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# Correlation of Lithuanian Maritime Pleistocene tills based on their mineralogy

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The previous studies of Pleistocene deposit in the Lithuanian Maritime Region (LMR) show the difficulty of its stratigraphical subdivision and correlation of sediment beds. Due to scarcity of biostratigrafical and absolute dating results, the variety of lito-stratigraphical criterions such as till petrography, geochemistry or even well rounded hornblende grain amount and other physical or visual characteristics used for lito-stratigraphy and correlation of tills did not give effective results. The article provides correlation of Pleistocene deposits based on mineralogical composition of the sandy fraction of tills from one geological profile located along the Lithuanian Baltic Sea coast using the multivariate statistics. The mineralogical data from six boreholes were statistically analysed and lithostratigraphical interpretation was made. Data analysis displayed that the till complexes have different amount of minerals from statistically derived mineral associations. It allowed distinguishing of six till complexes characterized by distinct mineralogical composition. These differences are clearly visible in the results of the statistical comparative analysis of the mineral composition of adjacent tills complexes. The stratigraphical identification of distinguished till complexes is based on its occurrence, inter-till deposit absolute dating and interglacial sediment palaeobotanical results.

**Key words:** Pleistocene, W Lithuania, till complexes, correlation, mineralogy

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## INTRODUCTION

Despite numerous geological surveys carried out in the Lithuanian Maritime Region (LMR), the stratigraphical subdivision, structure and consequently the sedimentation history of Pleistocene deposits is still obscure there. The Pleistocene sediment sequence in the LMR is represented by glacial sediments of complex deposit structure. The inter-till (especially interglacial) sediment beds are spread very sporadically, thus causing controversial stratigraphical interpretation. The scarcity of biostratigraphical data and absolute dating results also do not contribute to the solution of the mentioned problems. Only two sediment sections are identified as Butėnai (Holsteinian) Interglacial in the LMR area. The widespread inter-till fine sandy sediment bed of unidentified origin subdividing the Pleistocene sediment sequence into two separate parts occurs in the area. This sediment sequence containing organic matter pretends to serve as an important marker for stratigraphical subdivision of Pleistocene deposits. However, the age interpretation of these inter-till sediments varies in a very wide range (Vonsavičius, 1967; Gudelis, 1973; Kondratienė, 1967, 1971, 1996; Kondratienė et al., 2003; Kondratienė, Damušytė, 2009; Bitinas et al., 2013). The latest reported investigation results show that these sediments can be formed during a few cycles of sedimentation starting from the Late Saalian and ending with the Middle Weichselian (Bitinas et al., 2013). So this sediment bed can support the stratigraphical interpretations, but interpretation of its extension and stratigraphical position is also very dependent on successful correlation of widely spread till beds. For this, reliable criteria for the correlation of till beds composing the Pleistocene sediment sequence in the LMR are necessary.

Lithological features traditionally used for the stratigraphical subdivision and correlation of Pleistocene tills, such as pebble petrography, results of geochemical or even hornblende grain roundness analyses carried out in this region during geological mapping[1] and other investigations[2] do not give satisfactory results (Bitinas et al., 2011, 1999; Gaigalas et al., 1997). So, rather different stratigraphy and interpretation of the structure of Pleistocene deposits in the LMR were drawn by different researches.

Based on lithostratigraphical and palynological data some authors provide two (Vonsavičius, 1967) or three (Gaigalas et al., 1997) major glacial advances in the LMR during the Middle Pleistocene attributed to the Dainava (Elster), Žemaitija (Drenthe) and Medininkai (Warthe) glacial periods. Also two ice sheet advances corresponding to Marine isotope stage (MIS) 2 (Baltija and Grūda glacial stages) (Gaigalas et al., 1997) or three ones corresponding to MIS 5a–d (Varduva) and MIS 2 (Baltija and Grūda) (Vonsavičius, 1967; Baltrūnas, 1995) ice sheet advances are interpreted as occurred during the Nemunas (Weichselian) glacial period. Meanwhile, the latest investigation data in Lithuania provided evidence of ice-free conditions since the end of the Merkinė (Eemian) interglacial during the Early and Middle Weichselian glacial period (Satkūnas et al., 2012; Baltrūnas et al., 2013; Šeirienė et al., 2014). Differently, the recently published results of geological investigations in the Šventoji Harbour and the Klaipėda Strait showed that probably the part of or even the whole Western Lithuania was covered by yet another ice advance during the early Middle Weichselian (MIS 4) glacial period (Molodkov et al., 2010; Damušytė et al., 2011; Bitinas et al., 2011). However, the palaeogeographical conditions of this period, especially the extent of glacial advance during the early Middle Weichselian are very problematic and disputed in all Baltic Region. Possible glaciation during the early Middle Weichselian has been also reported from the SE part of the Baltic Sea from Poland (Marks, 2012; Olszak et al., 2011; Krzywicki, 2002) and Latvia (Zelčs, Markots, 2004; Zelčs et al., 2011; Saaks et al., 2012). This study together with available recently published data of inter-till sediment absolute dating propose a possibility of the subdivision and correlation of Pleistocene deposits in the LMR based on till mineralogy. We present the stratigraphical subdivision and correlation of glacial deposits of 6 boreholes in the LMR carried out on a basis of the mineral composition of the till sandy fraction. A statistical approach to analyze the structure of data and to identify the compositional differences between the till complexes was applied.

## MATERIALS AND METHODS

The mineralogical composition of tills from 6 boreholes was analysed by P. Šinkūnas in the 0.1–0.25 mm fraction using the immersion method. Light and heavy minerals were separated in bromoform. Approximately 250–350 mineral grains were counted in each sample under a polarising microscope (POLAM R-112). 15 heavy and 6 light minerals were identified and their number calculated in percentages for 66 samples of till.

A statistical canonical ordination analysis using the CANOCO 4.5 computer programme for multivariate statistical analysis (ter Braak, Šmilauer, 1998) was applied for mineralogical data to obtain the reliable subdivision and correlation of Pleistocene till beds. To summarize the major gradients in mineralogical data a preliminary Detrended Component Analysis (DCA) was performed on the data set, to estimate the gradient length in standard deviation (SD) units of the first DCA axis and to determine linear or unimodal ordination methods to use for the mineralogical analysis data (ter Braak, Šmilauer, 1998). Since the gradient length was less than two SD, a Principal Component Analysis (PCA) was applied on the data sets. The Principal

[1] Bitinas et al. 1997, 2000. Geological mapping at scale 1:50 000 at Kretinga and Šilutė areas [manuscript]; Šimėnas et al. 1989. Geological-geophysical mapping at scale 1:200 000 of the southeastern part of the Baltic Sea shelf bordering the territory of Lithuania [manuscript].

[2] Gaigalas and Saladžius. 1974. Lithostratigraphical criterions of Pleistocene deposits of north-western Lithuania [manuscript]; Malinauskas et al. 1986. Geological investigations of key-sections of the middle Pleistocene deposits and its paleogeography in Lithuania territory [manuscript].

Component Analysis (PCA) allowed accessing the main mineralogical differences between till complexes of different age.

## STUDY AREA AND GEOLOGICAL SETTING

The analysed boreholes are located along the Lithuanian Baltic Sea coast (Fig. 1). Upper Permian and Mesozoic sediments underlie Pleistocene deposits. Pre-Quaternary surface is intersected by dense net of paleoincisions of 30–40 m depth in average, reaching even 100–110 m in places (Bitinas, 2002). According to the borehole logs the Quaternary deposit thickness in the Lithuanian coastal zone is up to 140 m or 50–65 m on the average. The Pleistocene sediment sequence is generally composed of tills (Fig. 2). Inter-till deposits are interlaying sporadically, except the one widespread inter-till sediment complex named as Pamarys sub-formation (Bitinas, 2002; Bitinas et al., 2013). According to the last geological mapping results, the deposits of at least four glaciations have been distinguished in the Pleistocene sequence of the LMR (Bitinas et al., 2011). The Pamarys inter-till sandy sediment beds enriched with organic matter are widespread at the similar stratigraphical level and in a large part of the LMR subdivide the Pleistocene deposits into two segments, separating the Middle Pleistocene deposits from the Upper Pleistocene ones (boreholes 9605, 10423) (Bitinas et al., 2013). According to the borehole log descriptions, three till complexes (attributed to Dainava, Žemaitija and Medininkai glaciations of Middle Pleistocene) with sporadic interbeds of inter-till deposits could be distinguished beneath this inter-till sandy sediment bed. Two of these till complexes are more widespread. Visually the till complexes are characterised by a very changeable colour, which can hardly serve as correlative (Bitinas et al., 2011). The colours of tills vary from grey with various tints to brown and dark brown in lower till complexes and to brownish grey or greyish brown in the uppermost one. In the uppermost part of the Pleistocene sequence, also two or three litologically distinct till complexes interbedded with glaciofluval and glaciolacustrine deposits

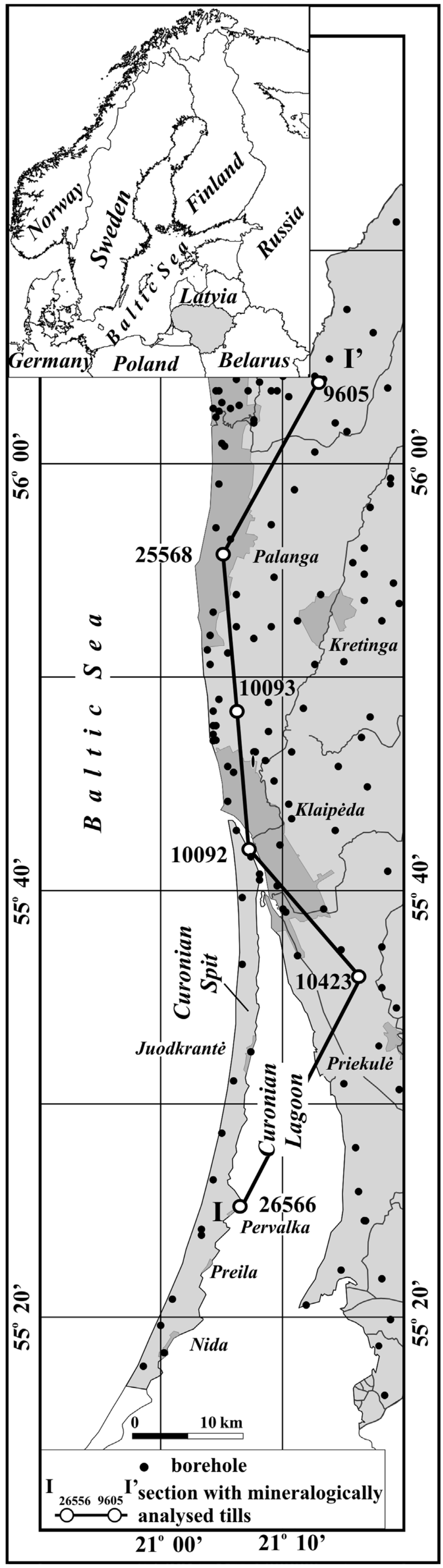


**Fig. 1.** Location of mineralogically analysed sections in Lithuanian Maritime Region

**1 pav.** Mineralogiškai tirtų pjūvių padėtis Lietuvos pajūryje

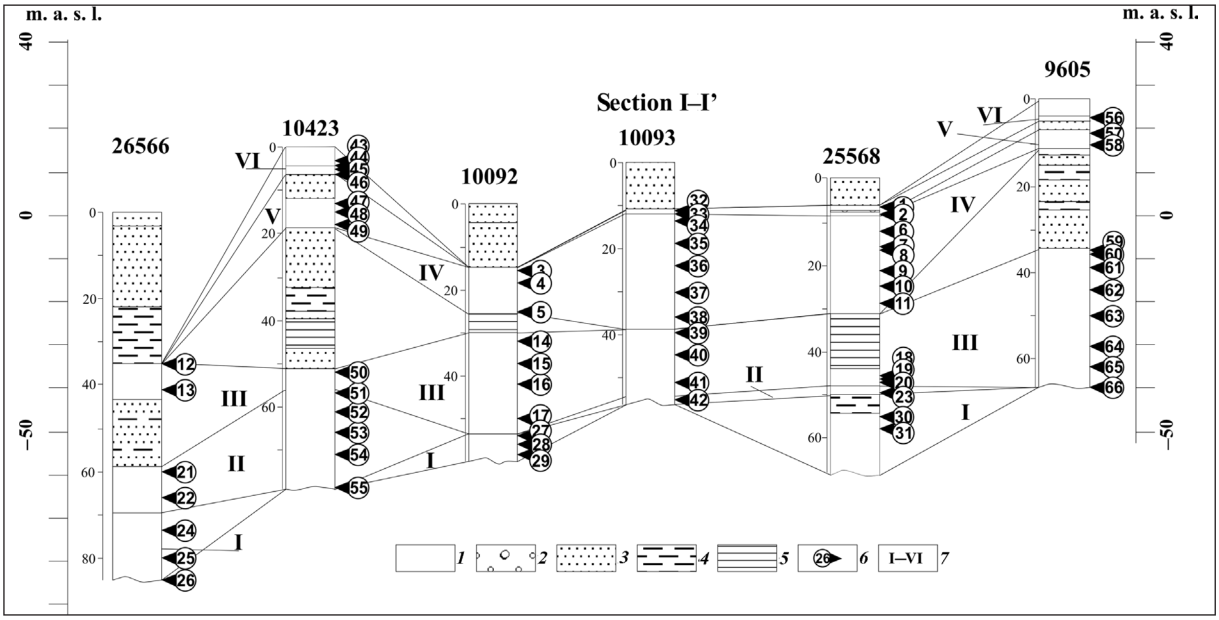

**Fig. 2.** Correlation of Pleistocene till complexes based on their mineralogy: *1* – till, *2* – gravel, *3* – sand, *4* – silt, *5* – clay, *6* – sampling point with number, *7* – till complexes

**2 pav.** Pleistoceno moreninių nuogulų koreliacija pagal jų mineralinę sudėtį: *1* – moreninės nuogulos, *2* – žvirgždas, *3* – smėlis, *4* – aleuritas, 5 – molis, 6 – mėginio vieta ir numeris, *7* – moreninių nuogulų kompleksai

are distinguished above the Pamarys inter-till sediment complex (boreholes 9605, 10423). However, the Pleistocene sediment sequence, mostly near the coastal zone is of an incomplete structure (composed of 1 or 2 till complexes), mostly its upper part is eroded by waves of the Baltic Sea during its subsequent development (boreholes 26566, 10093, 10092) and in most cases is directly overlain by recent aeolian (boreholes 10092, 26566) and marine or lacustrine sediments (borehole 25568). Generally, the grey colour with various tints in places of compact till in the lowermost part changes to brownish, greenish grey or greyish brown in the middle part of this upper part of the Pleistocene sequence and mostly to yellowish brown, spotty, soft and slightly weathered till prevails in its uppermost part.

## RESULTS

The results of the Principal Component Analysis (PCA) of the mineralogical data show that the mineral composition of tills differs mainly along gradients of quartz, pyrite, iron oxides and hydroxides, amphiboles, carbonates, garnet and epidotes (Fig. 3). The till samples can be well grouped into complexes along the main axis of gradient variation ($\lambda_1 = 0.34$), where the distinguished till complexes I and IV show the greatest dissimilarities of mineralogical composition. Meanwhile, the rest cluster of samples placed around the centre of the diagram shows a wide variation in the mineralogical composition, but still there are some differences allowing to distinguish separate till complexes. The results of PCA also display a relatively good correlation between the amount of pyroxenes, apatite, tourmaline, feldspars, staurolite, amphiboles and garnet (Fig. 3). A similar correlation has been established between the amount of pyrite, iron oxides and hydroxides, glauconite, leucoxene, biotite and disthen. So the results of the analysis disclose the associations of minerals reflecting best the mineralogical features and dissimilarities of individual till complexes. Arrangement of heavy minerals in the DCA biplot (Fig. 4) indicates the existence of such associations: 1) pyroxenes-tourmaline-garnet-epidotes-amphiboles, 2) rutile-white pyrite, 3) pyrite-disthen, 4) staurolite-apatite-phoshates-zircon-ilmenite and magnetite-leucoxene-iron oxides and hydroxides.

The values of mean mineral amount of the distinguished six till complexes in the LMR did not show any distinct compositional dissimilarity between different till complexes (Table). Meanwhile,

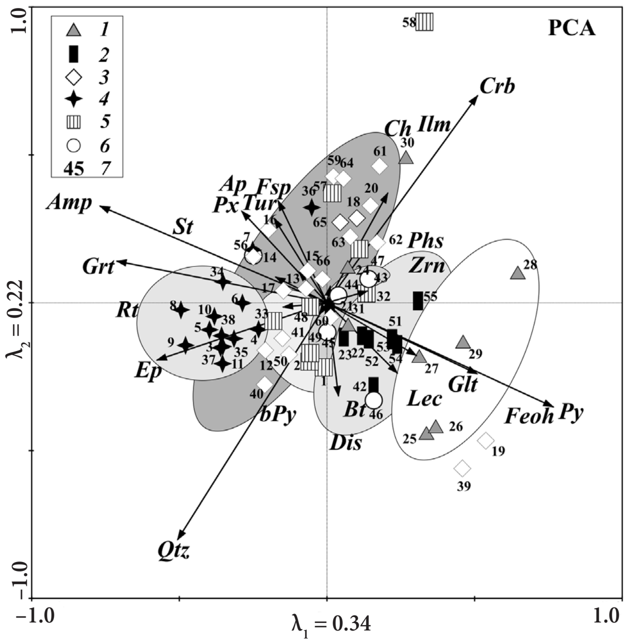


**Fig. 3.** Biplot of Principal Component Analysis (PCA) of till mineral composition (for mineral abr. see Table). Till complexes: *1* – I, *2* – II, *3* – III, *4* – IV, *5* – V, *6* – VI; *7* – sample number

**3 pav.** Moreninių nuogulų mineralinės sudėties pagrindinių komponentų analizės (PCA) diagrama (mineralų santrumpas žr. lentelėje). Moreninių nuogulų kompleksai: *1* – I, *2* – II, *3* – III, *4* – IV, *5* – V, *6* – VI; *7* – mėginio numeris

the amount sums of mineral associations well serve as a feature to express the mineralogical differences of the till complexes. However, the subdivision of some till beds into till complexes is quite problematic due to not very large mineralogical differences. Beneath the Pamarys sub-formation quite small differences are in between till complexes II and III, which mainly differ by amount of the associations pyroxenes-tourmaline-garnet-epidotes-amphiboles and pyrite-disthen (Fig. 4 PCA, 5). The oldest greyish with various tints till (Fig. 2, complex I) has been observed mostly in particular areas commonly spread in the depressions of pre-Quaternary surface and paleoincisions. It mineralogically clearly differs

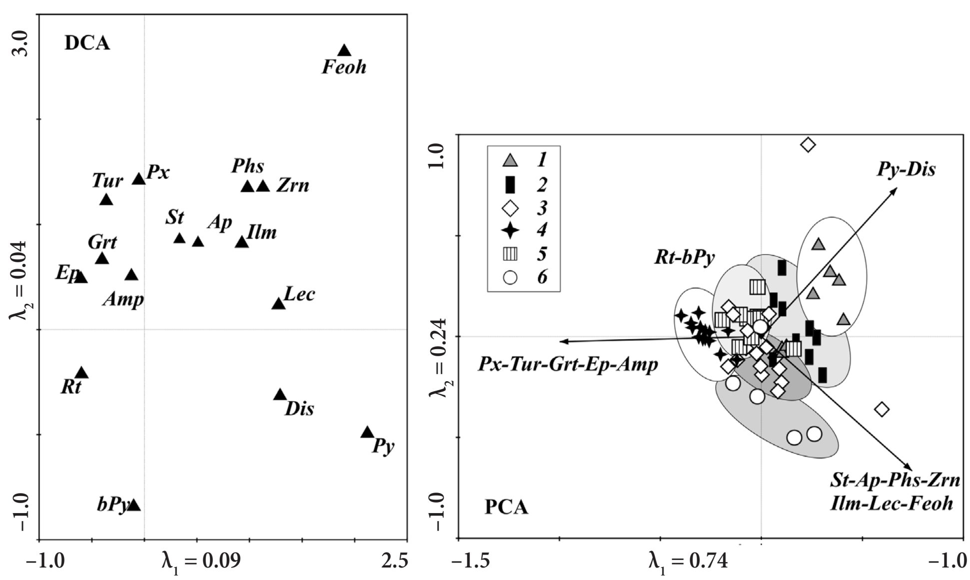


**Fig. 4.** Ordination diagrams of Detrended Correspondence Analysis (DCA) illustrating the arrangement of minerals and Principal Component Analysis (PCA) illustrating arrangement of till samples depending on amounts of mineral associations (for mineral abr. see Table). Till complexes: *1* – I, *2* – II, *3* – III, *4* – IV, *5* – V, *6* – VI; *7* – sample number

**4 pav.** Mineralų išsidėstymas netrendinės atitikties analizės diagramoje (DCA) ir moreninių nuogulų mėginių išsidėstymas pagrindinių komponentų analizės diagramoje (PCA) pagal mineralų asociacijų kiekius (mineralų santrumpas žr. lentelėje). Moreninių nuogulų kompleksai: *1* – I, *2* – II, *3* – III, *4* – IV, *5* – V, *6* – VI; *7* – mėginio numeris

Table. **Sandy fraction mineral composition of different till complexes. Abbreviations of minerals after D. L. Whitney and B. W. Evans (2010)**

Lentelė. **Skirtingų litokompleksų moreninių nuogulų smėlio frakcijos mineralinė sudėtis. Mineralų santrumpos pagal D. L. Whitney ir B. W. Evans (2010)**

| Till complexes | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| Number of samples | 8 | 9 | 21 | 14 | 9 | 5 |
| Mean amount (%) of heavy minerals | | | | | | |
| Ilmenite and magnetite **(Ilm)** | 17.86 | 14.90 | 17.36 | 12.46 | 15.06 | 16.78 |
| Iron oxides and hydroxides **(Feoh)***  | 8.04 | 11.52 | 7.95 | 3.06 | 4.98 | 18.04 |
| Pyrite **(Py)** | 20.99 | 15.56 | 10.23 | 3.37 | 10.56 | 3.36 |
| White Pyrite **(bPy)*** | 0.98 | 0.71 | 0.13 | 0.44 | 1.43 | 0.06 |
| Leucoxene **(Lec)*** | 4.08 | 4.66 | 3.19 | 2.67 | 3.78 | 2.50 |
| Rutile **(Rt)** | 0.13 | 0.20 | 0.06 | 0.27 | 0.28 | 0.06 |
| Zircon **(Zrn)** | 1.13 | 0.64 | 0.55 | 0.38 | 0.42 | 0.60 |
| Staurolite **(St)** | 0.65 | 0.64 | 0.66 | 0.93 | 0.50 | 0.52 |
| Disthen **(Dis)*** | 0.31 | 0.37 | 0.08 | 0.18 | 0.36 | 0.06 |
| Turmaline **(Tur)** | 0.93 | 1.17 | 1.84 | 1.69 | 1.86 | 2.16 |
| Garnet **(Grt)** | 13.76 | 15.42 | 16.71 | 23.24 | 15.49 | 17.24 |
| Apatite **(Ap)** | 0.26 | 0.52 | 0.49 | 0.61 | 0.37 | 0.50 |
| Epidotes **(Ep)** | 3.94 | 4.11 | 4.16 | 7.99 | 6.48 | 4.26 |
| Phosfates **(Phs)*** | 2.71 | 2.58 | 2.57 | 1.75 | 2.23 | 2.08 |
| Amphiboles **(Amp)** | 20.26 | 23.49 | 28.20 | 34.09 | 28.72 | 23.12 |
| Piroxenes **(Px)** | 4.03 | 3.51 | 5.81 | 6.86 | 7.50 | 8.66 |
| Mean amount (%) of light minerals | | | | | | |
| Quartz **(Qtz)** | 68.64 | 70.18 | 69.70 | 77.46 | 70.49 | 73.32 |
| Feldspars **(Fsp)** | 12.04 | 15.51 | 17.32 | 14.29 | 12.08 | 13.22 |
| Biotite **(Bt)** | 0.43 | 0.84 | 0.27 | 0.45 | 0.63 | 1.16 |
| Chlorite **(Ch)*** | 0.04 | 0.09 | 0.00 | 0.00 | 0.23 | 0.00 |
| Glauconite **(Glt)** | 4.09 | 3.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| Carbonates **(Crb)*** | 14.78 | 9.96 | 12.31 | 7.81 | 16.57 | 12.30 |

* Abbreviations not provided by D. L. Whitney and B. W. Evans, 2010.

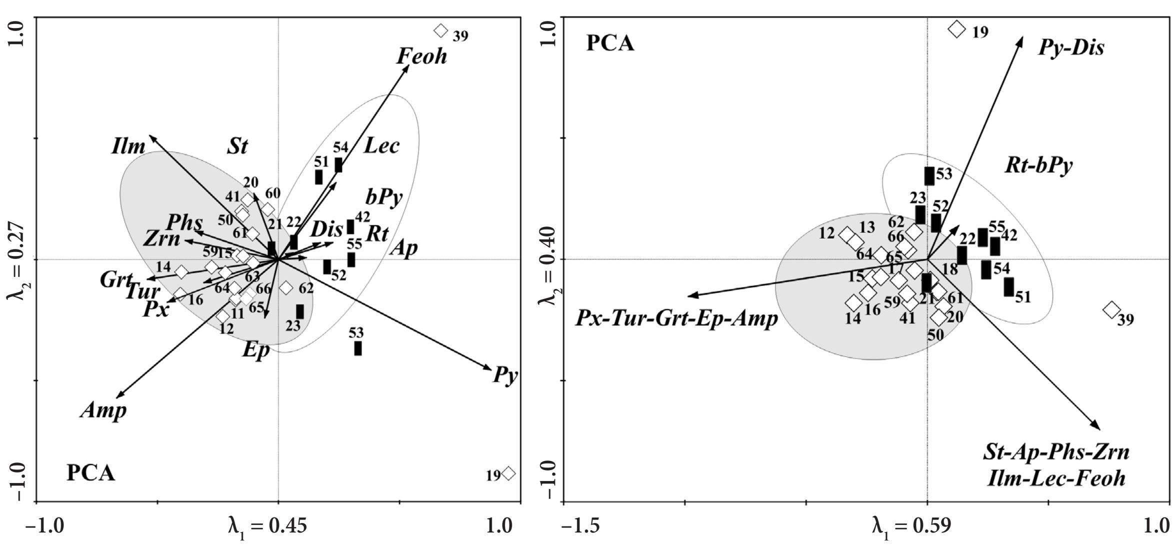


**Fig. 5.** Biplots of Principal Component Analysis (PCA) illustrating arrangement of till samples depending on mineral composition and amounts of mineral associations (for mineral abr. see Table, for till complexes see Figs. 3, 4)

**5 pav.** Moreninių nuogulų mėginių išsidėstymas pagrindinių komponentų analizės diagramose (PCA) pagal mineralinę sudėtį ir mineralų asociacijų kiekius (mineralų santrumpas žr. lentelėje, moreninių nuogulų kompleksus žr. 3, 4 pav.)

from other till complexes by the highest amount of the mineral association pyrite-disthen and the lowest amount of the mineral association pyroxenes-tourmaline-garnet-epidotes-amphiboles (Fig. 4 PCA). The average values of mineral composition of the rest two till complexes (II and III) show the similarity between these complexes (Table), however, the PCA biplots show that till complex III has higher amount of the pyroxenes-tourmaline-garnet-epidotes-amphiboles association minerals than till complex II (Fig. 4 PCA, 5).

The upper part of the Pleistocene sequence overlaying the widespread inter-till sediments of the Pamarys sub-formation consists of up to three visually distinct till beds. The greatest differences of mineralogical composition represent till complex IV (Fig. 4 PCA, 6). Its samples cluster as a discrete group along the mineral association pyroxenes-tourmaline-garnet-epidotes-amphiboles gradient showing the highest amounts of these minerals there in the sequence. The uppermost, mostly weathered till complex (VI), which commonly forms the present-day ground surface, is enriched with minerals of the association staurolite-apatite-phoshates-zircon-ilmenite and magnetite-leucoxene-iron oxides and hydroxides, while the till complex (V) occurring beneath the uppermost one is characterised by higher amounts of minerals of the rutile-white pyrite and pyrite-disthen associations (Fig. 6).

## INTERPRETATION

The compositional differences of the till complexes are determined by many factors: material source, transport conditions, pattern of sedimentation and weathering conditions of debris (Gaigalas, 1979; Klimašauskas, 1965, 1967; Juozapavičius, 1976; Šinkūnas, 1998). The components of till clastic material within the LMR accumulated by glaciers of Scandinavian Glaciations may be inherited from three lithologically distinct erosion sources: crystalline rocks of the Baltic Shield, transitional Palaeozoic carbonate and local Mesozoic rocks (Šinkūnas, 1998). Mineralogical differences between different till complexes are mainly defined by different ice flow directions from different glaciation centres during the Pleistocene. The minerals composing sand fraction in tills may be grouped into associations according to the correlation of mineral amount changes.

The ice of ice sheets moving throughout the crystalline rocks was enriched with quartz, biotite, feldspars, pyroxenes, epidotes, amphiboles and garnet (mostly Fennoscandian minerals) as well as weathering sensitive minerals – pyroxenes and amphiboles, while with erosion of sedimentary rocks (clay, sandstone, limestone, dolomite, marl) the amount of iron oxides and hydroxides, pyrite, glauconite, leucoxene, zircon and carbonate minerals in

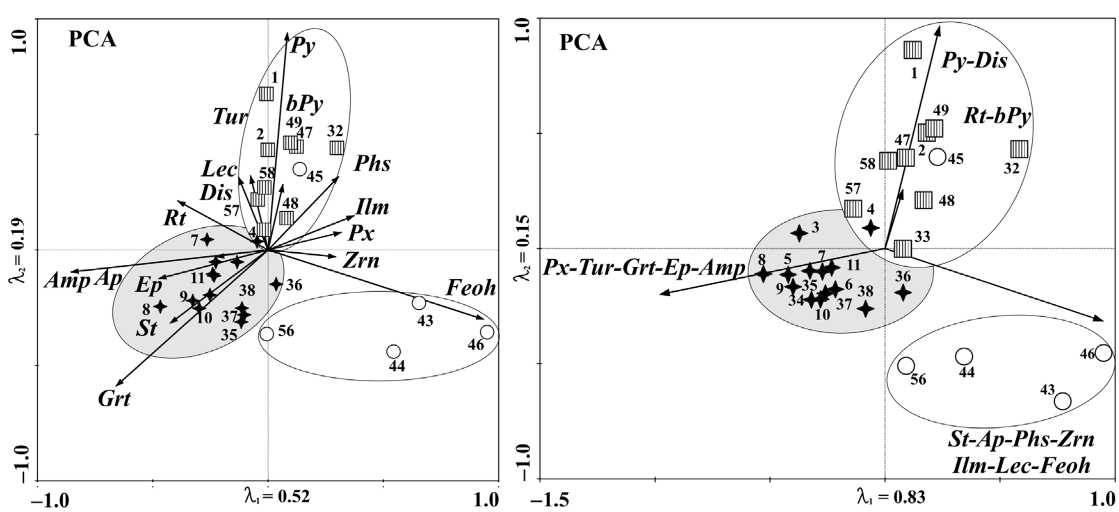


**Fig. 6.** Biplots of Principal Component Analysis (PCA) illustrating arrangement of till samples depending on mineral composition and amounts of mineral associations (for mineral abr. see Table, for till complexes see Figs. 3, 4)

**6 pav.** Moreninių nuogulų mėginių išsidėstymas pagrindinių komponentų analizės diagramose (PCA) pagal mineralinę sudėtį ir mineralų asociacijų kiekius (mineralų santrumpas žr. lentelėje, moreninių nuogulų kompleksus žr. 3, 4 pav.)

moraine increased. The mineralogical association pyroxenes-tourmaline-garnet-epidotes-amphiboles mostly reflects the rock composition of the Baltic Shield, while others may be associated with transitional Palaeozoic and local sedimentary rocks.

According to the latest investigations, the widespread sandy inter-till sediment beds of the Pamarys sub-formation enriched with organic matter identified in the major part of the LMR were formed during a few cycles of sedimentation starting from the Late Saalian and ending with the Middle Weichselian (boreholes 9605, 10423) (Bitinas et al., 2013). These sediment beds serve as a distinct marker, separating the Middle Pleistocene deposits from the Upper Pleistocene. So, three till complexes occurring beneath this inter-till sub-formation were attributed to the Middle Pleistocene, while three rest ones in the uppermost part of the sequence correspond to the Upper Pleistocene. The clear mineralogical difference of the lowest Middle Pleistocene till complex (I) from two overlying appears to be formed by separate glaciation with different ice flow direction and greater influence of the local pre-Quaternary rocks defined by their direct glacial erosion. In the eastern part of the LMR in two sections the till of this complex is covered with Butėnai (Holsteinian) Interglacial sediments. So, the till complex occurring below these interglacial sediments could be related to the Dainava (Elster) glaciation. The difference of mineral composition between two overlaying till complexes is rather imperceptible. Also inconsiderable other lithological differences hardly support their attribution to separate glaciations. These tills complexes usually overlie each other, and only in some places are separated by thin beds of inter-till deposits. The suggestions based on till lithology on existence of only one glaciation during the time in between the Butėnai (Holsteinian) and Merkinė (Eemian) interglacials in western Lithuania were proposed by V. Vonsavičius (1967). However, in accordance with the stratigraphical scheme for the Quaternary of Lithuania officially assigned for state geological investigations (Guobytė, Satkūnas, 2011), based on slightly different visual characteristics and mineralogical composition, we related these complexes to two different Žemaitija (Drenthe) and Medininkai (Warthe) glaciations.

Three visually distinct till complexes (IV, V and VI) attributed to the Upper Pleistocene are characterised by gradual decrease of the mineral content of the association pyroxenes-tourmaline-garnet-epidotes-amphiboles and increase of the staurolite-apatite-phoshates-zircon-ilmenite and magnetite-leucoxene-iron oxides and hydroxides mineral association in the direction from the lowermost till complex to the upper ones. Such mineralogical characteristics of these till complexes could be determined by the same source of erosion, but a slightly different composition of the underlying pre-Quaternary rocks. Probably these till complexes were formed during the re-advances of the same ice sheet during the Last Glaciation.

The tripartite glacial deposit structure based on mineralogical differences of the till complexes well correspond with the results of recent investigations in the LMR (Molodkov et al., 2010; Bitinas et al., 2011; Damušytė et al., 2011) showing that the coastal zone or even whole western Lithuania in the Late Pleistocene probably was first affected by ice sheet advance during the Middle Nemunas (Weichselian) glaciation. It would contradict the opinion on presence of non-glacial palaeoenvironments since the end of the Merkinė (Eemian) Interglacial through the Early and Middle Nemunas and that territory was covered by glaciers only in the Late Nemunas (Weichselian) time. The idea of Middle Nemunas till occurrence is also supported by OSL dates of the till complex underlying (113–84 ka) and overlaying (49–44 ka) inter-till sand deposits in the area of the Šventoji Harbour (Damušytė et al., 2011). Based on the dating results this till complex was attributed to the earliest stage of Nemunas (Weichselian) ice advance during the Middle Nemunas time and named as Melnragė sub-formation (Molodkov et al., 2010; Bitinas et al., 2011; Damušytė et al., 2011).

Two mineralogically and visually distinct uppermost till complexes are interpreted to be formed during the Late Nemunas glacial stages, however, there are no interstadial sediments found in the area (Bitinas, 2011).

## CONCLUSIONS

The results of mineralogical study of the till complexes in the Lithuanian Maritime Region (LMR) allow to draw some conclusions. Statistically derived mineralogical associations can express distinct dissimilarities between different till complexes and characterize them by means of mineral composition. The mineralogical differences allow distinguishing of six different till complexes in the LMR: three in the Middle Pleistocene sequence part and three in the part of Upper Pleistocene. The lowest amount of the mineral association pyroxenes-tourmaline-garnet-epidotes-amphiboles is characteristic of the oldest till complex. The till complexes in the LMR most differ in amount of this (Fennoscandian) mineral association which amount has the tendency to increase in younger till complexes. The two uppermost (youngest) till complexes, however, have slightly lower content of Fennoscandian minerals, but higher content of pyrite and disthen, whereas the uppermost till complex is notable for the highest amount of the mineral association staurolite-apatite-phoshates-zircon-ilmenite and magnetite-leucoxene-iron oxides and hydroxides.

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**LIETUVOS PAJŪRIO PLEISTOCENO MORENINIŲ NUOGULŲ KORELIACIJA REMIANTIS JŲ MINERALOGIJA**

*Santrauka*
Ankstesni pleistoceno nuogulų tyrimai parodė, kad stratigrafiškai suskaidyti ir sukoreliuoti pleistoceno nuogulas Lietuvos pajūryje yra labai sudėtinga. Trūkstant biostratigrafinių ir nuosėdų datavimo duomenų, įvairūs litostratigrafiniai kriterijai, pavyzdžiui, moreninių nuogulų žvirgždo ir gargždo petrografinė, geocheminė sudėtis, amfibolų grupės mineralo raginukės grūdelių tipomorfinių savybių tyrimų rezultatai, įvairios kitos fizinės savybės bei vizualinė charakteristika nedavė gerų rezultatų įvairaus amžiaus moreninių nuogulų litostratigrafinei koreliacijai. Straipsnyje pateikiama vieno geologinio profilio, einančio išilgai Baltijos jūros krantą, pleistoceno nuogulų koreliacija. Remtasi moreninių nuogulų smėlio frakcijos mineraline sudėtimi panaudojant daugiamatę statistiką. Statistiškai išanalizuoti šešių gręžinių moreninių nuogulų mineralinės sudėties tyrimo rezultatai ir atlikta jų litostratigrafinė interpretacija. Nuogulų mineralinės sudėties analizė parodė, kad įvairaus amžiaus moreninės nuogulos skiriasi statistiškai išskirtų mineralų asociacijų kiekiais. Tai leido išskirti šešis moreninių nuogulų kompleksus, pasižyminčius skirtinga mineraline sudėtimi. Šie skirtumai gerai matomi atlikus statistinę gretimų litokompleksų palyginamąją mineralinės sudėties analizę. Moreninių nuogulų litokompleksai atitinkamiems stratigrafiniams padaliniams priskirti remiantis jų slūgsojimo sąlygomis, tarpmoreninių nuogulų absoliutaus amžiaus datavimo bei tarpledynmečių nuogulų paleobotaninių tyrimų rezultatais.

**Raktažodžiai:** pleistocenas, Lietuvos pajūris, moreninių nuogulų kompleksai, koreliacija, mineralogija