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Assessment of grain-size composition spatial structure for Lithuania's Pleistocene surface deposits by statistical grid method

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The paper contains results of investigations done in Lithuania for the first time on the spatial structure of Pleistocene deposit grain-size composition. The statistical grid method has been applied for 2–2.5 m thick surface deposits with 5 × 5 km grids. The typology of diversity in grain size composition has been constructed, i. e. very uniform, uniform, rather diverse, diverse, and very diverse types were singled out. According to distribution peculiarities in grain-size composition diversity and different values of grids, the type micro-regions have been established and generalised by joining them into certain individual regions. The paper presents a concept of grain-size composition spatial structure diversity and peculiarity and shows that the main factors causing diversity in grain size composition are glacigenic and epigenetic processes. The grain-size composition diversity has been found to be highest at the interface of deposits of different genetic types (and different genetic types of relief). At the macro-level of the relief, the highest diversity was typical of upland and lowland interfaces formed by both glacial and aquaglacial processes, as well as those re-formed by epigenetic, especially fluvial, processes.

Key words: Pleistocene deposits, grain-size composition, spatial structure, statistical grid method, Lithuania's territory

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INTRODUCTION

The grain-size composition was and remains an important criterion for assessment of deposits per se as well as their formation (Рухина, 1973; Матвеев, 1976; Раукас, 1978; Данилов, 1983; Судакова 1990; Rattas, Kalm, 2001; Baltrūnas, Gaigalas, 2004; Piotrowski, Larsen, Menzies, Wysota, 2005).

The grain-size composition research of the Quaternary deposits making the relief of Lithuania's area covers the time span of about four decades. As an analytical and statistical method the grain size composition was used for stratigraphical division and comparison of Pleistocene surface till deposits (C horizon or soil-forming rocks, and deeper ones), as well as for statistical substantiation of geomorphological boundaries of the last (Nemunas) glaciation (Baltrūnas, 1995; Baltrūnas, Gaigalas, 2004) and phase boundaries of its Baltic stage (Климашаускас, 1965; Klimašauskas, Kudaba, Prakapaitė, 1972; Baltrūnas, 1995), for explanation of the till multi-layer problem (Эйдукявичене, 1980; Baltrūnas, 1995) and understanding the homogeneity or

multi-layer character of the till top (soil) cover (Eidukevičienė, Galvydytė, 1973; Багдонайте, Паярскайте, Эйдукявичене, 1980; Galvydytė, 1993). The results of analytical and statistical investigations enabled to distinguish out the basic geological factors, to assess the influence of both palaeogeographic and lithogenetic (genetic sedimentation) conditions on formation of till deposit composition. The weathering of the Middle Pleistocene till was established, differences in last glaciation Baltic stage glacier phases as well as grain size peculiarities for separate till deposit phases were substantiated (Baltrūnas, 1995). In the light of these achievements, the hypothesis about the role of till deposit age and periglacial conditions as factors determining the intensity of soil formation and grain-size composition as well as chemical transformations (Eidukevičienė, 2001) can be considered being relatively proved.

In fact, all these investigations have been done in reference areas and are of methodological character. The grain-size composition of deposits forming relief in all Lithuania is partly reflected in the geological map of the Lithuanian Quaternary (Guobytė, 1999; Guobytė et al., 2001) and maps of surface deposits (0–20 cm topsoil and parent, i. e. soil-forming rocks) (Grybauskas, 2001a, b, c, d). The spatial structure of grain-size composition had not been studied statistically. The methodological experience gained (by determination of grain-size element classification variety, grain-size related carbonate content, and errors of grain-size laboratory analyses) as well as the rapid development of geoinformation technologies, however, make a basis for construction of spatial structure. At rather low costs of labour and time, such investigations can be done not only for a small (reference) area, but also for the whole Lithuania. One of such new methods applied in Lithuania in surface cover studies (Vaitkus, 2005) is the statistical grid method which enables, although a formal but rather efficient, assessment of spatial structure regularities. The elaboration and improvement of this method cannot be dissociated from the general European reference grid idea proposed at the Joint Research Centre (JRC) of the European Commission and from the increasing demand of standardised data.

Knowledge of grain-size composition spatial structure regularities is important from both theoretical and practical points of view. The research results obtained in the last five decades on the European continental glaciation in Poland, Lithuania and Russia show that the cover of surface deposits is an indivisible natural body. The impact of intensive human activities on surface deposits in time and space is obvious, however, it is observed in changed physical and chemical properties mainly as deep as 1 m (Eidukevičienė, Ožeraitienė, Tripolskaja, Marcinkonis, 2001). In real space, the processes occurring in surface deposits, as well as the efficiency of economic activities are subject to nature laws, thus, the adjustment of the concept of sustainable development on the national level should be based on these laws.

The aim of the present work was to evaluate the spatial (horizontal) structure diversity of grain-size composition for surface deposits in the Lithuanian territory.

The tasks were chosen as follows: (1) traversing the grain-size composition spatial (territorial) structure distribution of surface deposits, and (2) assessing the diversity in grain-size composition spatial structure of surface deposits.

METHODS

The target of the work was the diversity in grain-size composition spatial (horizontal) structure of surface deposits in Lithuania (Fig. 1).

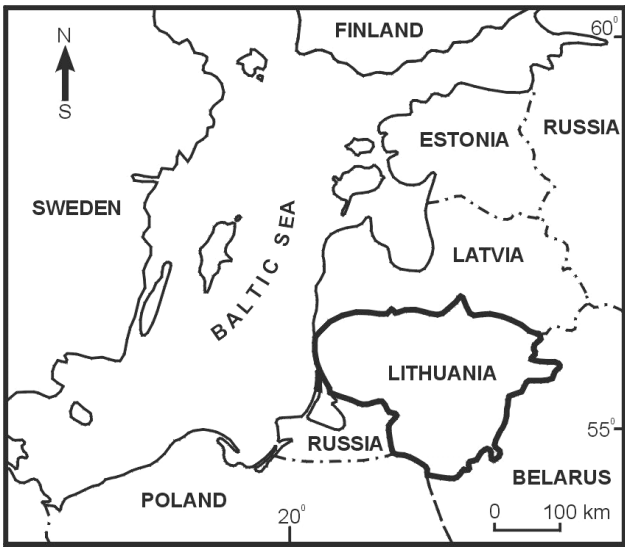

Fig. 1. Location of the study area
1 pav. Tyrimų objekto lokalizacijos schema

The research was carried on in two stages (Fig. 2): (1) compilation of a digital map for surface deposit grain-size composition, and (2) analysis of the digital map for surface deposit grain-size composition by the statistical grid method (statistical investigation of diversity).

1. The digital map of surface deposit grain-size composition has been compiled after the database of the Digital Map of Lithuania's Soils on a 1:300 000 scale (1998) stored at the Land Research and Assessment Department of the National Land Management Institute and the 1985 contour map of Lithuania's soils on a 1:300 000 scale. The good value of these contours is related to the fact that they are made be reducing the soil plans (1:10 000). Therefore, the contours present the undistorted spatial picture of a phenomenon and enable a detailed determination of the area of a certain land plot. The grain-size composition types are singled out according to the first member of soil combinations in a contour for two horizon groups and presented as a fraction, e. g., *ps/p*, where *ps* expresses grain size composition in upper

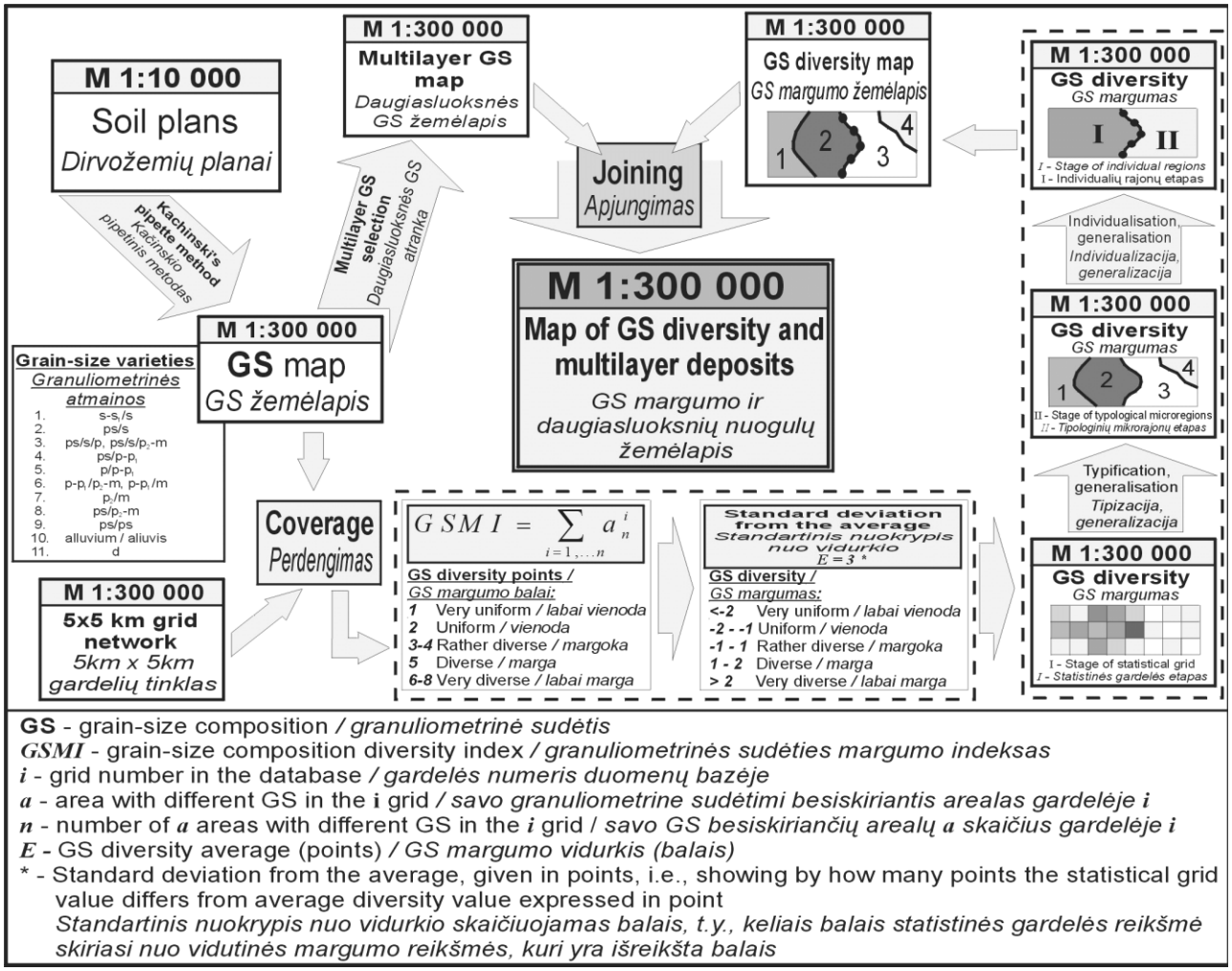

Fig. 2. Methodological scheme of grain-size composition (GS) diversity studies of surface deposits. Compiled by J. Volungevičius
2 pav. Paviršinių nuogulų granuliometrinės sudėties margumo tyrimo metodinė schema. Sudarė J. Volungevičius

soil horizons (A, E), and *p* is grain-size composition in the horizon B or soil-forming rocks (particles less than 1 mm). This means that the contour of the digital map compiled reflects only the prevailing grain size composition. The grain-size analyses were performed by N. Kachinski's pipette method, whereas the grain-size composition name was selected from the N. Kachinski's classification (according to the amount of particles less than 0.01 mm). This work was done at the Soil Laboratory of the National Land Management Institute (Мичманова, Долгов, 1966). Geo-logists (Gaigalas, 1995), engineers and soil researchers (Eidukevičienė, Grybauskas, Vaičys, 2001) use different grain-size composition classifications of deposits. According to N. Kachinski's classification used in the present work, deposits containing 0–5 percent of particles smaller than 0.01 (0.01–0.001) mm in fine soil are refered to as light sand, 5–10% as tight sand, 10–20% as sandy loam, 20–30% as light loam, 30–40% as medium loam, 40–50% as clay loam, and above 50% as clay. The map presents grain-size composition for fine soil (particle size below 1 mm) surface deposits lying as deep as 2–2.5 m. The legend of the map contains nine grain-size composition varieties for till (glacial), glaciolacustrine and glaciofluvial deposits, as compiled after the methods elaborated by R. Prapiestienė and M. Eidukevičienė (1993): (1) s – s_1/s, (2) ps/s, (3) ps/s/p, ps/s/p_2 – m, (4) ps/p – p_1, (5) p/p – p_1, (6) p – p_1/p_2 – m, p – p_1/ p – p_1/m, (7) p_2/m, (8) ps/p_2 – m, and (9) ps/ps, where *s* is light sand, s_1 – tight sand, *p* – light sandy loam, p_1 – medium loam, p_2 – clay loam, *m* – clay (Fig. 2). Fluvial and organogenic deposits, alluvium and peat, respectively (10^{th} and 11^{th} varieties, where *d* is peat), are singled out separately. Such approach was used to distinguish deposit areas which are important from the geological and geomorphological points of view. Theoretically, the first and second contours show glaciofliuvial and glaciolacustrine deposits – sands brought by meltwater and settled in the outwash deltas and plains, as well as glaciolacustrine basins; the third type contours comprise transformed till deposits, the sixth type – glaciolacustrine deposits in former glaciolacustrine basins, the seventh type – glaciolacustrine basin bottom with the finest particles settled, i. e. clay loam and clay, and the eight type – glaciolacustrine basin nearshore. This map has been compiled by R. Prapiestienė and M. Eidukevičienė.

In the present paper, as multilayer (inhomogeneous) deposits are regarded those that are formed of several layers of deposits of different grain-size composition (the 3rd variety), while homogeneous deposits lie in a bed of the same grain-size composition (1st, 5th and 9th varieties). Light and tight sand, as well as light, medium and clay loam are considered to be of the same grain-size composition. A more detailed partition of calcareous loam due to laboratory analysis errors, makes no sense in the present study. Figure 3 presents multilayer deposit contours which show a generalised view of till (ps/s/p, ps/s/p_2 – m) and glaciolacustrine (p – p_1/p_2 – m , p – p_1/ p – p_1/m and rarely occurring ps/s/p_2 – m) deposits.

The investigation of grain-size composition spatial structure for surface deposits and related regularities has been performed by the cartographic analysis method applied for the Lithuanian surface deposit grain-size data from GIS database on a 1:300 000 scale.

2. Applying statistical grids for analysis of spatial structures of Lithuania's surface deposits, the problem arises while selecting the size of a statistical territorial unit or statistical grid suitable for the evaluation purposes; this size should provide an unbiased reflection of information present in a map of a scale chosen. Different territorial units should be chosen for different scales. Taking into account the scale and details of the map analysed (1:300 000), the 25 km^2 (5 × 5) statistical grid has been chosen. This choice was caused by the pursuit of impartial evaluation of the territorial structure of surface deposits in order to reveal not only the glacigenic (glacial and aquaglacial) surface forming factors, but also some epigenetic (especially fluvial) processes. The grid size chosen is optimal for manifestation of diversity in territorial grain-size composition and internal grain-size composition structure of some separate parts inside a territory in the map of the scale analysed. If a smaller grid size (2 × 2 km) were used, the spatial diversity differentiation of the results would be shown according to the impact of glacigenic and epigenetic factors, while the effect of their interaction on the general diversity of grain-size composition would not be reflected.

After the area of Lithuania had been divided into grids, the diversity in surface deposit grain-size composition (for different contour numbers) was evaluated. The diversity in grain-size composition was expressed in diversity points (such points correspond to a number of contours differing in grain-size composition). According to diversity in spatial structure, the grain-size composition of Lithuanian surface is grouped into five categories: very uniform (1), uniform (2), rather diverse (3–4), diverse (5) and very diverse (6–8). The selection of intervals was caused by data set (normal distribution) structure. According to the standard deviation of the diversity point from the average (point 3) and the distribution of grids of different size, typological microregions have been singled out and generalised by joining them into regions (done by J. Volungevičius).

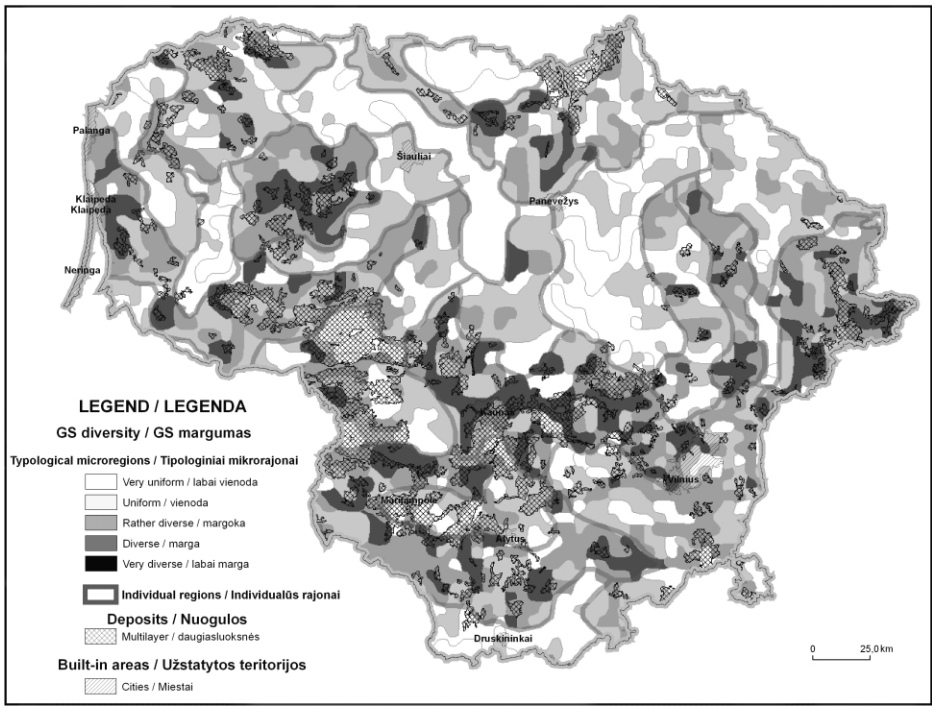

Fig. 3. Diversity in spatial structure of grain-size composition for surface deposits. Compiled by J. Volungevičius who used the map of soil grain-size composition in Lithuania compiled by R. Prapiestienė and M. Eidukevičienė in 2006 (source: the data base of the Digital Map of Lithuania's Soils, scale 1:300 000 (1998), Land Research and Assessment Department of the National Land Management Institute)

3 pav. Paviršinių nuogulų granuliometrinės sudėties erdvinės struktūros margumas. Sudarė J.Volungevičius, panaudojęs R. Prapiestienės, M. Eidukevičienės 2006 m. Lietuvos dirvožemio dangos granuliometrinės sudėties žemėlapį (šaltinis: Valstybinio žemėtvarkos instituto Žemės tyrimo ir vertinimo skyriaus skaitmeninio Lietuvos dirvožemių žemėlapio (M 1:300 000) duomenų bazė, 1998 m.)

RESULTS

Investigation of grain-size composition diversity spatial structure done for surface deposits by the statistical grid method and analysis of grain-size composition spatial structure by the cartographical method enabled us to show that the grain-size composition diversity (and the grain-size composition itself) is in fact determined by

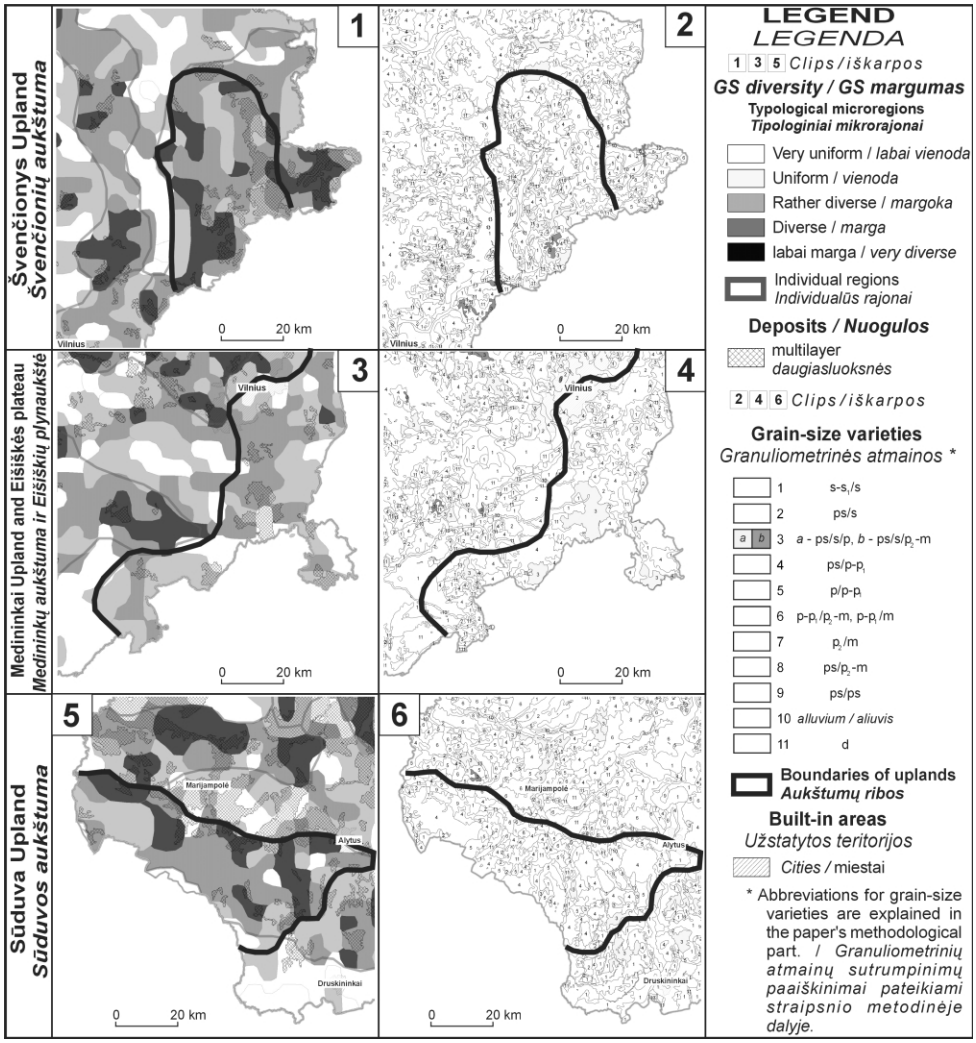

Fig. 4. Grain size-composition and its diversity for surface deposits in the Švenčionys, Medininkai and Sūduva uplands and Eišiškės plateau.

Compiled by J. Volungevičius (source: the data base of the Digital Map of Lithuania's Soils, scale 1:300 000 (1998), Land Research and Assessment Department of the National Land Management Institute)

4 pav. Paviršinių nuogulų granuliometrinė sudėtis ir jos margumas Švenčionių, Medininkų bei Sūduvos aukštumose ir Eišiškių plynaukštėje.

Sudarė J. Volungevičius (šaltinis: Valstybinio žemėtvarkos instituto Žemės tyrimo ir vertinimo skyriaus skaitmeninio Lietuvos dirvožemių žemėlapio (M 1:300 000) duomenų bazė, 1998 m.)

glacigenic and epigenetic processes. The basic reason for the diversity is the genesis of deposits and grain-size composition caused by it.

Both very diverse and very uniform grain-size composition typological micro-regions are observed in the relief of different genetic types (Kudaba, 1983; Jasinskas, Prapiestienė, Eidukevičienė, Česnulevičius, 2001).

A higher diversity of grain-size composition is characteristic of the surface areas that had experienced a relatively complex (if compared to adjacent areas) genesis (we say such areas are notable for polygenesis).

The highest diversity in grain-size composition are (as well as the genetically different relief) observed at the interface of genetically different deposits. Therefore, at the macro-level of relief, the highest diversity is noted for interfaces of uplands and lowlands formed by glacial and aquaglacial processes and re-formed epigenetically, especially by fluvial processes.

Very diverse grain-size composition is found at the interfaces of Žemaitija upland and Užventis lowland, Švenčionys upland and Dysna lowland, as well as at the confluences of such rivers as the Nemunas, Neris, Šventoji, Nevėžis and Dubysa.

Diverse and rather diverse grain-size composition is in fact typical of the marginal till and glaciolacustrine deposits. Till deposits with a sandy loam stratum (sandy loam/loam) prevail on the Baltija and Žemaitija uplands. Multistrata deposit contours are sporadic and small.

Glaciolacustrine basin areas in the Karšuva and Užnemunė lowlands are notable for loam and clay (loam/clay). Surface deposits in the nearshore areas of glaciolacustrine basins are of lighter grain-size – with a sandy loam layer (sandy loam/loam – clay). In the Mūša–Nemunėlis lowland situated in the glaciolacustrine basin area, the grain-size composition is unique – clay loam/loam; it is heavier than in the Karšuva and Užnemunė lowlands, and the contours of grain-size varieties are large. Such a diverse grain-size composition is observed at the confluences of the Merkys, Vokė, Šalčia and Verseka rivers.

Uniform and very uniform grain-size composition is in the ground till where the deposits are notable for homogeneity, and they contain more clay (loam/loam). In the Central Lithuanian and Maritime lowlands the surface deposits are formed of two main grain-size composition varieties – sandy loam/loam and loam.

Uniform and very uniform grain-size composition is observed at the southern margin of Lithuania, Medininkai upland, Eišiškės plateau and the centre of

the Švenčionys upland. A specificity of grain-size composition of surface deposits here is the occurrence of many deposit layers (Fig. 3). The deposits consist of sandy loam, sand and loam layers. Such deposit contours are large (Fig. 4).

The spatial structure of diversity in surface deposit grain-size composition and the grain-size composition itself confirm the regularities determined in the reference sites (Baltrūnas, 1995). The key feature becomes manifested – the degree of till deposits becoming more lighter/sandy is related with the age of the deposits per se (and relief). Surface deposits in the Middle Pleistocene relief are seen as a result of long-term epigenetic transformation of tills and soil-forming processes – deposits form many layers, but their grain-size composition is uniform and rather diverse. Young surface deposits in the subglacial tills are homogeneous, uniform and very uniform in grain-size composition. According to both grain-size composition diversity and grain-size composition per se, a similarity was observed between deposits of East and South Lithuanian phases of the Nemunas glaciation Baltic stage, as well as between those of Central and Northern Lithuanian phases.

DISCUSSION

In the reference sites, three basic factors of grain-size composition formation for till deposits of all Baltic stage (last) glaciation phases have been determined: exaration and crumbling of Scandinavian rocks (Baltrūnas, 1995). Investigations on the spatial structure of the diversity in grain-size composition and the grain-size composition per se show that the basic factor of the surface deposit grain-size composition is the conditions of lithogenesis. Epigenetic factors modify this diversity and highlight even more. As the till deposits become lighter / more sandy due to soil-forming processes, the grain-size composition diversity lessens, while the glaciofluvial and bogging processes increase the diversity.

The grain-size composition diversity and grain-size composition are similar in the Medininkai upland and Eišiškės plateau (Fig. 4), thus confirming the former assumptions (Baltrūnas, 1995) that they can be coeval.

1. It was found that by its age the central part of the Švenčionys upland should be compared to the Medininkai upland and Eišiškės plateau (Baltrūnas, 1995). The multilayer grain-size composition confirms that the central part of the Švenčionys upland is of a similar age as the Medininkai upland and Eišiškės plateau and differ from the Sūduva upland formed later (East Lithuanian phase of the Baltic stage). One more argument for this proposition is the same type (group) of soil given in the Soil Atlas of Europe (2005). In the centre of the Švenčionys upland, in the same way as in the Medininkai upland, soils specific of Lithuania (Planosols) have been singled out. More detailed investigations of grain-size composition diversity are expected to reveal new factual material.

2. After investigation of grain-size composition spatial structure is over, it is expedient to come back to the problem of grain-size composition relativity. Due to errors in laboratory analyses performed by Kachinski's pipette method for calcareous deposits, the real grain-size composition was found to be distorted (Эйдукявичене, 1980). For instance, loam with 15–18% carbonates has a lower content of fractions in the following range: 1–0.25 mm (1.4%), 0.05–0.01 mm (0.4%); 0.01–0.005 mm (4.0%); 0.005–0.001 mm (3.4%), and smaller than 0.001 mm (1.7%). Therefore the content of particles smaller than 0.01 mm decreases by 5–7%, while that of 0.25–0.05 mm fraction increases by 7.4% (Eidukevičienė, Grybauskas, Vaičys, 2001). From the methodological point of view, it is important to know which methods were used for grain-size analyses in the laboratory and to determine the group name of grain-size composition. When the grain-size composition group name is determined by the triangular diagram method according to the ratios of all fine soil fractions (1–0.001 mm) – sand (1–0.05 mm), silt (0.05–0.001 mm) and clay (smaller than 0.001 mm), the errors can in some cases affect the grain-size variety contours in the map (Eidukevičienė, Grybauskas, Vaičys, 2001). The grain-size composition name for most calcareous and clay-rich till deposits of the Upper Pleistocene age in the Central Lithuanian plain does not differ from that of the Middle Pleistocene weathered and carbonate-depleted till deposits in the Medininkai upland as shown by the map of soil-forming rock grain-size composition (Grybauskas, 2001b). Also, grain-size composition in the subglacial till plains is lighter than in the uplands. This contradicts theory and the results obtained while studying the reference sites (Baltrūnas, 1995). Therefore, we can say that the area formed by individual grain-size composition varieties in Lithuania, as shown in the soil-forming rock grain-size composition map (Grybauskas, 2001b), is determined relatively.

CONCLUSIONS

1. The basic factor determining the diversity in grain-size composition of surface deposits is lithogenetic conditions. Epigenetic factors modify this diversity and highlight it.

2. The multilayer character (inhomogeneity) of grain-size composition of surface deposits in Lithuania's territory is not always related to a high diversity in the spatial structure of grain-size composition. The diversity in grain-size composition for till deposits forming the Middle Pleistocene relief is low, although deposits form several layers. At the same time the diversity in grain-size composition is differing in the surface deposits occurring in former glaciolacustrine basins.

3. Both grain-size composition diversity and grain-size composition per se show a similarity between till

deposits of East and South Lithuanian phases, on the one hand, and between those of Middle and North Lithuanian phases on the other.

4. The results of the research on the diversity of grain-size composition spatial structure for Pleistocene surface deposits can be used for mapping areas unfavourable for farming (Less Favoured Areas) and the Lithuanian soil productivity correction works planned for the nearest future in order to reveal the types of soil productivity.

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LIETUVOS PLEISTOCENO PAVIRŠINIŲ NUOGULŲ GRANULIOMETRINĖS SUDĖTIES ERDVINĖS STRUKTŪROS ĮVERTINIMAS STATISTINĖS GARDELĖS METODU

Santrauka

Straipsnyje pateikti nauji pleistoceno nuogulų granuliometrinės sudėties erdvinės struktūros tyrimų Lietuvos teritorijoje rezultatai. Tirtos 2–2,5 metro storio paviršinės nuogulos. Tyrimas atliktas dviem etapais: pirmiausia sudarytas granuliometrinės sudėties žemėlapis, vėliau tirtas granuliometrinės sudėties margumas. Granuliometrinės sudėties žemėlapis sudarytas remiantis Valstybinio žemėtvarkos instituto skaitmeninio Lietuvos dirvožemių žemėlapio (M 1:300 000) duomenų baze (1998), kurioje užfiksuoti 1985 metų Lietuvos dirvožemių žemėlapio (M 1:300 000) kontūrai. Granuliometrinės sudėties margumas tirtas 5 × 5 km dydžio gardelėse statistinės gardelės metodu. Tokia metodika siekta išskirti geologiniu ir geomorfologiniu požiūriu svarbius nuogulų arealus ir objektyviai įvertinti teritorinę paviršinių nuogulų struktūrą išryškinant ne tik paviršių formavusius glacigeninius (glacialinius ir akvaglacialinius), bet ir kai kuriuos epigenetinius paviršių performuojančius procesus. Granuliometrinės sudėties margumas išreikštas margumo balu. Margumo tipologija: labai vienoda, vienoda, margoka, marga ir labai marga. Pagal margumo balą bei skirtingas reikšmes turinčių gardelių išsidėstymo dėsningumus išskirti tipologiniai mikrorajonai, kurie apibendrinti sujungiant juos į individualius rajonus.

Nustatyta, kad tiek labai margos, tiek ir labai vienodos granuliometrinės sudėties tipologiniai mikrorajonai paplitę įvairaus genetinio tipo reljefe. Didesnis granuliometrinės sudėties margumas yra būdingas toms paviršiaus teritorijoms, kurioms teko santykinai (lyginant su aplinkinėmis teritorijomis) sudėtinga genezė.

Margiausia granuliometrinė sudėtis yra skirtingų genetinių tipų nuogulų (ir skirtingų genetinių tipų reljefo) sandūroje. Todėl reljefo makrolygmeniu didžiausiu margumu pasižymi aukštumų ir žemumų sandūros, suformuotos glacialinių bei akvaglacialinių ir performuotos epigenetinių, ypač fliuvialinių, procesų.

Straipsnyje pateikta granuliometrinės sudėties erdvinės struktūros margumo ir dėsningumų koncepcija – glacigeniniai ir epigenetiniai procesai – yra svarbiausias veiksnys, nulėmęs granuliometrinės sudėties margumą.

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ОЦЕНКА ПРОСТРАНСТВЕННОЙ СТРУКТУРЫ ГРАНУЛОМЕТРИЧЕСКОГО СОСТАВА ПОВЕРХНОСТНЫХ ОТЛОЖЕНИЙ ПЛЕЙСТОЦЕНА ЛИТВЫ МЕТОДОМ СТАТИСТИЧЕСКОЙ СЕТКИ

Резюме

В статье представлены новые результаты исследований пространственной структуры гранулометрического состава плейстоценовых отложений на территории Литвы. Изучались поверхностные отложения 2–2,5-метровой толщины. Исследования проводились двумя этапами: прежде всего составлена карта гранулометрического состава, затем изучена пестрота гранулометрического состава. Карта гранулометрического состава составлена на основе базы данных карты почв Литвы в масштабе 1:300 000 (1998 г.), в которой зафиксированы контуры почв карты Литвы 1985 года в масштабе 1:300 000. Пестрота гранулометрического состава изучалась методом статистической сетки (5 × 5 км). Изучение по такой методике дало возможность выделить важные ареалы плейстоценовых отложений с геологической и геоморфологической точки зрения и объективно оценить пространственную структуру выявляя процессы не только гляцигенные (гляциальные и аквагляциальные) – формирующие поверхность, но и некоторые эпигенетические – преобразующие поверхность. Пестрота гранулометрического состава выражена в качестве бала пестроты. Составлена типология пестроты грануло-метрического состава: очень одинаковый, одинаковый, пестроватый, пестрый и очень пестрый. На основе бала пестроты и закономерностей пространственного распре-деления клеток с различными показателями выявлены микрорайоны. Микрорайоны обобщены в индивидуальные районы.

Установлено, что микрорайоны, как очень пестрого, так и очень одинакового гранулометрического состава, распространены в рельефе различных генетических типов. Более значительная пестрота свойственна территориям поверхности сложного генезиса. Наивысшая пестрота гранулометрического состава выявлена на стыке отложений различного генезиса (соответственно и рельефа различных генетических типов). Поэтому на макроуровне рельефа наивысшей пестротой отличаются территории на стыке возвышенностей и низменностей, сформированные как гляциальными, так и аквагляциальными процессами и преобразованные эпигенетическими, особенно флювиальными.

В статье представлена концепция разнообразия пестроты гранулометрического состава и закономерностей пространственной структуры гранулометрического состава – гляцигенные и эпигенетические процессы являются основным фактором, определившим пестроту гранулометрического состава.