper moraine. Hence it is clear that the properties of pseudomorainic slope deposits such as physical properties, mineral and chemical composition resemble those of the parent morainic material from the Moscow glaciation. The Moscow moraine occupies in the landscape the highest topographical position.

Under periglacial conditions of the Valdai glaciation the deposits of different origin, displaying a specific periglacial character came into being. The appearance of periglacial sediments is often similar to morainic deposits. In this region two types of pseudomorainic deposits overlying the Mikulino interglacial deposits can be distinguished.

The first type are slope solifluxion deposits, that spatially are the most closely connected with the Valdai moraine, but they originated in quite different period because they often overlie the interglacial series. This group of pseudomorainic deposits on one hand possesses some features inherited from the typical moraine (physical properties, chemical and mineralogical compositions) and on the other they display some specific structure characteristic of slope deposits and contain oriented stones.

To the second group of the pseudomorainic deposits belong the deposits of another primary origin (lacustrine). In the course of transformation under periglacial conditions they acquired new properties — a great admixture of humus, sorting of mineral components according to their specific gravity, differentiation of petrologic composition according to the resistance to weathering, low density and high porosity — deny the glacial origin of these deposits and indicate their water-basin sedimentation.

Table V

Types of terrestial moraine-like deposits

Glacial zone	Periglacial zone	Unglaciated zone
1. glaciofluvial 2. glaciolacustrine 3. solifluxion	1. eluvial 2. creeping 2. solifluxion 4. colluvial (delluvial) 5. muddy stream deposits 6. fluvial (channel-bed) 7. lacustrine	1. eluvial 2. colluvial (delluvial) 3. proluvial

The examples described above do not represent all kinds of pseudomorainic deposits originated in the periglacial zone, in the glaciated areas and in the areas deprived of ice-sheets. Therefore there are further examples from another areas presented hereinafter.

The deposits of water basin occur in many other regions of periglacial zone. The deposits strongly resembling those described from the Moscow region occur in the Amur valley. They are so-called "tan clays". The similar deposits have been encountered in the Vistula valley in Poland (some 50 km east of Cracow): they are tan silts with numerous well rounded coarse gravels. In the vicinity of Gdańsk the pseudomorainic colluvial deposits lie on peat dated on 7000±600 years B. P. In the same area there are the moraine-like deposits directly associated with the glacial material. It may therefore be said without exageration that the pseudomorainic deposits occur in almost every part of the periglacial zone. Unfortunately, these deposits have not been investigated with enough accuracy and interest.

Specific pseudomorainic deposits have been met in south-east Lithuania (GAJGALAS, MIKALAUŠKAS, JURGAJTIS, 1965). They occur within the sandr area and have been referred to as the colluvial deposits. Their structure, texture and mechanical composition resemble the moraine, but their formation was connected with glacial streams. Only the proximity of ice-sheet and attenuation of the stream power permitted to preserve the features of glacial deposits. The fluvioglacial deposits resembling the morainic ones were accumulated simultaneously with the proper moraine.

Table VI

Subdivision of moraines according to various criteria

Criteria of subdivision	Due to character of ice-sheet		Due to glacier types	Due to distance of transportation	Due to activity of glacier	Due to accumulational place in the body of glacier
Varieties of typical moraines	Transgressive	Stadial Phasal	Valley glacier	Erratic	Active glacier	Ground moraine
			Lobes	Transitional	Passive glacier	Inglacial moraine
	Regressive	Regressive Oscillational	Tongues	Local	Dead glacier	Ablational moraine

From the examples mentioned above results that various processes can lead to the formation of deposits similar to the morainic (glacial) deposits. The formation of pseudomorainic deposits can take place not only in the glacial zone — in a close vicinity of moraine — but also in the periglacial zone where part of moraine-like deposits are in a close spatial contact with the moraine and inherits its essential features of mineral composition though the deposits and the moraine originated in various time, e. g. solifluxion, deluvial and others. Some pseudomorainic deposits came into being due to the activity of various processes: fluvial, in lake-basins and others, and they show a distinct pattern of non-glacial sedimentological differentiation.

A large diversity of pseudomorainic deposits on one hand (Table V) and of the morainic ones on the other (Table VI) make their recognition difficult because of their very similar appearance. Only detailed studies permit to determine their origin. The properties of pseudomorainic and morainic deposits presented in Table IV facilitate to some degree to distinguish the deposits of glacial origin from those of non-glacial genesis, which in turn preserves from making faults in paleogeographical reconstructions. Paleogeographical and stratigraphical significance of a proper recognition of various types of pseudomorainic deposits is indisputable.

The present paper does not exhaust all the problems connected with the investigations of pseudomorainic deposits. The authors hope that the questions discussed above will be given careful attention.

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