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RADIOCARBON AGE OF LATE PLEISTOCENE GLACIGENIC SEDIMENTS IN JONIONYS SECTION OF MERKINĖ (EEMIAN) INTERGLACIAL

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Abstract: **The stratotype of Merkinė (Eemian) interglacial in Lithuania is the Jonionys section near Merkinė town in south Lithuania. The lacustrine sediments containing rich fossil flora in this section were formed under the conditions of Merkinė interglacial and Nemunas (Vistulian) glacial. The fossil-bearing Merkinė deposits are overlain by a probably complete sequence of Early Nemunas and partly of Middle Nemunas deposits. Rewashed till-covered organic sediments were found in the upper part of Jonionys section. The exact age of glacial sediments of this section has remained largely unknown. Peat with wood remnants under the rewashed till have been investigated in Gliwice Radiocarbon Laboratory (Gd-10825: 31,500+2300/-1800 BP and Gd-14000: >31,000 BP). Its deposition probably took place just before the maximum of the last glaciation. In Jonionys section the Merkinė interglacial, Early and Middle Nemunas nonglacial sediments were probably accumulated in the time of climatic fluctuations, but without glacigenic sedimentation. The glacigenic sediments in the upper part of Jonionys stratotype section are younger than 30,000 BP and belong to the Late Nemunas glacial maximum. Recent radiocarbon dating are important for the establishment of the standard area of the European Würm (Vistulian, Valdaian, Poozerian and Nemunas) glacial.**

1. INTRODUCTION

The last Merkinė (Eemian) interglacial and last Nemunas (Vistulian) glacial macrocycle of the Late Pleistocene (from 130,000 to 10,000 BP) in Lithuania is probably more intensely studied, than the other subdivisions of the Pleistocene. There are three stages of the last glaciation: Early (70,000-55,000 BP), Middle (55,000-30,000 BP) and Late (30,000-10,000 BP) (Gaigalas and Melešytė, 1999). The glacial activity was different at each stage. The data already obtained in the Jonionys section confirm the absence of an ice sheet in south Lithuania during the Early and Middle Nemunas (Gaigalas, 1995; Gaigalas and Hütt, 1996). The ability to date limno-alluvial sediments and soils by methods of absolute chronology provides the opportunity to establish reliable geochronology of the Upper Pleistocene in Lithuania (Gaigalas, 2000).

Merkinė interglacial deposits are presented by lake-bog deposits (gyttja, peat, clay, mud, loam and sand). The thickness of these deposits is variable. In some sections they are 2-3 m thick and in other they reach more than 20 meters. The Merkinė interglacial deposits are most widely spread. They were found in different areas of Lithuania except the west part near the seaside. Most sections have been examined in the south-eastern Lithuania between Merkinė and Druskininkai.

The region between Merkinė and Druskininkai is considered to be a stratotypical region and the deposits of Jonionys are assigned to be stratotypical ones (**Fig. 1**). The sections characteristic of the Merkinė (Eemian) interglacial are most frequently found in the vicinity of the town of Merkinė. The name of the Merkinė interglacial was taken from the name of this town (Kondratienė, 1965; Vaitiekūnas, 1968). The Merkinė interglacial stratotype deposits are located in the Jonionys-Maksimonys site (**Fig. 1**). At present more than 30 sections of the Merkinė interglacial were studied in Lithuania. Parastratotype sections are know from Netiesos, Kibyšiai, Druskininkai (Pušynas and park), Ratnyčia, Liškiava, Giraitiškės, Smalininkai, Kmitos, Puponys-674, Medininkai (bore-

holes 2, 117, 3), Mickūnai-Gaidūnai (boreholes 5, 7, 9), Bezdonys – 296 and 78, Arvydai – 79, Skersabaliai – 110, Kurkliai, Bukiškės-25 and 80, Gervelė-330, Gaurė and others.

2. SITE DESCRIPTION OF MERKINĖ INTERGLACIAL

The formation age of the Jonionys and many other sections comprises not only the Merkinė interglacial, but also Medininkai Glaciation and the Nemunas Glaciation.

The studied Jonionys section is an open natural exposure located on the left bank of the Nemunas River about 3 km west of Merkinė (south Lithuania). It reveals the socle of the second above flood plain terrace of the Nemunas River. The geological section (**Fig. 2**), from the bottom (above mean water level of the Nemunas River) to top, is the following:

1 – gIImd – till (morainic loam) of Middle Pleistocene, Medininkai Glaciation, of grayish brown color, 0.4 m;
2 – lgIImd-lIIImr – sandy silt of the end of the Medininkai Glaciation and beginning of the Merkinė interglacial (M_1 – *Pinus sylvestris, Picea obovata* and *Betula*), 0.2 m;
3 – lIIImr – clayey-silty sand with gravel, of dark gray color, with small shell of mollusks and detritus (M_2-M_{3a} – *Quercus petrea, Quercus pubescens, Pinus sylvestris Ulmus glabra, Ul. levis, Caulina flexilis* and *Scirpus lacustris*), 0.4 m;
4 – lIIImr – sand of yellowish gray color, middle-fine grain size, humic, with small shell of mollusks and detritus (M_{3b} – *Tilia tomentosa, T. platyphylos, T. cordata, Vitis, Hedrea, Acer compestre, A. platanoides, Alisma plantago aquatica* and *Ceratophyllum demersum),* 0.5 m;
5 – lIIImr – silty sand of grayish brown color, fine grain size, humic, with wood remains (M_{3c} – *Carpinus betulus, Corylus avellana, Tilia tomentosa, T. platyphylos, Caulina flexilis, Lemna trisulca, Osmunda cinnamomea* and *O. Regalis* and *Ligustrum, Vitis*), 0.4 m;
6 – lIIImr – sandy gyttja of grayish brown color, with small wood detritus (M_4 – *Picea obovata, Carpinus betulus, Swida sanguinea* and *Osmunda cinnamomea*), 0.2 m;
7 – lIIImr-lIIInm$_1$ – sandy silty clay of grayish blue color (lower part, about 0.1 m – (Merkinė interglacial), M_5 – *Pinus sylvestris* (upper part, about 0.3 m – lower Nemunas glacial), Nm_{1a} – *Pinus sylvestris*, *Alnus glutinosia, Acea obovata*, *Selaginella selaginoides, Sparganium simplex, Chenopodium album* and *Menyanthes trifoliata;* with rare shells of mollusks and small insertion of wood remains, 0.4 m. On the top of this sequence of Merkinė deposits of Jonionys (**Fig. 2**) there is the following succession of Early Nemunas sediments:
8 – lIIInm$_1$ – silt with lenses of sand, of dark gray color, humic, with rare carbonization remains of plants (J_1 – *Juniperus communis),* 0.1 m;
9 – lIIInm$_1$ – clayey sand silt, of gray color with brown tint, humic, horizontally stratified (J_1 – *Juniperus communis* and *Potamogeton perfoliata*), 0.15 m;
10 – lIIInm$_1$ – silty sand, of gray color with brown tint, humic (J_1 – *Betula alba, Alnus glutinosa, Pinus sylvestris, Potamogeton filiformis, Scirpus lacustris* and *Lycopodium clavatum*), 0.1 m;
11 – lIIInm$_1$ – silty clay, of gray color, humic, massive structure (J_1 – *Betula alba, Alnus glutinosa, Pinus sylvestris, Potamogeton filiformis, Scirpus lacustris* and *Lycopodium clavatum*), 0.15 m;

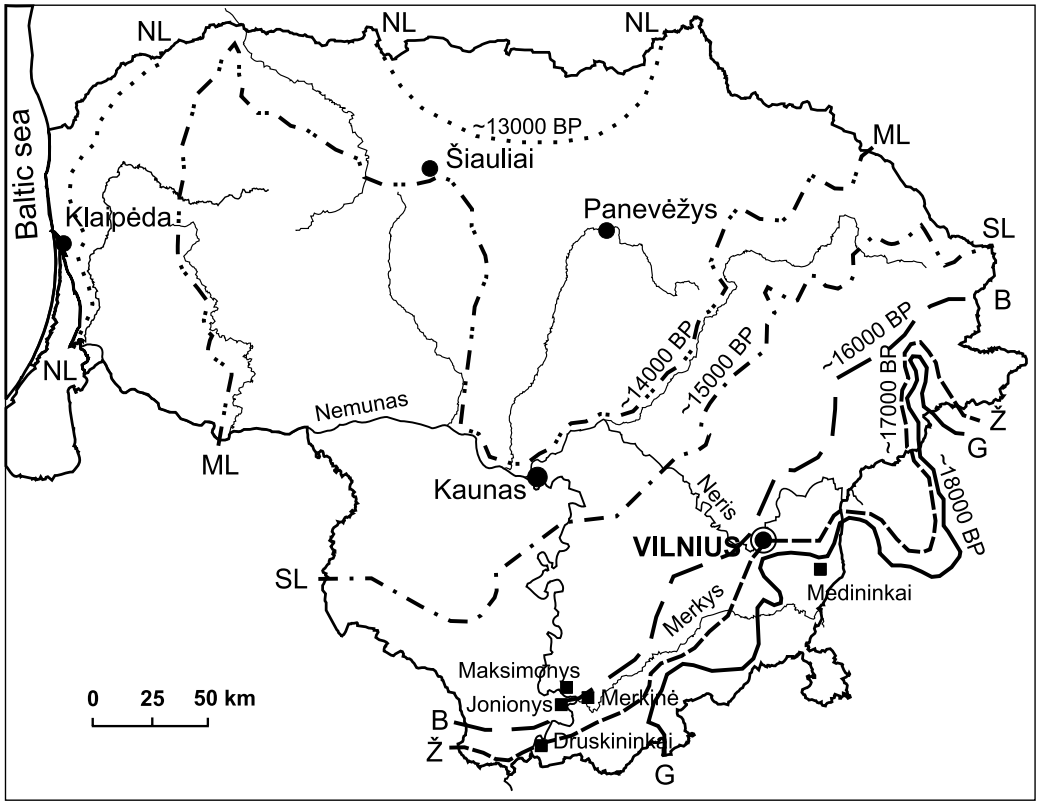

Fig. 1. *Location of the Jonionys section near the Merkinė town in stratotype region Druskininkai-Merkinė (stratotype palaeobasin of Jonionys-Maksimonys) with geochronological limits of Grūda Stadial (G), Žiogeliai Phasial (Ž), Baltija Stadial (B), South-Lithuanian (SL), Middle-Lithuanian (ML) and North-Lithuanian (NL) Phasials.*

12 – lIIIInm$_1$ – ferruginous sand, of gray color with brown tint, middle-fine grain size, massive structure, (Nm$_{1b}$ – *Najas marina* and *Urtica dioica*), 0.2 m;
13 – lIIIInm$_1$ – sand of brown color, fine-middle grain size, horizontally stratified, with lamina of silt (Nm$_{1b}$ – *Selaginella selaginoides, Hippuris vulgaris, Lycopodium alpinum, Botrychium boreale* and *Betula nana*), 0.15 m;
14 – lIIIInm$_1$ – sandy silty clay, of gray color with brown tint, massive structure (Nm$_{1b}$ – *Alnus glutinosa, Thalictrum, Betula nana, Lycopodium alpinum, Selaginella selaginoides, Botrychium boreale, Salix, Alnaster, Cyperaceae, Gramineae* and *Chenopodiaceae),* 0.15 m;
15 – lIIIInm$_1$ – sand of gray color with brown tint, with laminas of silt and ripples of flow, weakly humic, with rare detritus, in lower part shells of Anadonta (Nm$_{1b}$–J$_2$ – *Betula alba* and *Pinus sylvestris;* fauna of rodents: *Apodemus sp., Arvicola cf., terrestris* L., *Lemmus sibiricus* Kerr., *Microtus sp., M. agrestis* L. and *M. arvalis* Pall.*), 0.8 m;*
16 – lIIInm$_2$ – sand of lightly gray color, in the upper part – yellowish, with laminas of darkly brown gyttja (R$_1$ - *Betula alba, B. nana, B. pubescens, Polygonum sp., Pinus sylvestris, Quercus sp., Cyperaceae, Gramineae, Lycopodium clavatum* and *L. annolinum;* fauna of rodents: *Sorex sp., Arvicola aff. terrestris* L., *Microtus oeconomus* Pall., *M. sp., Pitymys of subterraneus* Sel.-Long. and *Alces sp.*), 0.4 m;
17 – lIIInm$_2$ – clayey silty sand of dark gray color, weakly humic, the upper contact is eroded (R$_2$ – *Betula nana*; fauna of rodents: *Polygonum lapahifolium),* 0.1 m;
18 – lIIInm$_3$ – sand of yellow color, mixed grain size, with allochtonous pieces of gyttja, the upper contact is eroded, 0.1 m;
19 – gIIInm$_3$ – rewashed till sand-gravel-pebble sediments with simple boulders, fragments of sedimentary rocks, prevail well-rounded, 0.25 m;
20 – silty sand of lightly yellowish gray color, fine grain size, 2.0 m.

The deposits of lake and bog origin have formed since the beginning of the interglacial up to the last glaciation in Jonionys site (**Fig. 3**). It has been established that the sediments in this location were formed under the conditions of Merkinė interglacial and Nemunas glacial (Kondratienė, 1996).

The results of the investigation at the Jonionys site illustrate the presence of three thermomers younger than the Eemian interglacial. The first two (correlated with Brörup and Odderade) are, according to recent data, rather widely represented in Lithuania and recently have been identified at several other sites (Satkūnas, Grigienė and Robertsson, 1998). The Jonionys-3 thermomer is separated from the preceding one by a cryomer layer formed under nonglacial condition. The Jonionys-3 interstadial corresponds to the Oerel interstadial. The cryomer Nemunas 2a marks the beginning of the isotope stage 4. This stage by some researchers is interpreted as representing a glacial advance. According to the data from southern and eastern Lithuania, no till beds that can be attributed to the beginning of the Middle Nemunas have been found.

The exact age of glacial sediments of this section has remained largely unknown. The Merkinė interglacial site at the stratotype locality of Jonionys is represented by lacustrine deposits containing a rich fossil flora. The lower boundary of Nemunas deposits can be defined on palaeobotanical criteria. The Nemunas ice-free deposits in the Jonionys section overlie the sediments of the

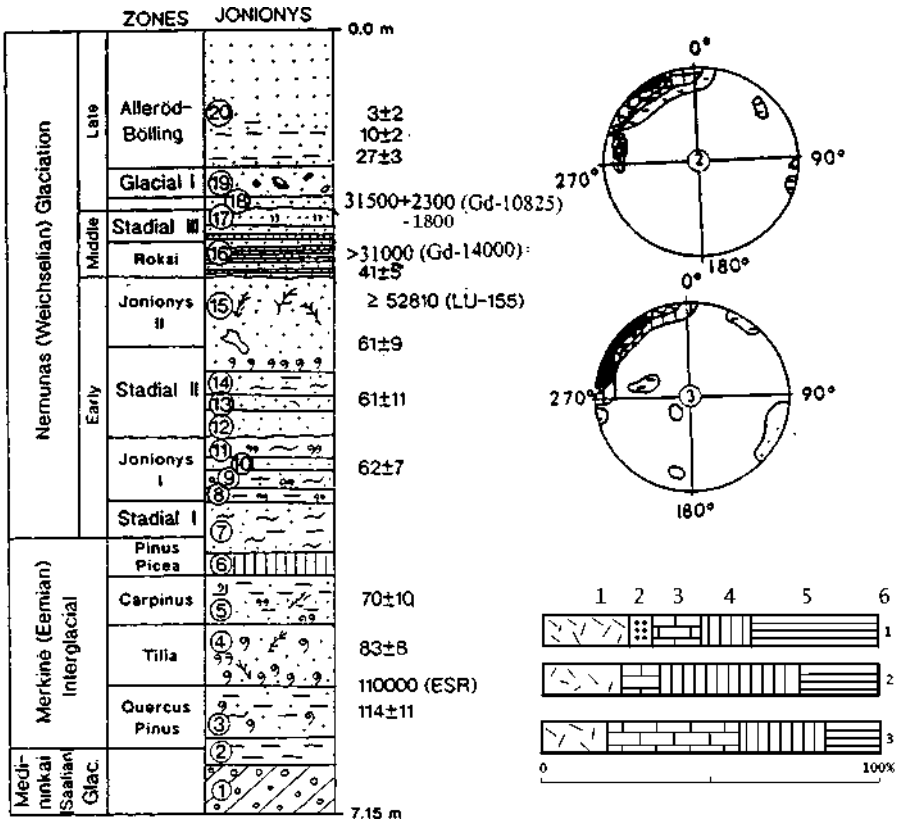

Fig. 2. *Stratigraphic sequence of the Merkinė and Nemunas deposits exposed at Jonionys with OSL (in ka), ESR and ^{14}C dates:*
1 – crystalline rocks, 2 – sandstones and siltstones, 3 – dolostones, 4 – Ordovician and Silurian limestones, 5 – other limestones, 6 – Mesozoic marls. Structural diagrams of pebble long axes orientation in tills.

Merkinė interglacial. The fossil-bearing Merkinė deposits are overlain by a probably complete sequence of the Early Nemunas deposits and partly of the Middle Nemunas. Rewashed till-covered organic sediments were found in the upper part of the Jonionys section. The interglacial deposits in the Jonionys area are stratigraphically covered by the till of Grūda (Brandenburgian and Leszno) stadial of Nemunas (Vistulian) glaciation and till of Žiogeliai (Frankfurtian and Poznań) phasial of Grūda (Brandenburgian and Leszno) stadial (**Fig. 3**).

3. DISCUSSION OF RADIOCARBON RESULTS

Peat with wood remnants have been investigated in Gliwice Radiocarbon Laboratory. For peat and wood remnants two radiocarbon dates were received: Gd-10825: 31,500 + 2300/- 1800 BP and Gd-14000: > 31,000 BP. Their deposition took place probably just before the transgression of the ice sheet. In the Jonionys section the Merkinė interglacial, Early and Middle Nemunas nonglacial sediments were probably accumulated in time of climatic fluctuations, but without glacigenic sedimentation. The glacigenic sediments (rewashed till with boulders) in the upper part of the Jonionys stratotype section are younger than 30,000 BP. An extensive expansion of inland ice in south Lithuania began in the Late Nemunas glacial time about 25,000-22,000 BP (Arslanov, 1987). The nonglacial sediments in the Jonionys section are older than the Late Nemunas glacial maximum in south Lithuania. They represent an ice-free interval of Early and Middle Nemunas fluvial and lacustrine sedimentation (Gaigalas and Satkūnas, 1996).

The first radiocarbon dates, enabling one to date the maximum distribution of the last ice advance about 20,000-22,000 years ago were obtained from Lausitzer Urstromtal in north German Lowland. However, the bedding conditions called for some precaution. Maximum advance of ice sheet in the northern part of Poland occurred between 32,900 and 12,460 BP at the Main Stadial (Mojski, 1985). The name of the Main Stadial was introduced by J.E. Mojski (1959) for a loess horizon. Later, this name also included the main part of the North Polish Glaciation in which glacial deposits of the Polish Plain, called the Leszno stadial, were formed. The maximum ice sheet limit of the Vistulian Glaciation in the mid-eastern part of the Chełmno-Dobrzyń Lakeland, northern Poland, occurred during the maximum phase of the main substage (20,000-18,000 BP; Wysota, 1999). The older glacial event was related to the Late Vistulian maximum (*ca* 22 ka BP) and the younger one represented ice sheet readvance about 19 ka BP in the lower Vistula region (Wysota, 2001). After the Merkinė interglaciation a long period of nonglacial conditions occurred – during the Early and Middle Nemunas time till 28 ka BP in south Lithuania (Gaigalas *et al.,* 1994).

The correlation of the youngest glaciation (Nemunas, Vistulian and Poozerian) is possible through deposits and forms of glacial relief preserved on the present area of Lithuania, Poland and Belarus (Lindner and Yelovicheva, 1998). In Poland the last ice sheet maximum was reached during the Leszno-Pomorze (Grūda-Žiogeliai) stadial (*ca* 20,000 BP) (Lindner and Marks, 1995). In Belarus the Vistulian Glaciation corresponds to the Pooozerian Glaciation, during which the last ice sheet covered only the

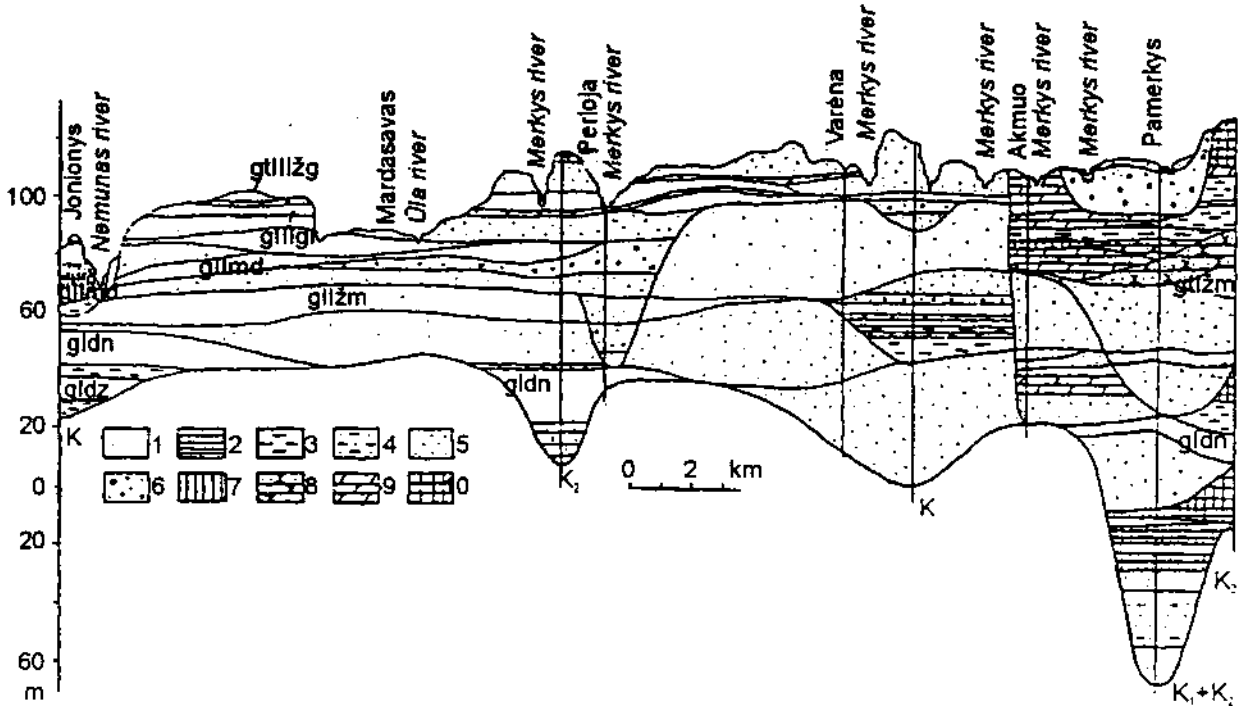

Fig. 3. *Cross-section of Quaternary cover Jonionys-Pamerkys in south-eastern Lithuania:*
1 – till, 2 – varved clay, 3 – silt, 4 – sandy silt, 5 – sand, 6-gravel and pebble, 7 – interglacial and interstadial deposits in Jonionys stratotype, 8 – sandstone, 9 – marl, 10 – chalk. Tills – gldz – Dzūkija, gldn – Dainava, gIIžm – Žemaitija, gIImd – Medininkai, gIIIgr – Grūda, gtIIžg – Žiogeliai, K_1 – Lower Cretaceous, K_2 – Upper Cretaceous.

area north of Grodno and Raduny as well as north of Minsk along the Ostrovets-Dokshitsy-Orsha line (Matveyev, 1995). Maximum range of the ice sheet during the Vistulian (Nemunas and Poozerian) Glaciation has been also reconstructed by T. Krzywicki (2001). During the Vistulian Glaciation the glacier advanced to the area of eastern Mazury, Suwałki and Grodno district during the Świecie stadial (*ca* 55,000-67,000 BP) and during the main stadial (*ca* 24,000-12,000 BP). The ice sheet limit during the Świecie (Varduva stadial and Ozierska phase). The phasial in this area was more extensive about 30 km further to the south of the limit of the main stadial (Krzywicki, 2001).

4. ^{14}C AGE OF MAXIMUM NEMUNAS GLACIATION IN LITHUANIA

Evidently, the ice sheet did not penetrate into the southeastern Lithuania region during the Early and Middle Nemunas (Valdaian, Vistulian and Weichselian) interval. Ice-free interval at the Early and Middle of the Vistulian (Weichselian and Valdaian) were identified in many sites of Middle and East Europe, where the last glacial maximum took place between 25,000 and 15,000 BP. In Lithuania lithological research led to the recognition of two independent Late Pleistocene Grūda and Baltija till horizons (Gaigalas, 1998, 2001; Gaigalas and Melešytė, 1999, 2001), which were correlated with the Brandenburgian (Leszno) and Pomeranian (Pomorze) glacial stages. This subdivision was confirmed by recent ^{14}C dating. The southeastern part of Lithuania was not covered by Late Nemunas glacier. The deposits of the Nemunas Glaciation maximum are not of glacial origin and are presented by periglacial sediments – glaciolimnic silts and clay (25,000-15,000 BP). The data (Gaigalas and Satkūnas, 1996) obtained so far from the study of the Medininkai section (borehole 117A) confirm the absence of an ice sheet in this region during the Early, Middle and Late Nemunas. The glaciolimnic silt and clay covered lacustrine and peat sediments with organics were probably accumulated during the interval from 29,800±1200 to 23,770±630. Their deposition probably took place during and just before the last glacial advance. The glaciolimnic silt and clay in Medininkai highland are simultaneous to maximum of the last ice cover (23,000-15,000 BP). Here and there between the upper glaciolimnic silt and clay sediments and the Merkinė interglacial sediments, layers of Early and Middle Nemunas deposits occur. In this section the Merkinė interglacial, Early and Middle Nemunas nonglacial sediments were probably accumulated during the interval from 114,000 to 23,000 BP, a period with climatic fluctuations, but without glacial sedimentation. Radiocarbon dating have confirmed the conclusions received by palynological research (Kondratienė, 1996). There were more palynological data indicating the presence of organic sediments of the Merkinė interglacial, lying on the surface of relief, not covered by the glacial sediments (tills) of the Late Pleistocene.

The south-eastern part of Lithuania was not covered by continental ice of either the Grūda or Baltija stadials of the Late Nemunas glacial. The petrographical composition of till of the Grūda stadial of Nemunas glacial in Lithuania indicates a Central Swedish source for erratic boulders and clastic material (Gaigalas, 1995). The Grūda till was enriched with local Mesozoic sedimentary rocks. Apart from Mesozoic marls clasts, this till is rich in crystalline rocks from Central Sweden, the Åland Island and the Baltic Sea floor. The Grūda ice sheet moved therefore from the north-west to the south-east. During the retreat a minor readvance of glacier, the Žiogeliai Phasial, occurred. The Baltija till deposited by the stadial glacier advance notably contains increased frequency of dolostones derived from Devonian rocks of the east Baltic region. The ice of the Baltija stadial transgressed the area of Lithuania in three distinct lobes: west Lithuanian, central Lithuanian and east Lithuanian. The glacial deposits of each of the three lobes differ in the petrographic composition of the erratics of crystalline rocks and clasts of sedimentary rocks. However, the main mass of the ice moved from the north to the south over east Baltic Palaeozoic rocks. The till of the Baltija stadial has specific association of Palaeozoic sedimentary rocks from east Baltic region and crystalline rocks from south Finland. Retreating and periodically recessing, the glacier of the Baltija stadial has left its phasial tills, which were distributed by tracks of East-Lithuanian (about 16,000 BP), South-Lithuanian (*ca* 15,000 BP), Middle-Lithuanian (*ca*14,000 BP), and North-Lithuanian (*ca*13,000 BP) phasials on the surface of Lithuania (Fig.1). The East-Lithuanian phasial corresponds to the maximum of the Baltija stadial (**Fig. 1**). In the zone of the south Lithuanian recessional phase, the three oscillational branches of end moraines have been found. Immediately after the each retreat of the ice sheet, vast areas of Lithuania were covered with big ice-dammed lakes in interphasials. The phasial tills are spread locally, in recession zones of phasial glaciers, so their full lithostratigraphical sequence may be revealed only by carrying out successive investigation and correlation of Baltija tills on the whole area of Lithuania.

5. CONCLUSIONS

The radiocarbon dating provides a more accurate chronology of the Late Nemunas (Vistulian) Glaciation. In Jonionys section rewashed till with boulders of the last ice cover of the Late Nemunas Glaciation is younger than 30,000 BP. The main Late Nemunas glacier covered the Baltic countries and reached south-eastern Lithuania about 22,000-20,000 BP. In Lithuania lithological research led to the recognition of two independent Late Pleistocene Grūda (before 22,000-18,000 BP and Baltija (16,000-13,000 BP) till horizons, which were correlated with the Brandenburgian and/or Leszno and Pomeranian and/or Pomorze glacial stages. The covering till strata at the vicinity of Jonionys belongs to maximum of the Late Nemunas Glaciation. The recent radiocarbon dating is important for the establishment of the studied area as a standard for the European Würm (Vistulian, Weichselian, Valdaian, Poozerian, Nemunas) Glacial.

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