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GEOCHRONOLOGY AND PALAEOMAGNETIC RECORDS OF THE SNAIGUPĖLĖ SECTION IN SOUTH LITHUANIA

VALENTINAS BALTRŪNAS[1], FEDOR E. MAKSIMOV[2], VLADISLAV YU. KUZNETSOV[2], BRONISLAVAS KARMAZA[1] and VALENTAS KATINAS[1]

[1]*Nature Research Centre, Institute of Geology and Geography, Akademijos str. 2, 08412 Vilnius, Lithuania*
[2]*Saint Petersburg State University, 10th Line, 33/35, V.O., 199178 St. Petersburg, Russia*

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Abstract: The interglacial deposits in the South Lithuanian Snaigupėlė outcrop and borehole Snaigupėlė-705 are marked for different bedding conditions though the sections are in proximity of each other. In the borehole section, the interglacial deposits are thicker and bedding at a greater depth than the analogous deposits of the outcrop. In the Snaigupėlė outcrop, the highest compatibility of isochronic-correction dates, calculated using L/L (method of leaching) and TSD (method of total sample dissolution) models, was determined for combination of three samples. With the help of the **f** value (section of isochrones in the axis of ordinates), the contribution of the primary pollution with thorium was determined where, as based on corrected analytical data, isochronic-correction dating was performed: 127^{+18}_{-14} ka years for the L/L model and 132^{+22}_{-16} ka for the TSD model. Palaeomagnetic investigations showed that the section of lacustrine sediments in the lower part of Snaigupėlė outcrop were orientated by reversed magnetic excursion and in the upper part by normal magnetic polarity. Collation of the obtained data with the global geomagnetic scale showed that the palaeomagnetic inversion observed in the Snaigupėlė section was related with the Blake Event in the Eemian Interglacial.

Keywords: ^{230}Th/U dating, palaeomagnetic record, Late Pleistocene, Eemian Interglacial, South Lithuania.

1. INTRODUCTION

The Snaigupėlė area is in South Lithuania, which is of essential significance for the stratigraphy of Pleistocene strata in the whole Lithuania. The outcrop of interglacial lacustrine sediments in the Snaigupėlė Rivulet valley was detected by V. Čepulytė whereas the data of palaeobotanical analysis was for the first time published by O. Kondratienė who attributed the sediments to the so called Riss-Würm Interglacial (Kondratienė, 1958). Sometime later, based on more detailed investigations, it was concluded that the sediments were older than Riss-Würm sediments but younger than Mindel-Riss Interglacial sediments and atributed to the newly distinguished (Odintsovo, Lubawski) Snaigupėlė Interglacial (Kondratienė, 1973, 1996).

In the spring of 1980, detailed works of geological mapping in the Lower Snaigupėlė were carried out. Some results of these studies were published in several papers (Kondratienė and Gaigalas, 1982; Gaigalas, 1987; Kondratienė, 1996; Baltrūnas and Bitinas, 1994; Baltrūnas, 1995, 2002). In the Snaigupėlė area, all Pleistocene deposits were studied by grain-size method and the tills also were analysed mineralogically, petrographically and chemically. The obtained analytical material was general-

Corresponding author: V. Baltrūnas
e-mail: baltrunas@geo.lt

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ised statistically and correlated with the known materials on the Druskininkai Town environs.

The results of laboratory studies, their statistical generalisation, macroscopical characteristic in the field, correlation of new boring sections with the nearest outcrops and sections of earlier drilled borings allowed explaining quite reliably the structure of Pleistocene strata and the mode of occurrence of separate layers in the Snaigupėlė area. The available data helped to identify deposits of the Dzūkija (Sanian 1), Dainava (Sanian 2), Žemaitija (Odranian), Medininkai (Wartanian) and Nemunas (Vistulian) glacigenic formations and sub-formations (**Fig. 1**).

The material of analytical and statistical investigations of till layers in the Snaigupėlė area allowed correlating the sections of Pleistocene deposits and understanding the structure of the strata. Unfortunately, the stratigraphical interpretation can be multi-variant, mainly because of different interpretations of the age of interglacial deposits in the Snaigupėlė outcrop and in the borehole Snaigupėlė-705 (Vonsavičius, 1975; Dreimanis and Raukas, 1975; Baltrūnas and Bitinas, 1994; Baltrūnas, 1995, 2002; Kondratienė, 1996).

The borehole data showed that the boreholes in the environs of Snaigupėlė outcrop (No. 705 and No. 703) reached thicker and more widespread lacustrine interglacial sediments which according to palynological data were identified as of Middle Pleistocene marine isotope stage MIS 7 and comparable with the Karlich (Lubawski) Interstadial sediments west of Lithuania and Odintsovo (Shklov) and east of Lithuania (Kondratienė, 1996; Ber, 2000). It was also determined that the thin layer of lacustrine sediments in the Snaigupėlė outcrop stratigraphically is positioned above the lacustrine sediments identified in the boreholes. This fact appeared dubious (Baltrūnas and Bitinas, 1994; Baltrūnas, 1995, 2002) and prompted to start new investigations.

The aim of this study is explore the geochronology and palaeomagnetic records of the interglacial sediments in the Snaigupėlė outcrop (South Lithuania) using new methods: ^{230}Th/U dating of interglacial organic deposits, determination of the anisotropy of the magnetic susceptibility and palaeomagnetic investigations. The new investigations allowed contributing to solution of this stratigraphic issue and linking the obtained results with the global phenomena.

Palaeomagnetic chron	Division	Subdivision	Formation, subformation	(MIS)
BRUNHES	Holocene			1
	Pleistocene	Upper	Nemunas (Vistulian, Valday)	2-5a-d
			Merkinė (Eemian, Mikulino)	5e
		Middle	Medininkai (Wartanian, Moskva)	6
			Snaigupėlė (Lubawski, Odintsovo)	7
			Žemaitija (Odranian, Dnepr)	8

Fig. 1. *Stratigraphic correlation scheme for the upper part of Quaternary deposits of the Lithuania (by Kondratienė, 1996; Ber, 2000).*

2. STUDY SITE AND MATERIAL

Study site

The study site of interglacial sediments is in South Lithuania, 2.5 km north-east of Druskininkai Town, on the left bank of the Nemunas River, in the Snaigupėlė Rivulet valley (coordinates: 23°59´57.8″; 54°01´52.1″) (**Figs. 2, 3**).

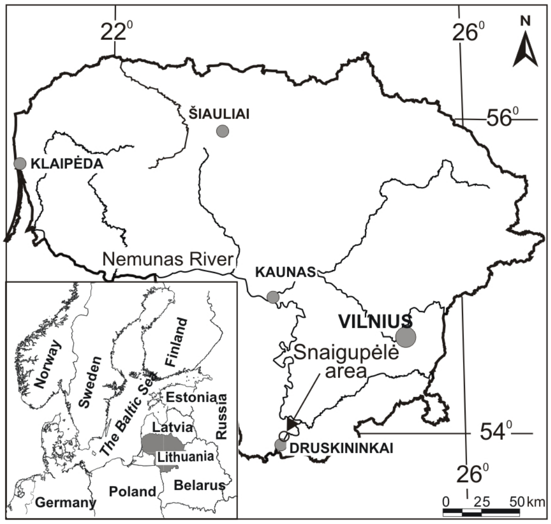

Fig. 2. *Location of the Snaigupėlė area (coordinates: 23°59´57.8˝; 54°01´52.1˝).*

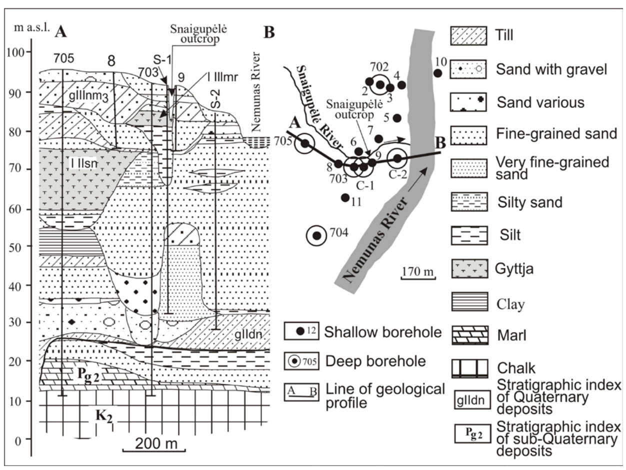

Fig. 3. *Arrangement scheme of boreholes in the Snaigupėlė area and structure of the Pleistocene deposits in the Snaigupėlė area based on studies of till composition (by Baltrūnas and Bitinas, 1994; Baltrūnas, 1995 modified by the authors). Stratigraphical index of sub-Quaternary deposits: K_2 – Upper Cretaceous, Pg_2 – Upper Paleogene. Stratigraphical index of Quaternary deposits: gIIdn – Dainava till, gIIžm – Žemaitija till, gIImd – Medininkai till, $gIIInm_3$ – Upper Nemunas till, IIsn – Snaigupėlė limnic sediments, IIImr – Merkinė limnic sediments.*

Geological description of the study site

Analysis of the relationship of the sub-Quaternary surface with the interglacial sediment sections of Snaigupėlė outcrop and borehole Snaigupėlė-705 revealed that the studied sections are positioned near the deeper sub-Quaternary palaeoincisions (Šliaupa, 2004). The layers of the interglacial deposits represent sedimentary continuations of overlying older glaciolacustrine layers (**Figs. 3, 4).** The interglacial sediments in the Snaigupėlė outcrop and in the borehole Snaigupėlė-705 are covered by tills. Yet sedimentary and structural bedding unconformity of deposits in the borehole Snaigupėlė-705 and in the Snaigupėlė outcrop was observed: they are bedded between till of different age. This situation may be indicative of two things: the Snaigupėlė outcrop is not *in situ,* i.e. it was moved and lifted by advancing glacier, or the sediments of the outcrop and borehole-705 represent different interglacials.

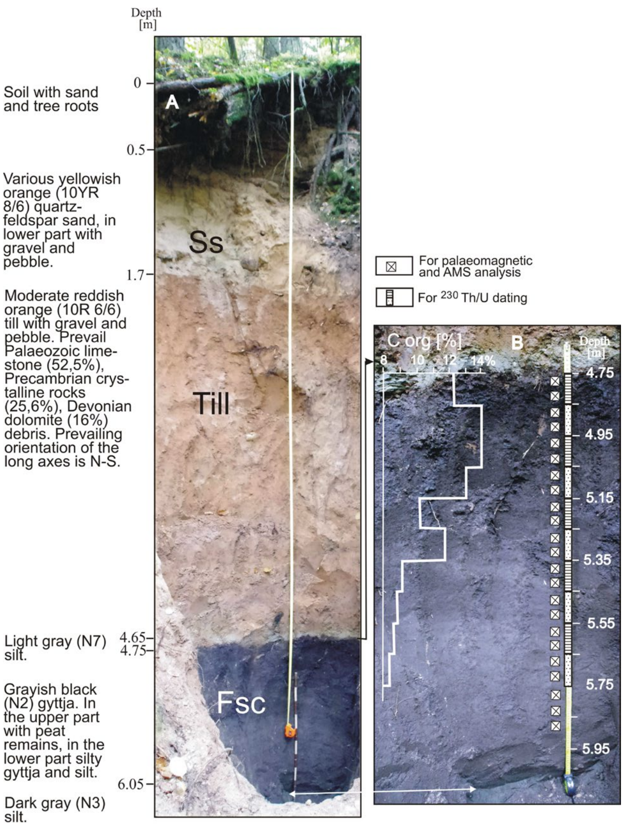

Fig. 4. *View of Snaigupėlė outcrop in 2013 (A) and places of samples (B) for AMS and palaeomagnetic investigations (on the left) and ^{230}Th/U dating (on the right). Colors by "Geological rock-color chart with genuine Munsell color chips" (2009). Glaciofluvial and limnic deposits are given by AD Miall lithostratigraphy code (1977).*

3. METHODS

Methodological background for ^{230}Th/U dating

Dating of various environmental objects, including **interglacial organic deposits** by the ^{230}Th/U method is based on two assumptions:

1) At the moment of formation, deposits only included uranium which was the source of daughter isotope ^{230}Th (referred to as radiogenic) accumulated in the course of time as a result of radioactive decay.
2) In the post-sedimentation time, the dated deposits represented a closed geochemical (radiometric) system in respect of uranium and thorium isotopes.

For ^{230}Th/U dating of environmental objects, it is necessary to determine in them the ^{230}Th/^{234}U and ^{234}U/^{238}U activity ratios (AR).

Organic-rich deposits, including peat and gyttja, at the moment of formation accumulated uranium. Therefore in principle they can be dated by the ^{230}Th/U method. Yet practical realisation encounters certain issues related with substantiation of theoretical assumptions which complicate the dating procedure.

In the post-sedimentation time after buried organic-rich layer formation, these deposits can be attributed to closed radiometric systems in respect of uranium and thorium isotopes in case of existence of natural geochemical barriers which prevent the penetration of water soluble forms of uranium into peat or gyttja. The subsurface water represents the main source of uranium isotopes in organic-rich deposits in the post-sedimentation time (thorium mainly migrates with mineral detritus. Our experimental data show that in many cases the marginal organic-rich layers have elevated concentrations of uranium and act as geochemical barriers preventing post-sedimentary penetration of uranium into the deeper parts of deposits. Sometimes these barriers can be represented by the impermeable under- or over-lying layers (for example, clay). Thus, for ^{230}Th/U dating of organic-rich deposits it is necessary to identify the layers belonging to closed geochemical systems.

The fact that at the moment of formation of organic-rich deposits some amounts of thorium isotopes (including ^{230}Th) from the mineral fraction are included in them along with uranium is another complicating factor for dating of this kind of deposits. Respectively, during the dating procedure it is necessary to deduct this primary component ^{230}Th. In such cases it is recommended to use the isochronous approach (Schwarcz and Latham, 1989; Geyh, 2001; Kuznetsov and Maksimov, 2003; Maksimov and Kuznetsov, 2010). As the primary contamination with thorium is characterised by concrete ^{230}Th/^{232}Th AR and is a constant in some samples of the same age, it can be determined through analysis of a number of such samples. In this case, the linear dependence (so called isochrone) is determined in the coordinates of ^{230}Th/^{232}Th – ^{234}U/^{232}Th AR. The intercept on the y-axis gives the corrected ^{230}Th/^{232}Th AR required for the detrital correction of the ^{230}Th/U age. During the next step, the isochronously-corrected age of deposits is calculated. The only problem is selection of samples of the same age belonging to closed radiometric systems and having the same value of the primary contamination with thorium. Usually for isochronous correction one method of chemical treatment of coeval samples is used, either the method of leaching (L/L-model) or the method of total sample dissolution (TSD-model). It is obvious that the parameters of linear dependence are predetermined by the selection of analytical points (samples). In view of the absence of reliable criteria for selection of experimental points for building isochrones, we suggest a new version of isochronous approach based on paired use of two techniques of chemical treatment of samples (L/L and TSD-models) followed by individual isochronous correction dating for each of the models (Maksimov *et al.*, 2006; Maksimov and Kuznetsov, 2010; Maksimov *et al.*, 2012, Kuznetsov and Maksimov, 2012). In this case, the proper combination of selected points is achieved and additionally controlled by the similarity of age determined based on the calculations for each model of chemical treatment of the same samples.

The ^{230}Th/U dating technique

The investigations were carried out in the laboratory of St. Petersburg State University. For ^{230}Th/U dating of buried organic-rich deposits of the Snaigupėlė outcrop using the new version of isochronous approach the following was done:

1) Radiochemical analysis of isotopes of U and Th in the same samples using the methods of leaching (L/L-model) and total sample dissolution (TSD-model);
2) Comparison of the experimental isotopic data and identification of samples belonging to closed geochemical systems;
3) Isochronous correction dating individually by each of the models (L/L and TSD) for different combinations of samples;
4) Determination of the final isochronous age based on the highest similarity of isochronously-corrected dates in the same combination of samples treated using L/L and TSD models.

The radiochemical analysis of organic-rich deposits includes the following steps (Maksimov and Kuznetsov, 2010; Kuznetsov and Maksimov, 2012):

1) Combustion of gyttja samples to constant weight at 500–700ºC;
2) The procedure of total sample dissolution of ashes is performed using acids HCL, HF, and mixture of $HClO_4$-HCl, HNO_3; the same samples also are treated by leaching using Aqua Regia followed by separation of solution from solid residue; a known amount of spike (^{232}U and ^{228}Th) was added to determine U and Th isotopes by isotope dilution technique.
3) Extraction, cleaning (from macro- and micro-admixtures and impeding alpha-radiation) and separation of U and Th fractions by ion exchange chromatography;
4) Electrodeposition of U and Th isotopes on platinum discs from spirit solution;
5) Alpha-spectrometric measurement of U and Th isotopes using α-spectrometer ALPHA-DUO (ORTEC).

Determination of the anisotropy of the magnetic suspectibility (AMS)

MS (magnetic suspectibility) and AMS (anisotropy of the magnetic suspectibility) was measured with a MFK1-B kappabridge (AGICO) at the laboratory of Nature Research Centre (Vilnius). The AMS measurements were made along fifteen different directions (Jelinek, 1977). The analysis of the AMS data was performed using the Anisoft 4.2 software. Many authors have reported that magnetic fabric provides a reliable strain indicator (Ferré *et al.*, 2004; Graham, 1966; Henry, 1973; Hrouda, 1979, 2002; Hrouda and Janak, 1976; Hrouda *et al.*, 1978; Kligfield *et al.*, 1982). The AMS of volcanic rocks was investigated in the East Carpatians (Panaiotu *et al.*, 2011). Magnetic susceptibility fabrics and AMS of mudstones were investigated in Plio-Quaternary sediments from Taiwan (Lee and Angelier, 2000). AMS characteristics of the Late Pleistocene-Holocene sediments were investigated in China (Liu *et al.*, 2005).

A total of 23 oriented samples from Snaigupėlė sections were taken by pressing in special plastic boxes (Natsuhara Giken Co.). Samples were taken in 6–7 cm interval.

Palaeomagnetic investigations

The natural remnant magnetization of samples was measured using a JR-6 spinner magnetometer. Magnetic declination and magnetic inclination was determined and plotted in each sample. All samples were subjected to stepwise alternating field (AF) demagnetisation with AF demagnetizer from Molspin. Characteristic directions were calculated using principal component analysis (Kirschvink, 1980).

23 oriented samples from the Snaigupėlė outcrop were taken by pressing in special plastic boxes in 6–7 cm interval, after AMS procedures palaeomagnetic research was performed.

The natural remanent magnetization of samples was measured using JR-6 spinner magnetometer at the laboratory of Nature Research Centre (Vilnius). Magnetic declination and magnetic inclination was determined and plotted in each samples. All samples were subjected to stepwise alternating field (AF) demagnetization with AF demagnetizer from Molspin. The results of demagnetization of samples were obtained: stereographic projections, M/Mmax, x,y,z projections. Dominant directions were calculated using principal component analysis (Kirschvink, 1980). The analysis of the natural remanent magnetization was performed using the Remasoft 30 software.

4. RESULTS

Results of ^{230}Th/U dating of interglacial organic deposits

Using the above described radiochemical method, the content of uranium and thorium isotopes isolated (extracted) using leaching (L/L-model) and complete dissolution (TSD-model) was determined in 7 samples from the Snaigupelė exposure.

Analysis of uranium distribution in gyttja deposits showed that the samples from the roof of the stratum (475–485 and 485–495 cm) can be attributed to open geochemical (radiometric) system (**Table 1**). These samples contained markedly elevated concentrations of uranium (in comparison with other samples) and, concomitantly, lower values of ^{230}Th/^{234}U AR. It is most likely that these layers accumulated uranium from ground waters in post-sedimentation time and prevented its penetration into the deeper part of gyttja. In respect of uranium, these layers acted as geochemical barriers. Moreover, the samples from the layer 495–505 cm bordering on the overlying barrier should be eliminated from further studies. In this sample, the ^{234}U/^{238}U AR differs from the value in other samples (more strongly for L/L-model and less obviously for TSD-model). Presumably this can be explained by additional redistribution of uranium isotopes between the organic and inorganic fractions as a result of the impact of groundwater.

The remaining four samples from horizons 505–515, 515–525, 525–535, 535–545 cm were used for isochronous correction dating. The dating was performed on five combinations including four samples (one combination) and three samples (four combinations). The highest compatibility of isochronously-corrected dates calculated using L/L- and TSD-models was determined for combination of three samples from depths 505–515, 515–525, and 535–545 cm. **Fig. 5** demonstrates linear dependences (isochrones) of three points and their linear parameters.

With the help of the **f** value (section of isochrones in the axis of ordinates), the contribution of the primary pollution with thorium was determined whereas based on corrected analytical data isochronic-correction dating was performed yielding 127^{+18}_{-14} ka for L/L model (ЛУУ-833L/L) and 132^{+22}_{-16} ka for TSD model(ЛУУ-833TSD).

Anisotropy of magnetic susceptibility (AMS)

The results of AMS measurement of 23 oriented samples from Snaigupėlė outcrop show the one direction of the flow of sedimentary material. Direction sedimentary flow direction in the Snaigupėlė outcrop have direction 301° with 8° degree angle (**Fig. 6**, **Table 2**).

Palaeomagnetic investigations

The results of palaeomagnetic investigations measurement of 23 oriented samples from Snaigupėlė outcrop. Examples of progressive AF demagnetization behaviour are presented on orthogonal plots and equal-area projections in **Fig. 8**. As the natural remnant magnetization (NRM) intensities before demagnetization are on the order of 10^{-4} A/m, samples measured with the JR-6 spinner magnetometer from AGICO. In the section of Snaigupėlė outcrop the stepwise AF demagnetization displays two kinds of demagnetization: reversed magnetic polarity samples removed in a field 30 mT, the normal magnetic polarity samples removed in a field 50–60 mT (**Fig.7**). Magnetic polarity scale from Snaigupėlė section

Table 1. *Results of radiochemical analysis of U and Th isotopes in gyttja samples from the Snaigupelė outcrop.*

Lab. №	Depth (cm)	^{238}U	^{234}U	^{230}Th	^{232}Th	^{230}Th/^{234}U	^{234}U/^{238}U
		(dpm/g)					
				L/L-model			
827	475–485	36.067 ± 0.679	37.672 ± 0.709	15.267 ± 0.653	1.410 ± 0.064	0.405 ± 0.019	1.045 ± 0.004
828	485–495	2.264 ± 0.087	2.425 ± 0.092	1.081 ± 0.058	1.488 ± 0.078	0.446 ± 0.029	1.071 ± 0.029
829	495–505	0.458 ± 0.014	0.602 ± 0.018	0.643 ± 0.029	1.347 ± 0.056	1.069 ± 0.057	1.314 ± 0.043
830	505–515	0.447 ± 0.013	0.535 ± 0.015	0.700 ± 0.036	1.341 ± 0.065	1.309 ± 0.077	1.198 ± 0.038
831	515–525	0.523 ± 0.025	0.594 ± 0.028	0.745 ± 0.042	1.355 ± 0.073	1.254 ± 0.092	1.136 ± 0.058
832	525–535	0.615 ± 0.021	0.705 ± 0.023	0.740 ± 0.044	1.336 ± 0.076	1.050 ± 0.072	1.146 ± 0.040
833	535–545	0.661 ± 0.024	0.745 ± 0.027	0.899 ± 0.048	1.549 ± 0.078	1.206 ± 0.077	1.126 ± 0.043
				TSD-model			
827t	475–485	39.712 ± 1.612	43.878 ± 1.758	18.820 ± 1.224	2.152 ± 0.299	0.429 ± 0.033	1.105 ± 0.033
828t	485–495	3.211 ± 0.105	3.423 ± 0.111	1.762 ± 0.091	2.388 ± 0.118	0.515 ± 0.031	1.066 ± 0.030
829t	495–505	1.527 ± 0.047	1.395 ± 0.044	1.371 ± 0.062	2.325 ± 0.096	0.983 ± 0.054	0.914 ± 0.030
830t	505–515	1.463 ± 0.048	1.412 ± 0.047	1.461 ± 0.063	2.379 ± 0.095	1.035 ± 0.056	0.965 ± 0.034
831t	515–525	1.466 ± 0.052	1.464 ± 0.052	1.486 ± 0.093	2.439 ± 0.142	1.015 ± 0.073	0.999 ± 0.038
832t	525–535	1.609 ± 0.049	1.542 ± 0.048	1.408 ± 0.067	1.942 ± 0.088	0.913 ± 0.052	0.958 ± 0.031
833t	535–545	1.509 ± 0.052	1.487 ± 0.051	1.420 ± 0.080	1.936 ± 0.102	0.955 ± 0.063	0.985 ± 0.036

Table 2. *AMS parameters of Snaigupėlė section: (mean magnetic susceptibility (K_m), magnetic lineation (L), magnetic foliation (F), anisotropy degree (P), shape parameter (T), long axis (K_{max}) and short axis (K_{min}).*

Site	N	K_m (10^{-5}SI)	L	F	P	T	K_{max} (°)	K_{min} (°)
Snaigupėlė	23	5,93E-5	1.002	1.006	1008	0.414	301/8	93/81

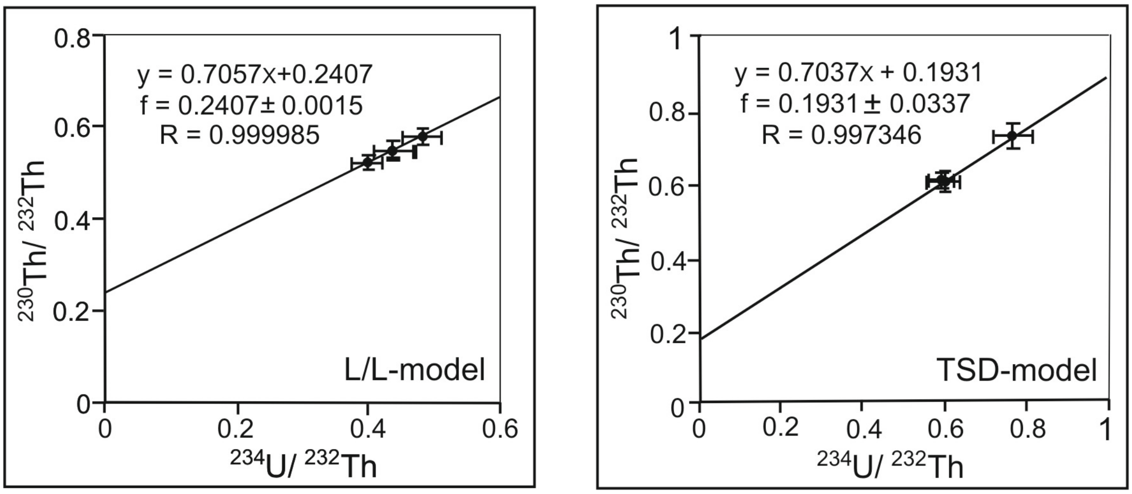

Fig. 5. *Linear dependences in the isochronous built on analytical data of horizons 505–515, 515–525, and 535–545 cm.*

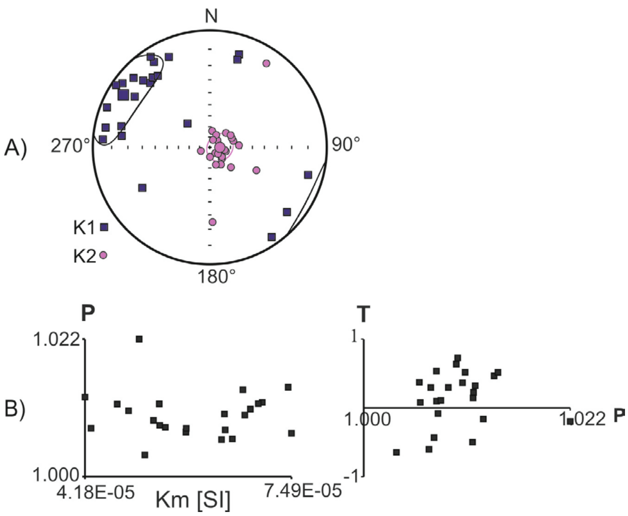

Fig. 6. *AMS directional results of Snaigupėlė section: A) Small symbols represent specimen eigenvectors; high symbols are mean eigenvectors, square – K_{max}, circle K_{min}. A – I direction, B – II direction. B) Anisotropy degree P and shape parameter T, versus magnetic susceptibility Km.*

is the following: from 6.20 to 5.11 m the section represented the reverse magnetic polarity and from 5.11 to 4.65 m — normal magnetic polarity (**Fig.8**). Small stratigraphic volume of section does not compare directly to the global palaeomagnetic scheme.

5. DISCUSSION

The discussion about the age of the interglacial deposits in the Snaigupėlė outcrop has been going on for many years. The first palynological investigations of these lacustrine sediments showed that the development of vegetation is characteristic of Merkinė (Riss-Würm) Interglacial (Kondratienė, 1958). Further investigations allowed revising this conclusion. Analysis of diagrams by graphic and mathematical-statistic methods gives the grounds to assume, that the difference between those two types is considerable (Kondratienė, 1973). There exists a difference between conditions of occurrence and vegetative remains. It is supposed that deposits, having the diagram of 2nd type, belong to another, older than Merkinė (Eemian, Mikulino) and younger than Butėnai (Holsteinian, Lichvin) Interglacial (Kondratienė, 1973) (**Fig. 9**).

However the well-boring data obtained in 1980 discovered that according to the bedding conditions the age of this section corresponds with the Merkinė Interglacial (Baltrūnas and Bitinas, 1994; Baltrūnas, 1995, 2002). The fact that the section of lacustrine sediments contains pollen from the older interglacials can be explained by accumulation, erosion and reworking of the sediments of at least two interglacials occurring close to the investigated section (Baltrūnas, 1995, 2002). Overall, Merkinė Interglacial sections in Lithuania are well identified and reliably correlated with Last Interglacial (Eemian, Muravian,

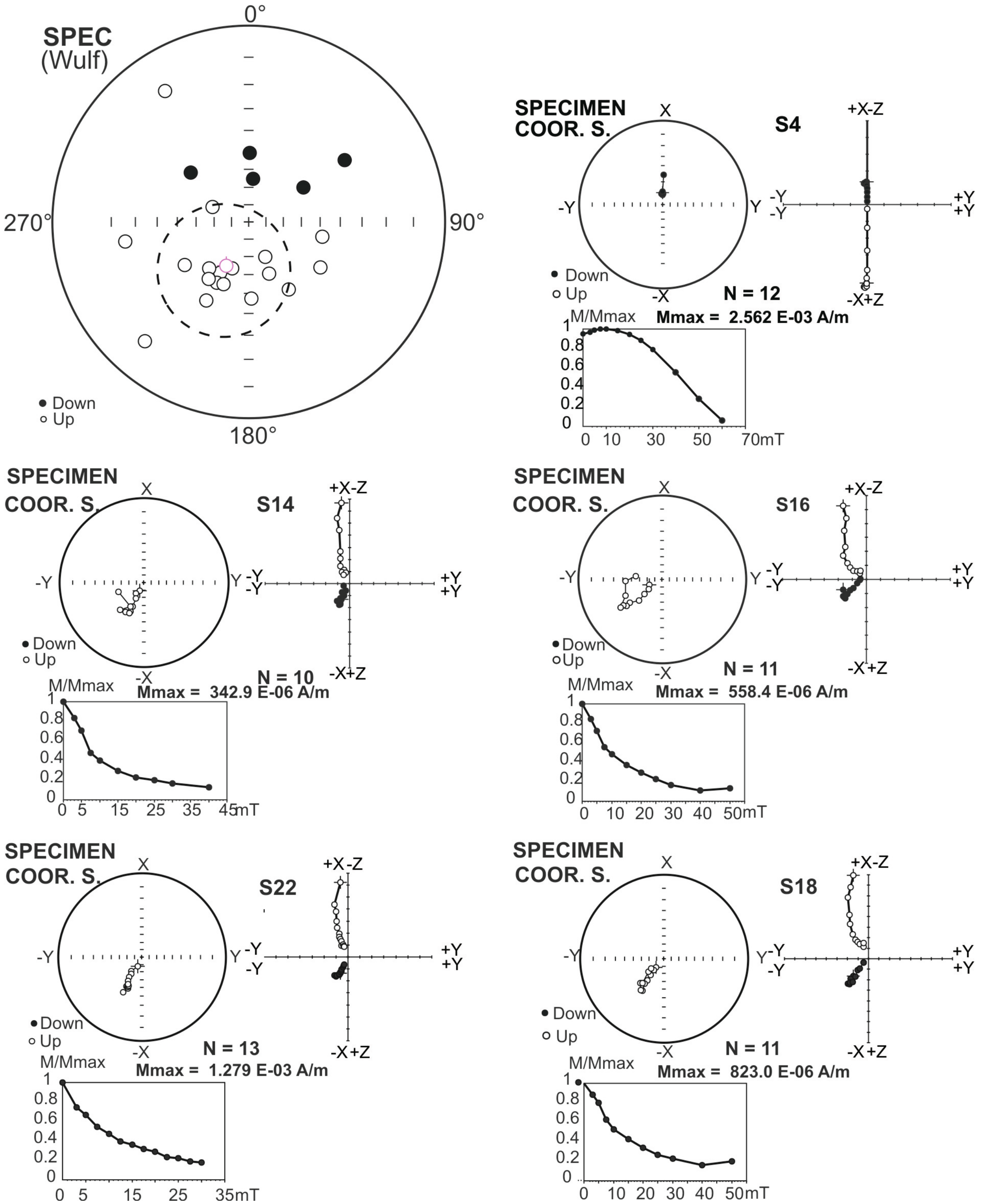

Fig. 7. *Representative demagnetization data from Snaigupėlė outcrop: A) chrm directions. Mean directions of the Snaigupėlė section reversed (high circle) / normal polarity: (Dm, Im) = (204.4°, –60.5°), N = 18, a95 = 5.06° / (Dm, Im) = (18.9°, 57.1), N = 5, a95 = 6.98°; B) demagnetization of samples S4, S14, S16, S22 and S18.*

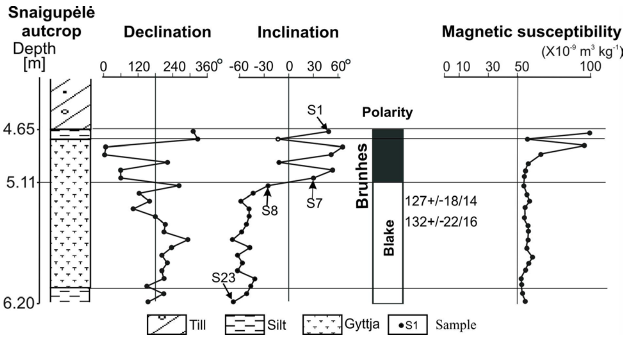

Fig. 8. *Lithology and data of palaeomagnetic investigations of the Snaigupėlė outcrop: 1 – till, 2 – silt, 3 – gyttja.*

Mikulian) sections in other European countries (Ber, 2000; Lindner *et al.*, 2013; Shick, 2014; Stephan, 2014; and other). The environmental history of the Merkinė (Eemian) Interglacial (130–117 ka) is rather well studied (Guobytė and Satkūnas, 2011).

Dating of organic sediments in Snaigupėlė outcrop by ^{230}Th/U method yielded the age of 127^{+18}_{-14} ka for L/L model (ЛУУ-833L/L) and 132^{+22}_{-16} ka for TSD model (ЛУУ-833TSD). These are the dates of the beginning of the Eemian Interglacial though with some errors they cover the whole interglacial. The conducted AMS and palaeomagnetic investigations showed that magnetic polarity scale from the Snaigupėlė outcrop is the following: from 6.20 to 5.11 m section represented the reverse geomagnetic polarity and from 5.11 to 4.65 m — normal geomagnetic polarity (**Fig. 8**). The dating of sediments allows linking the reverse geomagnetic excursion to the geomagnetic Blake Event in the Eemian Interglacial. The recently obtained data may be related to those of Head *et al.* (2008), Cohen and Gibbard (2011).

It is worth mentioning that the material of palaeobotanical investigations confirms the assumption that sediments of Blake Event accumulated during the climate optimum (Baltrūnas *et al.*, 2013). The fact that the end of the Blake Event coincides with the end of spread of *Corylus* and *Quercus* and the beginning of spread of *Carpinus* has been determined recently in Germany. The investigations carried out in the Geisel valley (Saxony-Anhalt, Germany) (Sier and Dekkers, 2013) showed that the top of the Blake Event is situated in pollen zone IVb3 (*Corylus* is maximum), before zone V (*Carpinus* is maximum). Analogous situation, when the vegetation development and sediments show a cycle from wet to dry was observed in the section of the Snaigupėlė outcrop (**Fig. 9**).

The doubt is for dates difference of Blake Event in Snaigupėlė outcrop and in Netiesos outcrop, South Lithuania (Baltrūnas *et al.*, 2013). The reasons, probably, are in age determination methods. In recent works the age of Blake Event is related with MIS 5e — about 0.12 Ma (Head *et al.*, 2008; Cohen and Gibbard, 2011 and other). A new palaeomagnetic study of the Last Interglacial calcareous tufa sequence at the archaeological site of Caours (northern France) identified a geomagnetic excursion that interpret as the Blake Event and relate with MIS 5e (Sier *et al.*, 2015).

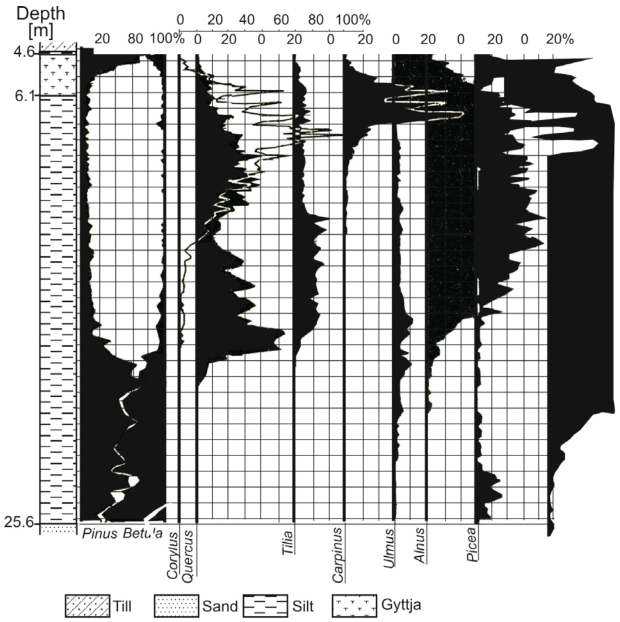

Fig. 9. *Spore and pollen diagram of the interglacial sediments in the Snaigupėlė outcrop (Kondratienė, 1973).*

6. CONCLUSIONS

1) The interglacial deposits in the South Lithuania Snaigupėlė outcrop and Snaigupėlė-705 borehole are distinguished for different bedding conditions though the sections are in close proximity of each other, above the elevation of sub-Quaternary surface and very close to palaeoincision. The sediments of these sections are bedding between layers of glacigenic deposits. The interglacial sediments of the borehole section are bedding at a greater depth and thicker than the comparable deposits in the outcrop.
2) In the Snaigupėlė outcrop, the highest compatibility of isochronic-correction dates calculated using L/L and TSD models was determined for combination of three samples from depths 505–515, 515–525, and 535–545 cm. With the help of the **f** value (section of isochrones in the axis of ordinates), the contribution of the primary pollution with thorium was determined where, as based on corrected analytical data, isochronic-correction dating was performed yielding 127^{+18}_{-14} ka for L/L model (ЛУУ-833L/L) and 132^{+22}_{-16} ka for TSD model (ЛУУ-833TSD).
3) The results of anisotropy of magnetic susceptibility (AMS) measurement of 23 oriented samples from Snaigupėlė outcrop show the one direction of the

flow of sedimentary material (**Fig. 6**). Direction sedimentary flow direction in the Snaigupėlė outcrop has direction 301° with 8° degree angle. The very small slope angle is indicative of slow transport of sedimentary material in the palaeobasin.

4) Palaeomagnetic investigations showed that the section of lacustrine sediments in the lower part of Snaigupėlė outcrop were orientated by reversed magnetic excursion and in the upper part by normal magnetic polarity. Collation of the obtained data with the global geomagnetic scale and isochronic-correction dating showed that the palaeomagnetic inversion observed in the Snaigupėlė outcrop was related with the Blake Event in the Eemian Interglacial.

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