GEOLOGIJA. 2004. T. 45. P. 16–26

Sedimentologija • Sedimentology • Седиментология

Trace fossils from Upper Pleistocene varved clays S of Kaunas, Lithuania

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Gaigalas A., Uchman A. Trace fossils from the Upper Pleistocene varved clays S of Kaunas, Lithuania. *Geologija*. Vilnius. 2004. No. 45 P 16–26. ISSN 1392-110X.

Relatively common trace fossils *Gordia*, *Helminthoidichnites*, *Galaciichnium*, and rare *Cochlichnus*, W*arvichnium*, and curved ridges occur in the Upper Pleistocene varve clays at Balbieriškis and Girininkai, S of Kaunas. They occur in single laminae every one or two decimetre in clayey lamina packages and are absent in laminae rich in carbonates. It is not clear whether such a distribution resulted from rare occurrences of proper preservational conditions or from incidental colonization of the lake floor. The trace fossils are typical of the *Mermia* ichnofacies. The *Cursichnia* ichnocoenosis represented by *Glaciichnium* and *Warvichnium* and the *Gordia* ichnocoenosis (new one) represented by *Gordia* and *Helminthoidichnites* are distinguished. Their dominance suggests that the study deposits accumulated in the transition from metalimnion to hypolimnion.

Key words: trace fossils, Pleistocene, varved clay, sedimentation, environments, Lithuania

Received 7 November 2003, accepted 2 January 2004

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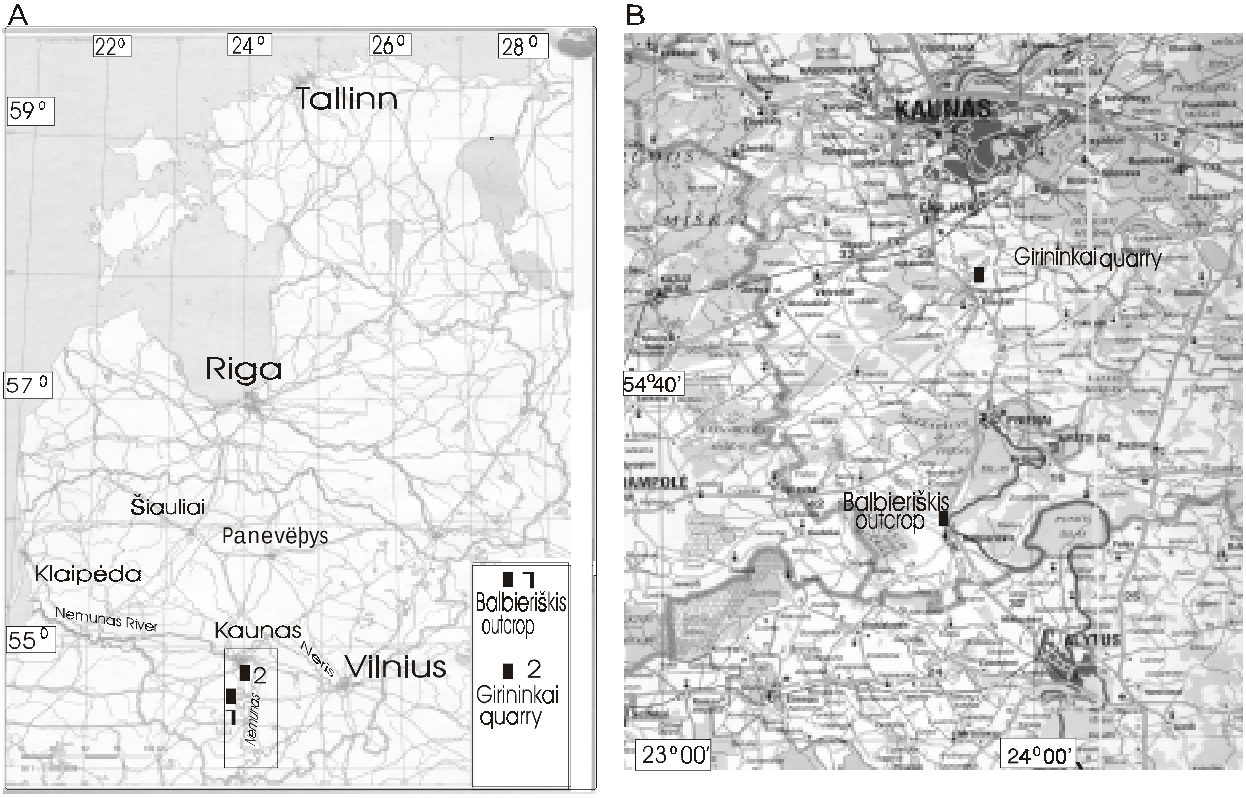
INTRODUCTION

Commonly, trace fossils are the only evidence of macrofaunal life in sedimentary record, especially in non-marine siliciclastic facies. This concerns also varve clays deposited in Quaternary proglacial lakes. Occurrence of trace fossils in these sediments foremost shows that the bottom of the proglacial lakes was not an arctic desert but was a habitat for different invertebrate animals. Potentially, the trace fossils can be used for recognition of lacustrine subfacies and climatic changes. Trace fossils are both sedimentological and palaeontological entities. They represent potential environmental indicators in the sequence of glaciolacustrine sediments.

Trace fossils from Quaternary varved clays have been described or reported from Sweden (Högbom, 1893, 1915; Andersson, 1897), Germany (Schwarzbach, 1938, 1940; Dahm & Otto, 1953; Ludwig, 1963; Hannemann, 1965; Walter, 1985, 1986; Fuchs, 1988; Walter & Suhr, 1998), USA (Tarr, 1935), Austria (Fliri et al., 1971), Canada (Banerjee, 1973; Gibbard & Dreimanis, 1978), England (Gibbard & Stuart, 1974); Finland (Gibbard, 1977), and Poland (Merta, 1980; Skompski, 1991). This is the first report on their occurrence in Lithuania. They were studied in two sections, at Balbieriškis and Girininkai, S of Kaunas (Figs. 1–3), where the Upper Pleistocene (about 15,000–14,000 years old) varved clays crop out. The illustrated specimens are housed in the Vilnius University. The samples were collected from investigated outcrops by A. Uchman and A. Gaigalas. The palaeontological identifications of fossil traces was carried out by Alfred Uchman.

PREVIOUS INVESTIGATIONS

The geomorphology and palaeogeography of glaciolacustrine basins in Lithuania were studied by some researchers (Basalykas, 1967, Mikalauskas, Mikutie-



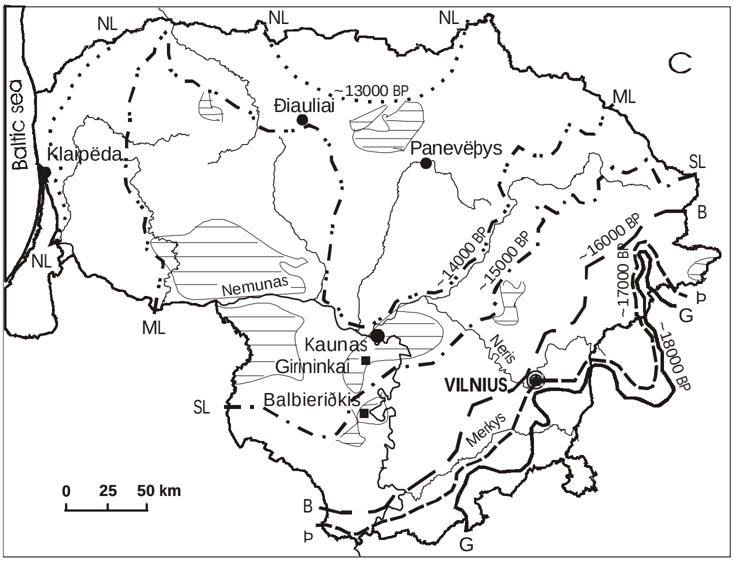


Fig. 1. Location maps:
A – Baltic countries, *B* – Map S of Kaunas with location of the study sites Balbieriškis and Girininkai, *C* – the largest ice-dammed basins near the edge of retreating ice cover of South-Lithuanian, Middle-Lithuanian and North-Lithuanian phasials of Baltija stadial of Nemunas glaciation
1 pav. Lokaliniai þemëlapiai: *A* – Baltijos šalys, *B* – á pietus nuo Kauno tyrinëtø pjûviø vietø þemëlapis, *C* – didieji prieledyniniai baseinai, pasitvenkæ prie Nemuno apledëjimo Baltijos stadijos Pietø Lietuvos, Vidurio Lietuvos ir Ðiaurës Lietuvos faziø atsitraukianèio ledyno pakrašèio

në, 1970, Garunkðtis, 1975, Юргайтис, 1970 and others). Studies on the lithology, distribution and duration of sedimentation and facies features of glaciolacustrine clays and geological structure were carried out by V. Mikaila (1957, 1958, 1959, 1965, 1966, 1975, 1991), Gudelis and Mikaila (1960). Some investigations on the sedimentology of the laminated clays were carried out also by Dvareckas and Basalykas (1959), Микшис и Гайгалас (1983), Гайгалас и др. (1996), Kazakauskas and Gaigalas (1999), Kazakauskas (2000).

Glaciolacustrine deposits and varved clays have been formed in dammed proglacial basins near the margin of the retreating ice sheet of the Last Glaciation. The general pattern of deglaciation of Lithuania is known (Gaigalas, 1994). The recessional ice margins are well defined and dated. The glaciolacustrine basins and their sediments have been “tied” to former ice margins. Deglacial deposits commonly lack datable and palaeontological material. Against the background of a gradual climatic warming there occur remarkable cooling time intervals causing halts or even advances of the degrading ice cover, marked in topography by distinct ice marginal dammed glaciolacustrine basins of South-, Middle- and North-Lithuanian phases. Lithuania was probably freed from the continental ice in Daniglacial time about 16,000–12,500 years ago. The ice-dammed basins were located in glaciodepressions. Some of glaciolacustrine basins emerged as a result of filling up the existing depressions in the relief with melt water. The origin of the majority of other basins is connected with the damming up of water by the front of an active glacier.

A regular succession of Daniglacial climatic and sedimentation changes in the local proglacial glaciolacustrine basins, conditioned by recession of the last Scandinavian ice sheet, was revealed in the glaciolacustrine-lacustrine sediments (Gaigalas et. al., 2001). The largest Lithuanian glaciolacustrine basin sediments were ascribed to facies of proglacial lakes that developed through the interaction of glacial and proglacial environments (Ðinkûnas and Jurgaitis, 1998). The genesis of different glaciolacustrine sediments of the Lithuanian proglacial lakes is discussed and sedimentation environs in proglacial limnic basins have been reviewed earlier by us, too (Kazakauskas and Gaigalas, 1999). A palaeomagnetic study of varved clay near the Girininkai section has been carried out (Gaigalas et al., 2002). The declination (D), inclination (I) and intensity (J) of the natural remnant magnitization of glaciolacustrine clays in this section were measured. The magnetic direction is fairly stable. Magnetic declination is rather scattered, and is hardly diagnostic for the geomagnetic secular variation, the expected variation of which would be close to true North. The shallow inclination may indicate compaction of the sediments after its deposition in a glaciolacustrine basin. This effect may be significant for preservation of fossil traces of organisms in the sequences of glaciolacustrine sediments.

The isotopic composition of oxygen and carbon stable isotopes of biochemogenic carbonaceous samples from glaciolacustrine varved clays of Balbieriškis and Girininkai sections has been studied (Gaigalas et al., 2001). The revealed gradual warming of climate is connected with the South-Lithuanian to Middle-Lithuanian and the Middle-Lithuanian to North-Lithuanian interphasials as well as with the South-Lithuanian interoscillations of retreating phases of the Baltija stage ice cover.

GEOLOGICAL SETTING AND SEDIMENTATION ENVIRONMENTS

In Lithuania, there are some glaciolacustrine basins differing in the size as well as structure and texture of varved sediments. The largest glaciolacustrine basins in Lithuania are as follows: Balbieriškis–Simnas in the south, Kaunas–Kaišiadorys in the middle part of Lithuania, Jûra–Ðeðupë in West Lithuania, Vievis–Ðirvintos and Dysna in the eastern part and Mûða in North Lithuania. In Lithuania, large proglacial glaciolacustrine basins had formed near the glacier edge of the South-, Middle- and North-Lithuanian phases of the Baltija stage of the Nemunas glaciation.

The Balbieriškis–Simnas glaciolacustrine basin existed during the South-Lithuanian phase (about 15,000 years ago) of the Baltija stadial of the Nemunas glaciation. The Kaunas–Kaišiadorys glaciolacustrine basin had formed at the time of the Middle Lithuanian phasial about 14,000 years BP. The investigation of trace fossils in 2003 were carried on in the section of glaciolacustrine varve clay sediments of the Balbieriškis outcrop (Balbieriškis–Simnas proglacial basin of the South Lithuanian phasial) and in the section of glaciolacustrine sediments of the Girininkai clay quarry of the Rokai ceramic plant (Kaunas–Kaišiadorys proglacial basin of Middle Lithuanian phasial). Development of glaciolacustrine proglacial basins and varve clay sedimentation in Lithuania are closely connected with the course of Scandinavian ice sheet retreat during the Daniglacial time from 16,000 till 13,000 years BP.

The gradual warming of climate is connected with South-Lithuanian to Middle-Lithuanian and the Middle-Lithuanian to North-Lithuanian interphasials as well as with the South-Lithuanian interoscillations. The interphasial lacustrine sedimentation with rhythmical lamination of carbonaceous sediments was observed in the middle part of the Balbieriškis section (at a depth of 3.1–5.9 m).The activity of the organisms increased during summer time intervals and influenced the sedimentation of calcareous seasonal bands with carbonates in autumn.

The deposits studied are traditionally called varved clays, however, they contain clayey and silty laminae, locally with drop stone and pebbles. In the study sections of the deposits we find: 1) sedimentologically different dispersed glaciolacustrine sediments of glacier oscillations, recession and advances, and 2) lacustrine varved clay sediments with seasonal bands of carbonates, which accumulated during temperature rises in warmer interphasial time intervals. The differentiated sedimentation of carbonates shows changes in the hydrochemical state of the basin and the influence of the organic world, which increased during summer periods of the interphasials.

The Balbieriškis section is situated on the left bank of the Nemunas River, about 0.5 km north of the small town of Balbieriškis. The average thickness of varved deposits reaches 7.43 metres (Fig. 2). This and other outcrops in this place are very impressive. Their cordinates (longitude and latitude) are 54°3206"; 23°53’16", relative height about 40 m, width 130 m. There are two layers of varved deposits, divided by tills of the Upper Pleistocene. The upper layer of varved sediments is bedding directly on the till of the South Lithuanian phasial (Baltija stadial of Nemunas Glaciation). The contact of glaciolacustrine sediments with the till is distinct.

In the Balbieriškis section it is easy to distinguish some different sedimentogenetic series of proglacial basin sediments, which are connected with oscillations of the retreating ice cover of the South Lithuanian phasial (Gaigalas et al., 2001). There are five climatic evolutionary stages of the existing Balbieriškis–Simnas basin: 1) climatic warming and intense retreat of the glacier expressed by sedimentation of laminated sediments and traces of fossils (layer 1), 2) stabilisation and oscillation of the glacier, during which climatic cooling took place (layer 2), 3) sudden climatic warming and fast glacier retreat, characterised by lacustrine (lake) sedimentation and abundance of trace fossils (layer 3), 4) sudden climatic cooling and glacier oscillation, characterised by prevailing clay of glaciolacustrine sedimentation (layer 4), 5) final climatic warming and glacier retreat, characterised by the ablation till of last (III) oscillation glacier of the South-Lithuanian phasial (layer 5).

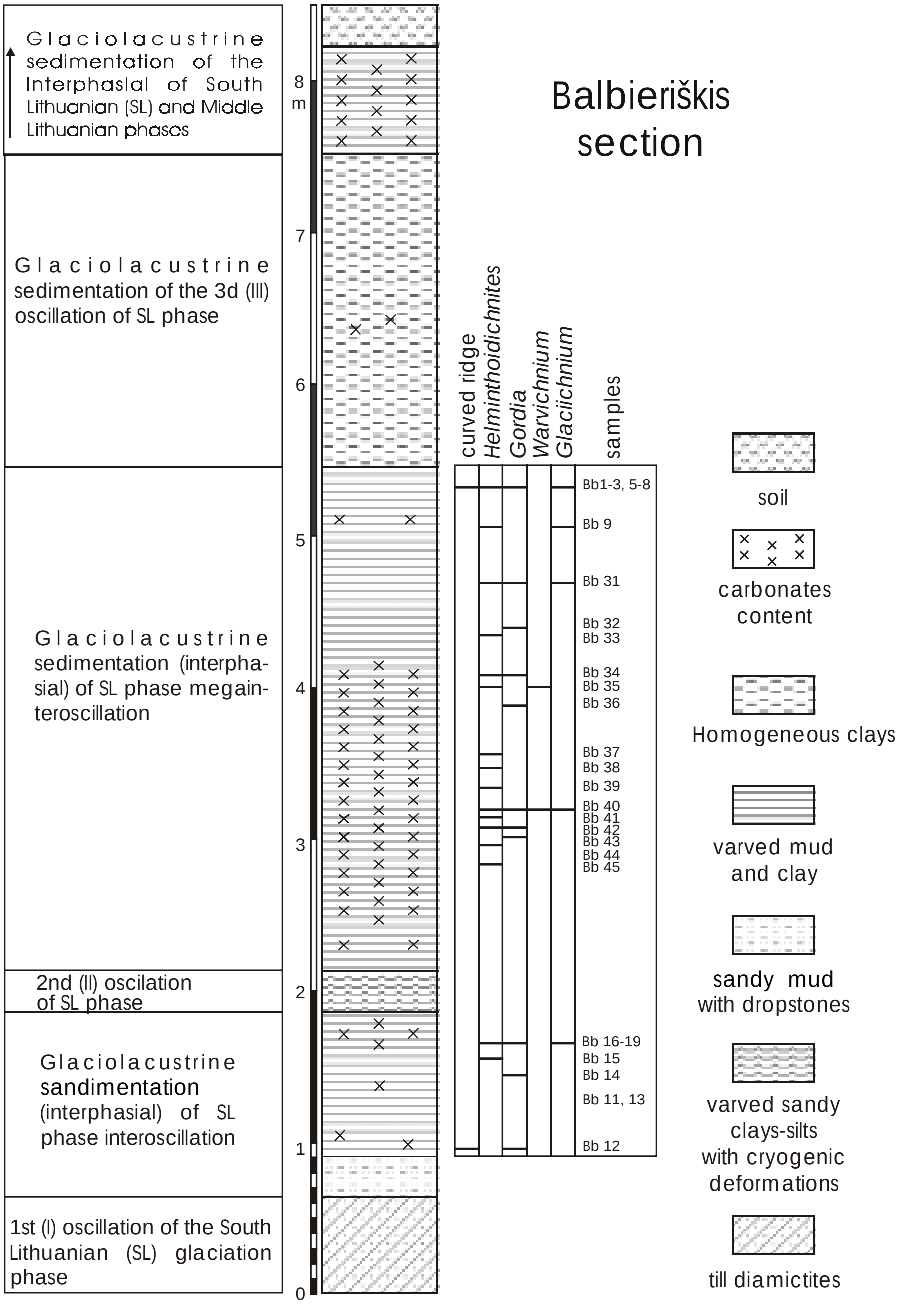


Fig. 2. Balberiškis section
2 pav. Balbieriðkio pjûvis

Trace fossils are distinguished in the lacustrine (lake) laminated sediments of the interphasials of a warmer climate (layer 3) and rarely in the glaciolacustrine laminated sediments (layer 1). They are absent in cool climate glaciolacustrine sediments (layer 4) and disturbed by oscillations of the glacier (layer 2). Summer bands are predominating in layer 3, which was formed during a warmer climate interval of the megainterphasial. The thickness of the summer bands reaches 2.0–2.5 cm. The average makes 1.2–1.5 cm.

The summer varved sediments are more calcareous and silty. They are easily seen in the lamination of the section. Sediment lamination commonly reflects an annual temperature cycle (Gaigalas et al., 2001). Deposition of calcareous laminae is characteristic of late summer and autumn seasons. Their accumulation depended on temperature, pH reaction, organisms or organic matter content and CO_2 regime. Sediment lamination reflects an annual rhythm of sedimentation conditioned by the annual temperature cycle. This cycle caused variations in the physical and biological conditions of a lake and a sedimentary matter influx.

Girininkai section is located in the quarry of the Rokai ceramic plant, which was being exploited in 2003 (Fig. 3). Its coordinates (longitude and latitude) are 54°45'23"; 23°56'30". This section of varved clay is connected by its origin with the halt of the ice margin on the Middle-Lithuanian ridge of end moraines. In the Girininkai section, three climatic evolutionary episodes were determined (Gaigalas et al., 2001): 1) short climatic warming with an oscillatory retreat of the glacier, characterised by sedimentation of distinctly laminated clays with prevailing winter sediments (at an interval of 0.2–3.2 m); 2) more stable climatic conditions characterised by sedimentation of indistinctly laminated clays and with distinct traces of fossils (at a interval of 3.2–5.9 m); 3) climatic warming characterised by sedimentation of laminated silty and calcareous clays (at a interval of 5.9–9.2 m). In this interval, humidic matter was observed. With the second climatic episode, at an interval of 3.2–5.9 m, activity of the organisms in the basin became higher at the time of the South-Lithuanian – Middle-Lithuanian phasial.

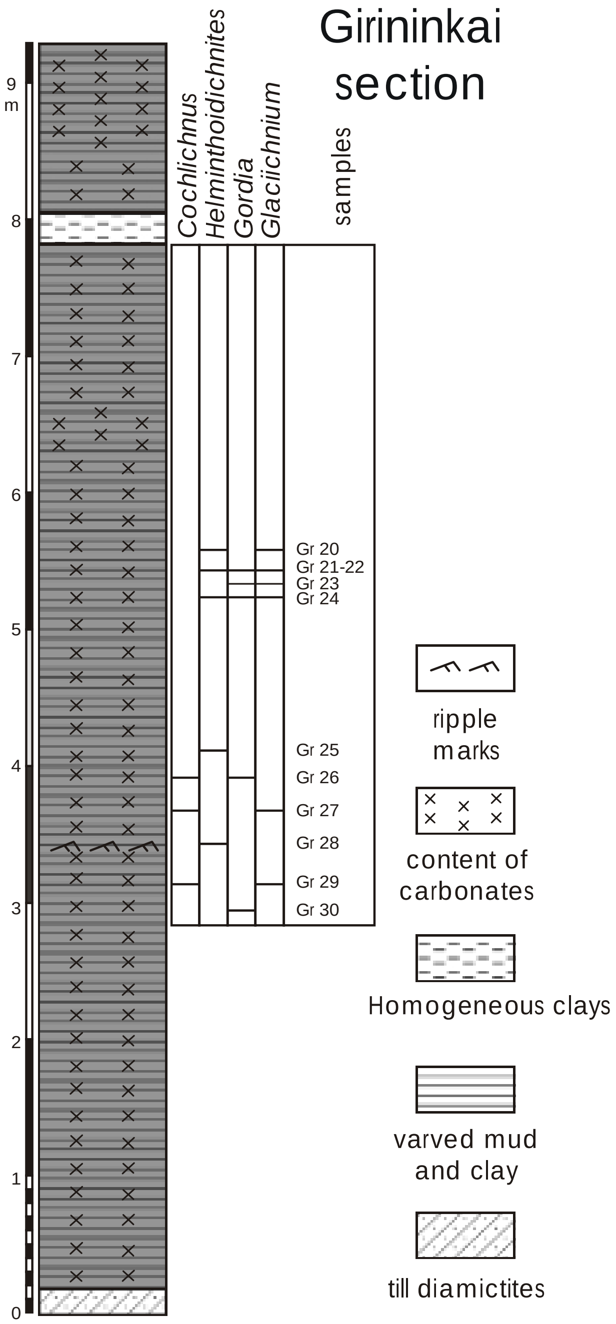


Fig. 3. Grininkai section
3 pav. Girininkø pjûvis

TRACE FOSSILS

The described trace fossils were observed on parting surfaces during a careful lamina-by-lamina splitting of varved clays. Occurrences of trace fossil are confined only to some, commonly single laminae, rarely to adjacent 2 or 3 laminae. Most of the trace fossil bearing laminae are about one or two decimetres apart in the sections. The laminae are more clayey and less marly than the laminae without trace fossils. The traces of fossils are connected with shallow water lithofacies of glaciolacustrine basins. Their formation took place during warmer climate intervals of the interphasials. The behavioural record of benthic organisms was observed on the surface of winter sediment layers, because they were active in summer.

Systematic ichnology

Cochlichnus Hitchcock 1858
Cochlichnus anguineus Hitchcock 1858
Fig. 4 A–B

Description. Very thin meandering grooves on the upper parting surfaces or hypichnial meandering ridges on the lower parting surfaces, which display only first-order sinuous meanders. The width of the grooves or ridges ranges between 0.4 and 0.6 mm. The wavelength of the sinuous meanders ranges between 4 and 8 mm, and the amplitude between 1 and 1.7 mm.

Remarks. Cochlichnus anguineus is the type ichnospecies of *Cochlichnus*, but its type specimens from the Triassic of Cincinnati are known only from drawings (Hitchcock, 1858). *Cochlichnus* was discussed by several authors, especially the Palaeozoic material (*e.g.*, Fillion & Pickerill, 1990; Gìuszek, 1995; Walter & Hofmann, 2001). Only surface traces have been included in *Cochlichnus* by Rindsberg (1994). The subsurface forms have been distinguished by the latter author as a new ichnogenus *Cymatulus*. However, Stanley & Pickerill (1998) argued that the distinction is very subtle and regarded *Cymatulus* as a junior synonym of *Cochlichnus*.

Different organisms are regarded as producers of non-marine *Cochlichnus*. Hitchcock (1858) suggested annelids; however, recent traces of this morphology are produced mainly by insect larvae (Toula, 1908). Larvae of biting midge (family Ceratopogonidae) (Michealis, 1972) and dipteran larvae (family Therevidae) have been found to produce such traces (Metz, 1987). The chironomid dipterous insects, including *Chironomus motilator* (Emerson in Tarr, 1935), are also suspected to produce this kind of trace (Andersson, 1897). Other authors regarded it as nematode trails (Moussa, 1970; Chamberlain, 1975, Metz, 1998). Indeed, experiments with nematodes confirm the latter idea (Sandstedt et al., 1961; Rode & Staar, 1961). Walter & Hofmann (2001) underlined the occurrence of *Cochlichnus* in extreme environments, what is certainly true for proglacial lakes.

Glaciichnium Walter 1985
Glaciichnium liebegastensis Walter 1985
Fig. 4 C, D

Description. Straight to winding convex forms on the upper parting surfaces and concave forms on the lower parting surfaces, composed of a central groove or ridge bounded by disrupted levee, 0.3–1.2 mm wide. The groove is accompanied by very thin, short (up to 1.5 mm long) lateral groves or ridges, inclined concordantly at an angle up to 45° to the main course of the trace fossil. In some specimens the lateral grooves or ridges are poorly visible, and only the central axial part is preserved. In other specimens the central groove is poorly preserved and the lateral elements dominate.

Remarks. This is a typical trackway of an arthropod with drag marks, which is commonly preserved in different ways as under tracks, *i.e.* impressions of appendages on lower laminae (cf. Goldring & Seilacher, 1971).

Glaciichnium liebegastensis can be interpreted as a trackway of an isopod insect from the genus *Asellus* as shown by experiments with water hoglouse (*Asellus aquaticus*) (Schwarzbach, 1938; Gibbard & Stuart, 1974), which is a typical animal of glacial lakes feeding on algae and plant detritus. It is able to survive temporary freezing (Gibbard & Dremanis, 1978).

Gordia Emmons 1844
Gordia isp.
Fig. 5 A, B

Description. Smooth, horizontal ribbons on parting surfaces forming irregular loops. The ribbons

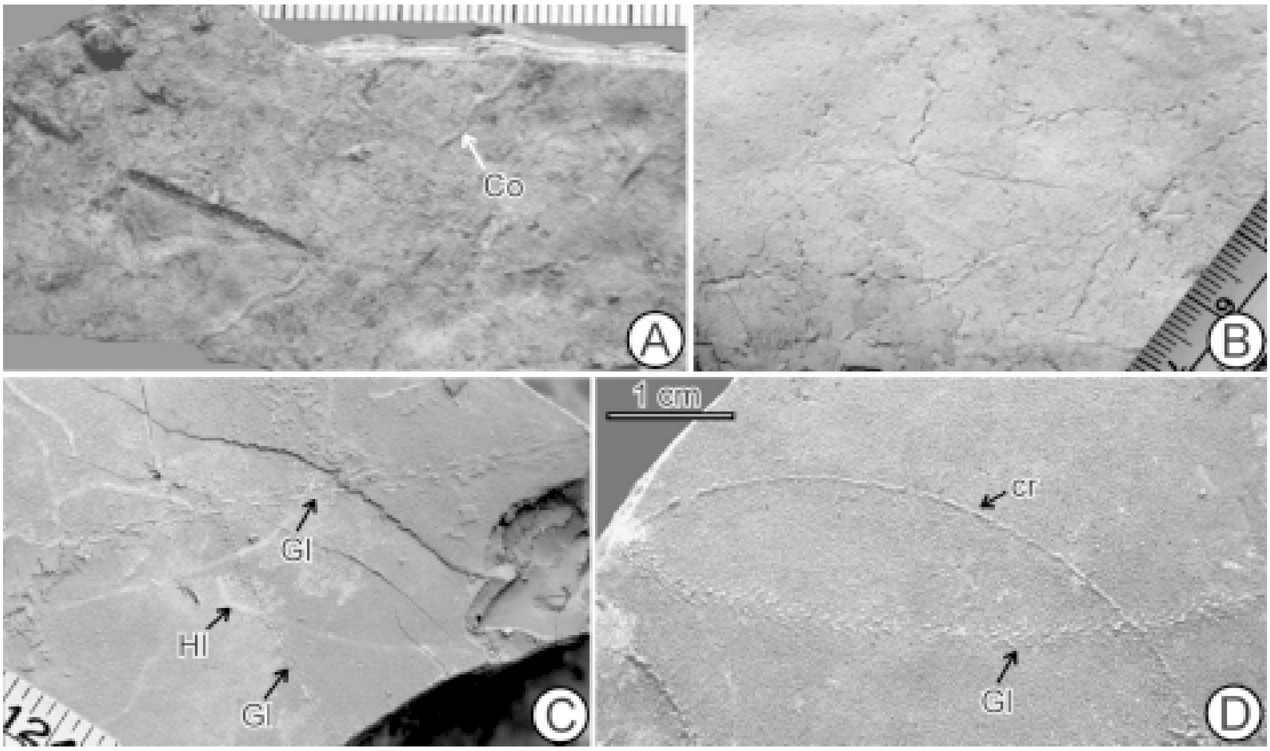


Fig. 4. Trace fossils from the varve clays. *A, C, D* – millimetre scale. *A* – *Cochlichnus anguineus* (Co), lower laminae surface, Gr 27; *B* – *Cochlichnus anguineus*, upper laminae surface, Gr 26; *C* – *Glaciichnium liebegastensis* (Gl) and *Helminthoidichnites* isp. (Hl), lower laminae surface, Bb 6; *D* – *Glaciichnium liebegastensis* (Gl) and curved ridge (cr), lower laminae surface, Bb 2

4 pav. Organizmø fosiliniai pėdsakai varviniuose moliuose

are 0.5–0.7 mm wide, and loops are about 10–20 cm in diameter.

Remarks. Gordia is separated from *Helminthoidichnites* (Hoffmann, 1990), however, in the analyzed material transitional forms occur (see discussion for *Helmithoidichnites*). *Gordia* is a facies-crossing form known from marine and non-marine settings (*e.g.*, Pickerill et al., 1984). It occurs commonly in lacustrine deposits (Pickerill, 1987; Buatois & Mangãno, 1990; Ace¹olaza and Buatois, 1991). In the terrestial environment, loop-like trails are produced by the millepede *Julus* and are caused by a body dragging in wet mud (Boy, 1976, Fig. 41b; Rolfe, 1980, p. 135, Fig. 5A), as well as by crane fly larvae (Ahlbrandt et al., 1978, Fig. 1M.). Looped trails are also left by pulmonate gastropods (*e.g.*, Abel, 1935, p. 209). In fresh waters, similar traces can be interpreted as locomotion trails (repichnia) or feeding traces (pascichnia) produced by insect larvae (Gibbard & Dreimanis, 1978) or gastropods (Gibbard & Stuart, 1974; Merta, 1980).

Helminthoidichnites Fitch 1850
Helminthoidichnites isp.
Figs. 4 C, 5 A

Description. Irregularly winding horizontal smooth ribbons on both parting surfaces, rarely ridges on the upper parting surface or grooves on the lower parting surface. Most of them are 0.5–07 mm wide. The ribbons differ in colour from the surrounding rock.

Remarks. Helminthoidichnites displays only occasional loops, whereas in *Gordia* Emmons (1844) loops are the most characteristic feature. In contrast to these genera, *Helminthopsis* has no loops (Hofmann & Patel, 1989). The differences between *Helminthoidichnites* and *Gordia* have been confirmed by computer analysis (Hofmann, 1990). However, in some specimens from the analysed material there are transitions from *Gordia* to *Helminthoidichnites*, suggesting that these trace fossils were produced by the same tracemaker. This is a strong suggestion for synonymization of these two ichnogenera, but it needs further studies. In this paper, *Gordia* and *Helminthoidichnites* are described separately. So far, *Helminthoidichnites* has been known to range from Precambrian (Narbonne & Aitken, 1990) to Lower Cretaceous (Fregenal Martinéz et al., 1995). Thus, the forms described here represent the youngest record of this ichnogenus. *Helminthoidichnites* is known from marine and nonmarine settings. In the latter case, it has probably been produced by nematofors or insect larvae (Buatois et al., 1997).

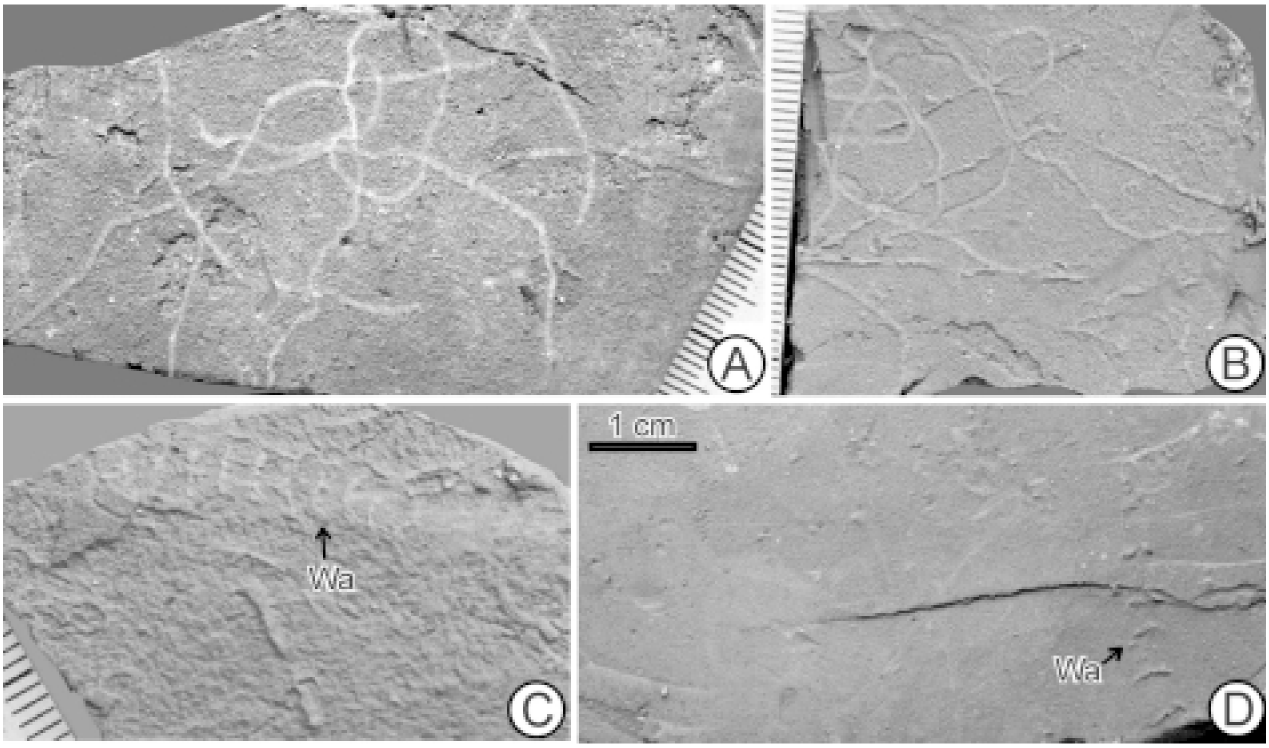


Fig. 5. Other trace fossils from varve clays. *A, C, D* – millimetre scale. *A* – *Gordia* isp., transition to *Helminthoidichnites* isp, upper laminae surface, Bb 48; *B* – *Gordia* isp., upper laminae surface, Bb 19; *C* – *Warvichnium ulbrichi* (Wa) and simple ridges (?*Helminthoidichnites* isp.), upper laminae surface, Bb 40; *D* – *Warvichnium ulbrichi* (Wa) and an indistinct trackway in the upper part (?*Warvichnium*), upper laminae surface, Bb 35.
5 pav. Kitø organizmø fosiliniai pėdsakai varviniuose moliuose

Warvichnium Walter 1985
Warvichnium ulbrichi Walter 1985
Fig. 5 C, D

Description. Only two specimens have been found, in which the trace fossil is preserved as concave forms on the upper parting surface. A single row of arcs, about 0.5 mm wide and 3 mm long, located concordantly 3–4 mm apart. A 7 mm wide double row of small pits, located 3–4 mm apart on each side of the row, probably belongs to the same trace fossil.

Remarks. This trace fossil is part of an arthropod trackway. The row of arcs is typical of the axial part of *Warvichnium ulbrichi*, probably an imprint of insect abdomen (Walter, 1985, fig. 2c, pl. 1, fig. 7, 1986, fig. 4; Fuchs, 1988, fig. 2).

Curved ridges
Fig. 5 C

Description. Simple accurate ridge on the lower parting surface, about 0.3 mm wide. It displays irregular enlargements and disruptions. The longer axis of these disruptions is elongated according to the ridge course.

Remarks. The disruptions and constrictions suggest a pulsatory mode of movement of the tracemaker. It is not excluded that this trace fossil was produced by a small mollusc, and the pulsatory movement can be related to the work of its foot.

DISCUSSION

The described trace fossil assemblage is dominated by *Gordia*, *Helminthoidichnites*, and *Glaciichnium*. *Cochlichnus*, *Warvichnium* and the curved ridges are rare. In many laminae the trace fossils co-occur (Figs. 2, 3). Most probably the trace fossils represent communities of trace markers. In a few cases, *Gordia* cross-cuts *Glaciichnium* and in a few other cases the opposite situations have been found.

The occurrence of the described trace fossils only in some (every few tens) laminae can be interpreted as a result of preservation or as an ecological phenomenon. Most of the trace fossils are very delicate and require a narrow range of sediment consistency in order to be preserved. Such a consistency can occur once for many years, for instance, due to a lowered sedimentation rate or delicate erosion. Certainly very soft water-saturated sediments (soupy ground) lower very much the preservational potential. The general absence of trace fossils in laminae rich in carbonates cannot be easily explained, but we cannot exclude that it is related to the preservational potential. It is also possible that only in some summers the lake floor is colonised by the trace markers. If the latter suggestion is true, it is interesting to study a possible regularity in their occurrence. Also the longer segments of the sections without trace fossils are interesting from such a perspective. In the case of the Girininkai section, the absence of trace fossils in the upper part of the measured section probably resulted from a strong fracturing of the rocks, which makes difficulties in obtaining an appropriate parting substrate. The fracturing, caused probably by heavy digging equipment, decreases down the section.

Walter & Suhr (1998) distinguished three basic ichnocoenoses in Pleistocene varve clays. The cursichnia ichnocoenose contains arthropod trackways, which are represented in the investigated Balberiškis and Girininkai sections by *Glaciichnium* and *Warvichnium*. The *Cochlichnus* ichnocoenose contains foremost *Cochlichnus* and some other small (1–3 mm) trails. *Cochlichnus* occurs only locally in the Girininkai section. The repichnia ichnocoenose contains small (less than 1 mm) wide seam-like trails. This ichnocoenosis does not occur in the investigated sections. We could add the *Gordia* ichnocoenosis, which is represented by abundant *Gordia* and *Helminthoidichnites* in the Balberiškis and Girininkai sections. However, these ichnogenera commonly co-occur with *Glaciichnium*, which is the member cursichnia ichnocoenosis. Also *Cochlichnus* occurs together with *Glaciichnium* in the Girininkai section. Thus, we have difficulties in distinguishing pure ichnocoenoses as proposed by the cited authors. In general, the trace fossil association can be ascribed to the *Mermia* ichnofacies, which is typical of a lacustrine environment (Buatois & Mangcno 1998).

According to Walter & Suhr (1998), the repichnia ichnocoenosis is typical of epilimnion in proximal depositional settings (delta forsets), the cursichnia ichnocoenosis should occur in metalimnion, and the *Cochlichnus* ichnocoenosis in hypolimnion in less oxygenated waters. The *Gordia* ichnocoenosis can be considered as an equivalent of the *Cochlichnus* ichnocoenosis. Assuming that this is true, it is possible to suppose that the investigated deposits accumulated in the transition from metalimnion to hypolimnion. The isopod *Asselus aquaticus*, the probable producer of *Glaciichnium*, is typical of a lake littoral zone (Stañczykowska, 1986).

CONCLUSIONS

The presence of trace fossils in varve clays of proglacial glaciolacustrine basins of the Upper Pleistocene reflects the climatic fluctuations during glaciolacustrine–lacustrine–glaciolacustrine sedimentation of the South-Lithuanian, Middle-Lithuanian or

North-Lithuanian phasials and interphasials of the Baltija (Pomeranian) stadial of the Nemunas (Vistulian) glacial.

The relatively common trace fossils *Gordia, Helminthoidichnites, Galaciichnium* and the rare *Cochlichnus, Warvichnium* and curved ridges are found in the section studied. The fossils are typical of the *Mermia* ichniofacies. The cursichnia ichnocoense is represented by *Glaciichnium* and *Warvichnium*, the *Gordia* ichnocoensis represented by *Gordia* and *Helminthoidicnites.*

The warmer climate of interphasials or interoscillations is represented by lacustrine sediments with traces of *Cordia, Helminthoidichnites, Galaciichnium* and rare *Cochlichnus, Warvichnium* fossils. The traces of fossils in laminated sediments of aquatic origin in Lithuania correspond to interphasial episodes of the Late Pleistocene. They represent the lacustrine (lake) sedimentation in the glaciolacustrine basin during climatic warming in the glaciated area of North Europe. Dominance of cursichnia ichnocoenosis and *Gordia* ichnocoenosis suggests that varve deposits accumulated in the transition zone from metalimnion to hypolimnion. Traces of fossils in this case can be used for recognition of lacustrine subfacies and climatic warming.

ACNOWLEDGEMENTS

This research was sponsored by the Jagiellonian University (BW funds) and financially supported by Lithuanian State Science and Studies Foundation, grant No T-13.

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FOSILIJØ PËDSAKAI VIRŠUTINIO PLEISTOCENO VARVINIUOSE MOLIUOSE LIETUVOJE Á PIETUS NUO KAUNO

Santrauka

Balbieriðkio ir Girininkø apylinkëse á Pietus nuo Kauno virðutinio pleistoceno varviniuose moliuose pirmà kartà surasti fosilijø *Gordia, Helminthoidichnites, Galaciichnium* pëdsakai palyginus yra daþni, retesni *Cochlichnus, Warvichnium* ir lanko formos pëdsakai. Fosilijø pëdsakø pasitaiko molingø laminarijø pavirðiuose, o karbonatø turtingose laminarijose jø nerasta. Surasti fosilijø pëdsakai yra bûdingi *Mermia* ichnofacijoms. Cursichnia ichnocenozei atstovauja *Glaciichnium* ir *Warvichnium*, o *Gordia* ichnocenozei (naujai iškirta) – *Gordia* ir *Helminthoidichnites*. Jø vyravimas leidþia tvirtinti, kad tyrinëti varviniai moliai kaupësi pereinanèioje ið metalimnijono á hipolimnijonà zonoje. Vëlyvojo pleistoceno tarpfaziø ir tarposciliacijø ðiltesná klimatà, kurio poþymiai uþfiksuoti eþerinëse nuosëdose, patvirtina tyrinëtø fosilijø pëdsakai prieledyniniø baseinø sluoksniuotø nuogulø pjûviuose. Vëlyvojo pleistoceno limnoglacialiniø nuosëdø sluoksniuose surandamus fosilijø pëdsakus galima panaudoti iðskiriant eþerines subfacijas ir klimato atðilimo laikotarpius, nes jie yra susijæ su tarpfazialø sedimentogeneze.

Альгирдас Гайгалас, Альфред Ухман

СЛЕДЫ ФОССИЛИЙ В ЛЕНТОЧНЫХ ГЛИНАХ ВЕРХНЕГО ПЛЕЙСТОЦЕНА К ЮГУ ОТ Г. КАУНАСА, ЛИТВА

Резюме

В окрестностях Бальберишкис и Гирининкай к югу от г. Каунаса в ленточных лимногляциальных глинах верхнего плейстоцена обнаружены фоссильные следы *Gordia, Helminthoidichnites, Galaciichnium,* которые условно часто встречаются, реже наблюдаются следы *Cochlichnus, Warvichnium* и дугообразные следы. Следы фоссилий найдены на поверхностях отдельных глинистых слойков. Они не обнаружены в слойках, обогащенных карбонатами. Обнаруженные следы фоссилий характерны для ихниофаций *Mermia*. Ихниоценоз *Cursichnia* представлен *Glaciichnium* и *Warvichnium,* а ихниоценоз *Gordia* (нововыделен) – *Gordia* и *Helminthoidichnites*.

Преобладание упомянутых ихниоценоз даст возможность утверждать, что исследованные ленточные глины осаждались в переходной зоне приледниковых озер от металимниона к гиполимниону. Потепления климата во время межфазиалов и межосцилляций, признаки которого зафиксированы в озерных отложениях, отмечены следами организмов в разрезах слоистых отложений приледниковых бассейнов. Обнаруженные следы в лимногляциальных отложениях можно использовать при выделении озерных субфаций и интервалов потепления климата позднего плейстоцена, так как они связаны с межфазовым седиментогенезом.