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Vetygala Exposure: the problem of the lower boundary of Pleistocene

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The presented results of palaeomagnetic and lithological investigations of the Vetygala Exposure are one more attempt to solve the problem of the lower boundary of the Pleistocene in Eastern Lithuania. Five lithological complexes distinguished in the deposit sequence of the Vetygala Exposure of up to 22 metres height were studied by means of lithology and palaeomagnetism. Carbonate analysis undertaken showed that the amount of carbonates is increasing only in the uppermost part of outcrop, but some carbonate content in the lower part suggests that the sediments in the Vetygala Exposure could have formed at the beginning of the Pleistocene. Results of measurements of the magnetic susceptibility of sediments and the determination of the anisotropy of magnetic susceptibility and remanent magnetisation for orientated samples from clayey silt interlayers demonstrate that changes of Earth's magnetic field polarity were frequent during the sediments deposition and maintain about a relatively long period of sedimentation. The results of recent lithological and palaeomagnetic studies do not give a straight answer about the stratigraphical identity of investigated sediments. Thus, the stratigraphical subdivision of sediments in the Vetygala Exposure and their correlation with neighbouring geological sections are still open to variable interpretation.

Key words: Pleistocene boundary, carbonate content, palaeomagnetism

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INTRODUCTION

The Neogene and Early Pleistocene strata represented by lacustrine and alluvial sediments are widely distributed in the environs of Anykščiai, Eastern Lithuania. Here they overlie the Devonian bedrock and are overlain by the Pleistocene glacial deposits. These sediments only outcrop in the Šventoji River valley and its tributaries, including the Vetygala Exposure. Despite the fact that the sediments of Vetygala and similar neighbouring exposures (Daumantai, Gyliai, Šlavė) were studied starting from 1926 by J. Dalinkevičius (1928) and were continued until

the resent decades by a large number of investigators (Baltakytė-Vienožinskienė, 1956; Gudelis, 1961, 1973; Vienožinskienė, 1960; Kondratienė, 1965, 1971a, 1971b; Baltakis, 1966; Klimašauskas, 1970; Klimašauskas, Prakapaitė, 1971; Riškienė, 1968; Vaitiekūnas, Chomutova, 1972, 1973, 1975; Juozapavičius, 1976; Vaitiekūnas, 1977a, 1977b; Velichkevich, 1982; Gaigalas, 1987; Malinauskas, 1985; Satkūnas, 1990, 1991; Kondratienė, Satkūnas, 1993; Kondratienė et al., 1993; Šinkūnas et al., 2001; Kondratienė, Šeirienė, 2001; Kondratienė et al., 2001a, 2001b; Baltrūnas et al., 2013), the problem of the lower boundary of the Pleistocene in Eastern Lithuania is still under discussion. The Vetygala Exposure (location: N 55° 27' 17", E 25° 00' 06"; top of the outcrop: about 85.5 metres a. m. s. l.) is one of the key-sections where the mentioned stratigraphical problem could be solved. The presented results of palaeomagnetic and lithological investigations of the Vetygala Exposure are one more attempt of the mentioned problem solution.

MATERIALS AND METHODS

Five lithological complexes were distinguished in the deposit sequence of the Vetygala Exposure of up to 22 metres height (Fig. 1).

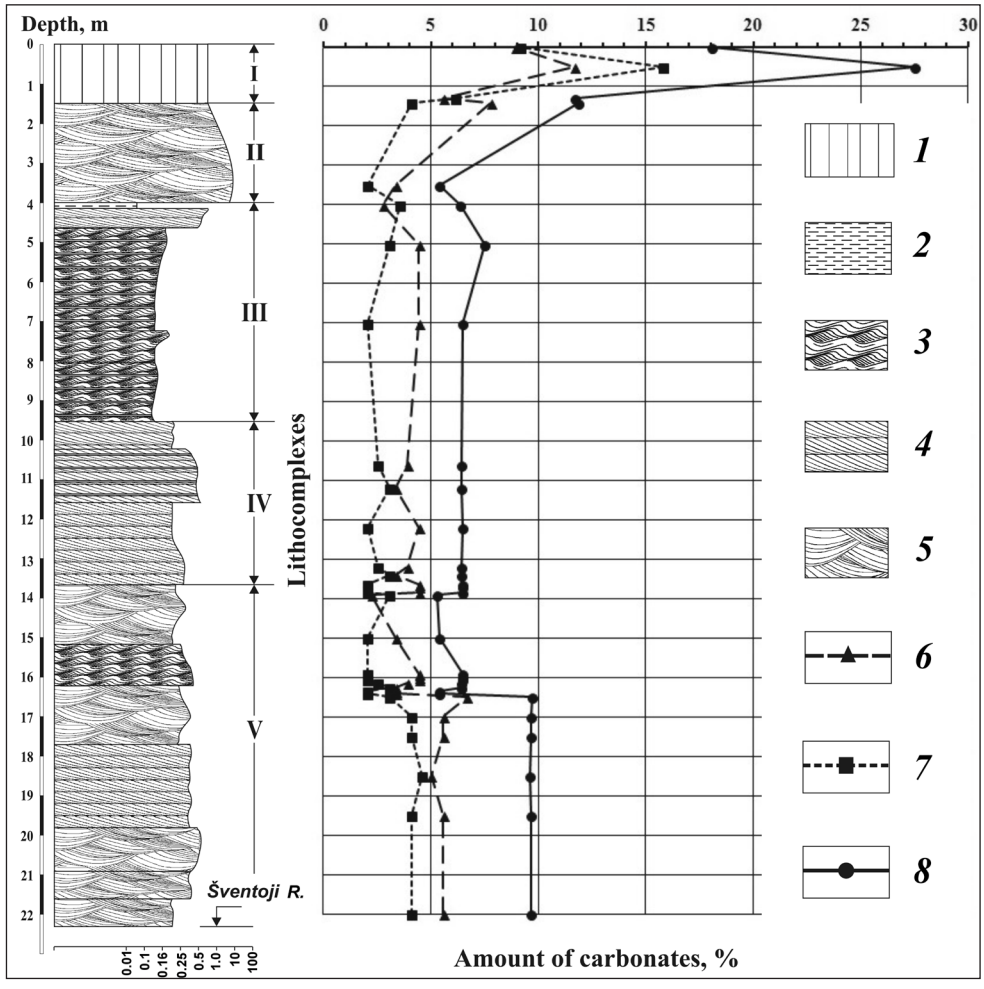

Fig. 1. Investigated sediment sequence and amount of carbonates in Vetygala Exposure: *1* – till; *2* – fine sediments of massive structure; *3* – ripple laminated sediments; *4* – tabular cross stratified deposits; *5* – trough cross bedded deposits; *6* – calcite; *7* – dolomite; *8* – total carbonate content

1 pav. Ištirtų nuogulų seka ir karbonatų kiekis Vetygalos atodangoje: *1* – moreninės nuogulos; *2* – smulkios masyvios tekstūros nuosėdos; *3* – banguotai sluoksniuotos nuosėdos; *4* – lygiagrečiai įkypai sluoksniuotos nuogulos; *5* – kryžmiškai įkypai sluoksniuotos nuogulos; *6* – kalcitas; 7 – dolomitas; *8* – bendras karbonatų kiekis

Lithocomplex I (0.0–1.5 m depth) is composed of brown till, with gravel and pebbles and rare small boulders.

Lithocomplex II (1.5–4.0 m depth) is composed of trough cross bedded brown gravel with pebbles and boulders and brown till lumps.

Lithocomplex III (4.0–9.55 m depth) is composed of coarse greyish white sand interlayered with silt at the upper part of the lithocomplex. The sand is tabular cross laminated with lamina dip direction of 140°. The main part of the lithocomplex is composed of the white indistinctly ripple laminated sand and grey silt lamina interlayering. The thickness of the sand laminae is 5–15 cm and 1–5 cm of the silt.

Lithocomplex IV (9.55–13.65 m depth) is composed of white coarse and middle grained sand. Sand in lenses of up to 5 m long and up to 30 cm thick is tabular cross stratified with the lamina dip direction to the NW. Thin laminas of silt can be observed in between the sand lenses.

Lithocomplex V (13.65–22.25 m depth) is composed of white and yellowish white sand trough and tabular cross stratified in lenses of 2–5 m long and up to 0.5 m thick with the lamina dip direction to the SE. At the lowermost part of the lithocomplex the sand is of massive structure, grey, middle grained with blue clay lumps.

The carbonate analysis was undertaken on 30 samples collected from the Vetygala Exposure. A calcimeter was used to determine CO_2 volume in the bulk samples: both calcite and dolomite were determined using this method (Rudnickaitė, 1980).

In the Vetygala Exposure 200 bulk samples (every 10 cm) were collected for measurements of magnetic susceptibility and 36 orientated samples from clayey-silt interlayers for the determination of the analysis anisotropy of magnetic susceptibility (AMS) and remanent magnetisation.

RESULTS AND DISCUSSION

The total amount of carbonates in different sandy layers varies from 5.3% to 9.7% (Fig. 1). The amount of calcite and dolomite is approximately equal – inconsiderable prevalence of calcite or dolomite (up to 1–2%) is varied in separate layers. The total amount of carbonates is increasing only in the uppermost part of outcrop – in the sandy gravel (until 11.9%) and in the till (until 27.5%). The calculated mean ratio of dolomite / calcite in the till layer is 1.16.

The distribution of carbonates in the Vetygala Exposure shows that all sediment beds contain carbonates – this mineralogical composition is not characteristic of the Pliocene sediments. During the Paleogene–Neogene warmer climatic conditions and strong chemical weathering prevailed – only under such conditions the monomineral quartz sand units could be formed in Eastern Lithuania (Juozapavičius, 1972). Thus, it is possible to suggest that the sediments in the Vetygala Exposure could have formed immediately at the beginning of the Pleistocene. The presence of blue clay lumps, typical for the Devonian sediments of this region, in the lowermost part of exposure indicates that erosion of the local bedrock was in progress during the deposition of discussed sediments.

The magnetic susceptibility parameters obtained from the Vetygala Exposure vary from -2×10^{-9} m^3 kg^{-1} until 30×10^{-9} m^3 kg^{-1} (Fig. 2). The results of the anisotropy of magnetic susceptibility (AMS) of the orientated samples maintain that the magnetic sedimentary particles have a clearly reflected orientation – three directions of material orientation were determinate (Table): A – all samples have a general direction of 66°, i. e. west–southwest (WSW) to north–northeast (NNE) with a low dip angle;

Table. **Anisotropy of magnetic susceptibility (AMS) parameters of the Vetygala Exposure: amount of samples (N), mean magnetic susceptibility (K_m), magnetic lineation (L), magnetic foliation (F), anisotropy degree (P), shape parameter (T), azimuth and dip of long axes (K_{max}) and short axes (K_{min})**

Lentelė. **Magnetinio imlumo anizotropijos parametrai Vetygalos atodangoje: mėginių kiekis (N), vidurkinis magnetinis imlumas (K_m), magnetinis linijiškumas (L), magnetinis sluoksniuotumas (F), anizotropijos laipsnis (P), ilgųjų (K_{max}) ir trumpųjų (K_{min}) anizotropijos elipsoido ašių azimutas ir polinkio kampas**

Exposure	N	K_m (10^{-6}SI)	L	F	P	T	K_{max} (°)	K_{min} (°)
Vetygala (A all samples)	36	5.47E-5	1.005	1.012	1.017	0.342	66/9	213/79
Vetygala (B direction)	9	2.72E-5	1.005	1.015	1.021	0.371	110/2	212/81
Vetygala (C direction)	8	2.07E-5	1.005	1.006	1.011	0.162	53/28	204/59

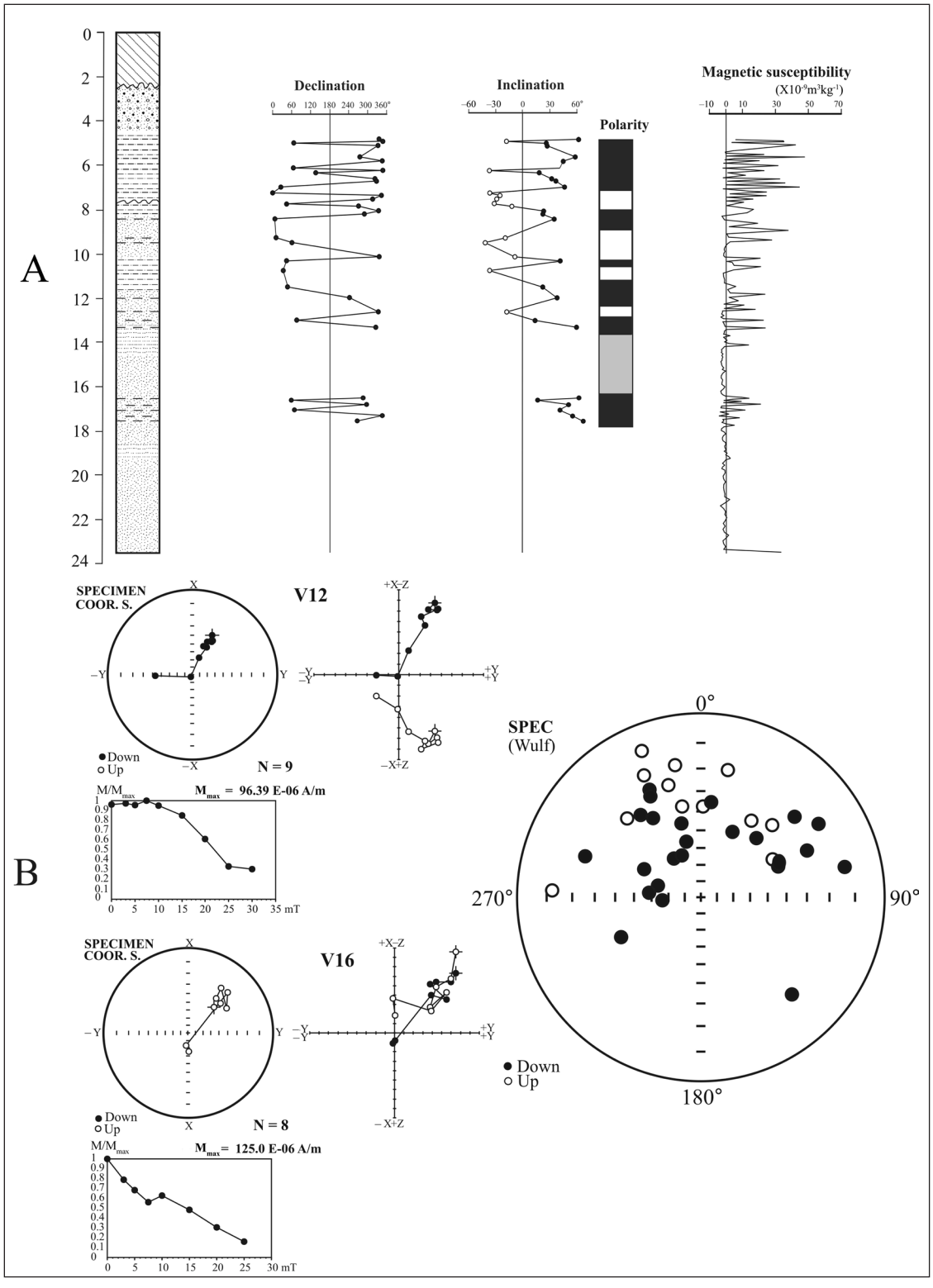

Fig. 2. Results of palaeomagnetic investigations of deposits in Vetygala Exposure: A – lithology and palaeomagnetic characteristics; polarity: white – normal, black – reversed, grey – gap of palaeomagnetic data; B – representative demagnetization data of samples V12 and V16, and characteristic remanence (ChRM) directions

2 pav. Vetygalos atodangos nuogulų paleomagnetinių tyrimų rezultatai: A – litologija ir paleomagnetinės charakteristikos; poliškumas: balta – normalus, juoda – atvirkščias, pilka – trūksta paleomagnetinių duomenų; B – V12 ir V16 mėginių išmagnetinimo tipiški duomenys ir būdingos liekamosios kryptys (ChRM)

B – an azimuth direction of 110°, i. e. W–E orientation, with a low dip angle; and C (the uppermost part of the outcrop) – an azimuth direction of 53° (WSW–ENE orientation) and a relatively steep dip of 28°.

The results of the AMS measurement indicate that the main azimuth of the flow direction of sedimentary material was very similar in the majority of the sections investigated: i. e. generally from W to E or WSW to NNE. The anomalously steep dip (28°) recorded in the uppermost part of the Vetygala Exposure can be attributed to post-depositional glaciotectonic deformation of the sediments during glacial overriding during one of the subsequent Pleistocene glaciations. AMS data are partly contradicted by the dip measurements and the orientation of sandy beds: the lower sandy units of the Vetygala Exposure were deposited by water flowing from SE (Šinkūnas et al., 2001).

The palaeomagnetic measurements demonstrate that changes of Earth's magnetic field polarity were frequent during the sediments deposition (Fig. 2). Relatively frequent polarity changes are more characteristic of the Matuyama and Gauss polarity chrons: it is most probable that the sediments of this polarity predominate in the exposure investigated. On the other hand, the ability of polarity chrons maintains about a relatively long period of sedimentation.

CONCLUSIONS

It is possible to conclude that the results of recent lithological and palaeomagnetic studies do not give a straight answer about the stratigraphical identity of the investigated sediments. Thus, the stratigraphical subdivision of sediments in the Vetygala Exposure and their correlation with neighbouring geological sections are still open to variable interpretation.

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VETYGALOS ATODANGA: PLEISTOCENO APATINĖS RIBOS PROBLEMA

S a n t r a u k a

Publikacijoje pateikiami preliminarūs litologiniai ir paleomagnetiniai duomenys, charakterizuojantys Vetygalos atodangos pjūvio nuogulas. Atsidengiančių nuogulų sekoje išskirti penki litologiniai kompleksai, pasižymintys skirtinga nuogulų granuliometrija, tekstūrinėmis, karbonatingumo ir paleomagnetinėmis savybėmis. Išvadose konstatuojama, kad atliktų litologinių ir paleomagnetinių tyrimų rezultatai neleidžia nuoguloms suteikti vienareikšmiškos stratigrafinės prieskyros, tačiau tikimasi, kad gauti duomenys vienaip ar kitaip pravers tam ateityje.

Raktažodžiai: pleistoceno riba, karbonatingumas, paleomagnetizmas