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Cenomanian–Coniacian Upper Cretaceous foraminiferal fauna of Lithuania

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Foraminiferal assemblages form a unique fauna succession from the Cenomanian to Maastrichtian stages in Lithuania; the Cenomanian–Coniacian succession is discussed in this paper. The first Cretaceous planktonic foraminifera species appeared in the Early Cenomanian. The Cenomanian planktonic foraminiferal association consists of the relatively abundant genus *Hedbergella*. However, Cenomanian planktonic foraminifera are rare compared to benthic; the latter are numerous, and their assemblage contains various calcareous and agglutinated species. As a result of environmental changes, foraminiferal assemblages gradually changed as well. The newly formed deep-water niches in the Turonian allowed spreading the keeled forms of planktonic foraminifera. Taxonomically, Turonian–Coniacian foraminiferal assemblages are mainly composed of species of the following genera: *Praeglobotruncana*, *Helvetoglobotruncana*, *Dicarinella*, *Marginotruncana*.

Key words: foraminifera, planktonic, benthic, Upper Cretaceous, biostratigraphy, palaeogeography

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INTRODUCTION

The principle of faunal succession by William Smith (1790) states that fossils occur in a definite, invariable sequence in the geologic record. This principle is the basis of modern biostratigraphy which relies on the fact that some of the fossils found in rocks can be used to obtain a relative age by comparing the fossils to a known standard succession or "zonation" (Wilson et al., 2003).

The taxonomical and morphological diversity of Cenomanian–Coniacian foraminifera is reflected in changing foraminiferal assemblages. This faunal succession was affected by environmental changes, mostly the relative sea level changes in a basin (Grigelis, 1994; 1996).

The Cretaceous foraminifera of Lithuania were first studied by S. Abramavičiūtė-Garunkštienė (Abramavičiūtė, 1957; Garunkshtene, 1960) and later by A. Grigelis (Grigyalis et al., 1961; Grigyalis, 1962, 1963, 1970, 1976; Grigyalis et al., 1980; Grigyalis, Gorbachik, 1980) and A. Venckutė-Aleksienė (2005). The biostratigraphical zones on the basis of benthic foraminifera were established by A. Grigelis (Grigyalis, 1963).

The main trend among the Cretaceous planktonic foraminifera is the evolution of keeled forms. At the beginning of the transgression in the Albian time, the marine basin in the Lithuanian territory was shallow (up to 50 m deep), and its depth progressively increased up to 200–500 m (Grigelis, 1996). Newly formed deep-water niches allowed spreading more complex one- and two-keeled planktonic foraminifera forms. The first one – keeled specimens *Praeglobotruncana delrioensis* (Plummer) and *Pr. stephani* (Gandolfi) – appeared in the Lower Cenomanian of Lithuania, while no biostratigraphic marker species of Rotalipora were not detected. The planktonic foraminiferal fauna succession in the Turonian shows a short period of rapid species diversification with the appearance of the genera *Whiteinella*, *Dicarinella*, *Helvetoglobotruncana, Marginotruncana* and *Archaeoglobigerina*.

LITHOSTRATIGRAPHY OF CENOMANIAN–CONIACIAN STAGE

Upper Cretaceous sedimentary rocks, composed of terrigenous and carbonatic sediments, are distributed in the southern and southwestern Lithuania (Grigelis, 1996).

The non-sedimentation regime existed until the middle Albian when the Polish–Lithuanian Depression began to evolve. A widespread marine transgression developed from the southwest and reached as far as the present Lithuanian–Latvian border (probably the whole northeastern part of Lithuania was eroded by the glacier in the Quaternary) (Grigelis, 1996). An epicontinental, relatively shallow marine basin prevailed uninterruptedly throughout the whole Late Cretaceous. Different fauna, including benthic and planktic foraminifera, lived in this basin (Grigelis, 1994; 1996).

The thickness of Cretaceous sedimentary rocks generally increases SW-wards up to about 200 m in South Lithuania (Fig. 1). Cretaceous rocks comprise different formations. Two major facies zones are defined in Lithuania: the Klaipėda zone in West Lithuania and the Kaunas zone in Middle-Southeast Lithuania (Grigelis 1996; Grigelis and Leszczynski, 1998).

The lithostratigraphic units of the Cenomanian–Coniacian age of the Klaipėda facies zone include the Labguva Formation (Cenomanian) and the Brasta Formation (Turonian–Santonian) (Fig. 2).

The Labguva Formation consists of greenish-grey calcareous sand, silt and sandy silt. The basal sandstone contains phosphorite nodules. The Brasta Formation is composed of light grey marl and siltstone, silicified in some places.

Chalky deposits dominate the Kaunas facies zone and are subdivided into Akmuo Formation (Middle and Lower Cenomanian), Kašėta Formation (Upper Cenomanian), Pamerkys Formation (Middle and Lower Turonian) and Mielupis Formation (Upper Turonian–Maastrichtian).

The Akmuo Formation is composed of greenish-grey calcareous sandy glauconitic siltstone. Abundant phosphorite nodules are present in its basal layer. The Kašėta Formation is composed of grey sandy marls and sandy chalk. The Pamerkys Formation consists of light-grey chalk or chalky marl. The Mielupis Formation is composed of white chalk (Fig. 2) (Grigelis, 1996; Grigelis, Leszczynski, 1998).

Fig. 1. Thickness map of the Cretaceous (after Grigelis, Leszczynski, 1998) and studied boreholes
1 pav. Kreidos storio žemėlapis (Grigelis, Leszczynski, 1998) ir tirtų gręžinių išsidėstymo schema

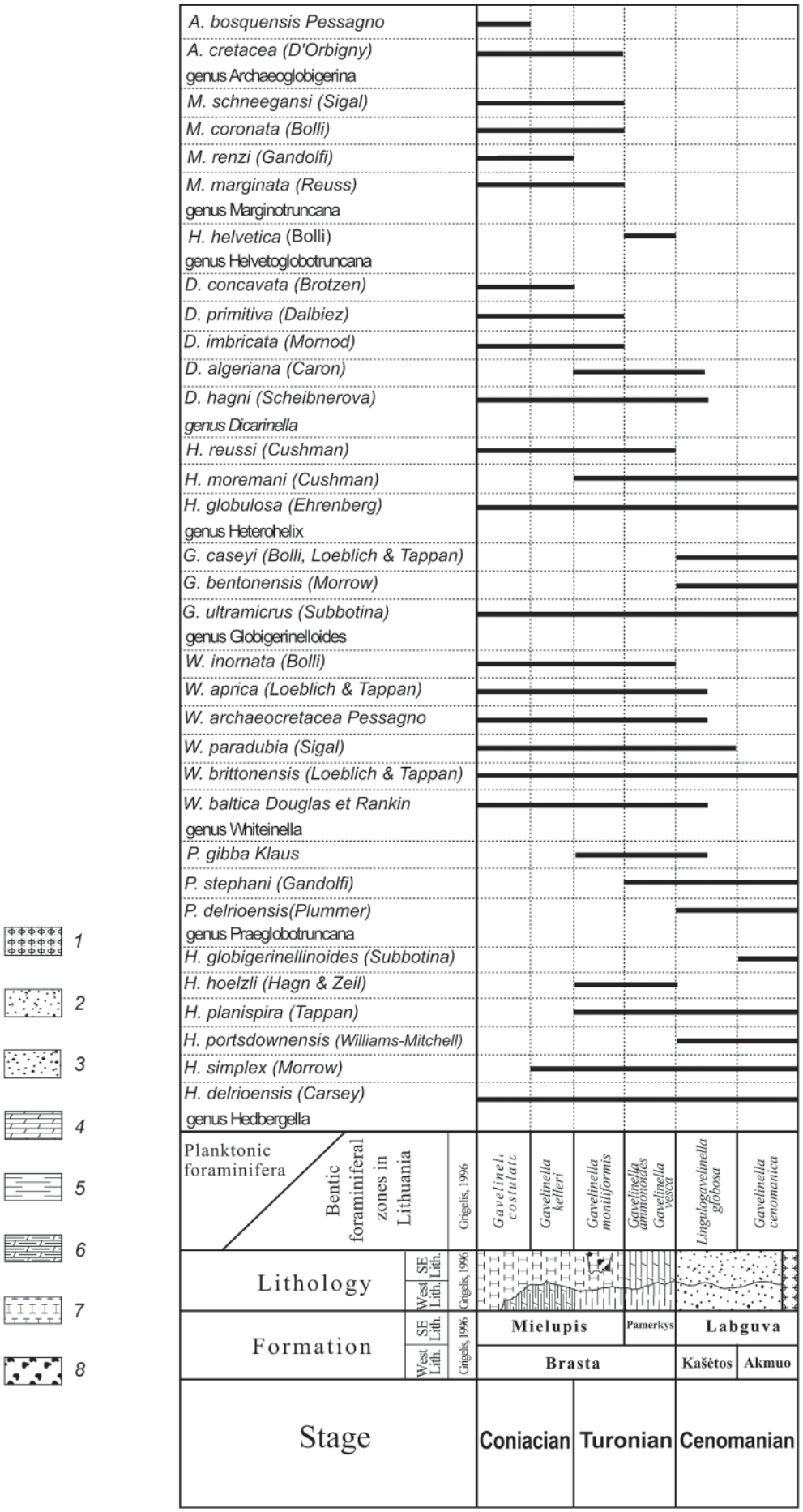

Fig. 2. Geological section, stratigraphy and occurrence of foraminifera:
1 – fosforite nodules, *2* – sandstone, *3* – glauconitic sandstone, *4* – flint nodules, *5* – marl, *6* – silicified marl, *7* – clay, *8* – chalk

2 pav. Viršutinės kreidos nuogulų pjūvis ir foraminiferų vertikalus paplitimas:
1 – fosforitinė plyta, *2* – smiltainis, *3* – glaukonitinis smiltainis, *4* – titnago konkrecijos, *5* – mergelis, *6* – silifikuotas mergelis, *7* – molis, *8* – kreida

MATERIALS AND METHODS

Samples were collected from the following boreholes: Žalgiriai-1, Paikojai-10, Baltašiškė-267, Neravai-453, Varnupiai-445, Salapieraugis-451, Punios šilas-351, Paversekis-59, Drucminai-63 (Fig. 1). In total, 244 samples were studied. Samples for micropalaeontological analysis were taken approximately every 1 m.

The planktonic foraminifera was removed from the partially disaggregated rock material by the Soda method. The collection of foraminifera is housed at the Institute of Geology and Geography. Planktonic foraminifera were identified with reference to the works of F. Robaszynski and M. Caron (1979 a, b), A. R. Loeblich and Jr. H. Tappan (1988), D. Peryt (1980). The fauna of benthic foraminifera had been described by A. Grigelis (Grigyalis et al., 1961; Grigyalis, 1963, 1976; Grigyalis et al., 1980; Grigyalis, Gorbachik, 1980; Grigelis, 1994, 1996).

Images of species were taken using a scanning electron microscope at Musée National d'Histoire Naturelle in Paris within the frames of the Sythesys project (2007).

RESULTS

The foraminiferal assemblages studied represent the earliest planktonic foraminiferal association found in the Cenomanian stage. Planktonic foraminifera are quite poor, and hedbergellids are the dominant species in the early the Cenomanian. The diversity and quantity of planktonic foraminifera started increasing from the middle Cenomanian. Later, the genus *Whiteinella* started to prevail. Also frequent are *Globigerinelloides ultramicra, G. caseyi, G. bentonensis, Heterohelix globulosa, H. moremani* (Figs. 2 and 3). The described species are of little stratigraphic value and can be used only in the regional correlation.

S. Abramavičiūtė-Garunkštienė referred the *Rotalipora appenninica* (Renz) species (Abramavičiūtė, 1957), but she provided neither a description nor illustrations, and the collection is missing. The *Rotalipora* genus is absent in the studied Cenomanian planktonic foraminiferal assemblages (Venckutė-Aleksienė, 2005). *Heterohelix globulosa* and *H. moremani* were documented in the Cenomanian samples. Heterohelicids were also found sporadically and in big amounts during the Upper Cenomanian and the Turonian stages (Figs. 2 and 3).

In the study area, planktonic foraminifera of the Cenomanian age are generally rare compared to benthic foraminifera, especially from the Early Cenomanian. The assemblages of benthic foraminifera contain calcareous and agglutinated species.

The benthic foraminiferal association of the Cenomanian is represented by *Gavelinella cenomanica* (Brotzen), *G. baltica* Brotzen, *Gaudryinella frankei* Cushman, *Bolivinita eouvigeriniformis* Keller, *Lingulogavelinella globosa* (Brotzen), *Brotzenella belorussica* (Akimez), *Cibicides formosus* (Brotzen), *Cibicides* sp., *Lenticulina* sp., *Nodosaria* sp. and by agglutinate forms: *Gaudryina* sp., *Arenobulimina* sp., *Trochammina* sp., *Tritaxia* sp., *Ataxophragmium* sp. (Grigyalis et al., 1961; Grigyalis, 1963, 1976; Grigyalis et al., 1980; Grigyalis, Gorbachik, 1980; Grigelis, 1994).

The local biostratigraphic zonation of the Cenomanian is based on benthic foraminifera. The Lower Cenomanian is inferred on the presence of *Gavelinella cenomanica* (Brotzen). The occurrence of the *Lingulogavelinella globosa* (Brotzen) indicates an age not younger than the Upper Cenomanian (Grigyalis, 1962; 1963; 1976).

The diversity and abundance of the planktonic foraminiferal assemblages increase gradually in the overlying sediments, i. e. in the Turonian strata (Fig. 2). These assemblages are characterized by the occurrence of the one-keeled species *Helvetoglobotruncana helvetica* (Bolli), *Praeglobotruncana gibba* Klaus and the two-keeled species *Dicarinella hagni* (Scheibnerova) and *D. algeriana* (Caron). Samples from the Lower Turonian include *Whiteinella baltica* (Douglas & Rankin) and *W. archaeocretacea* Pessagno (Figs. 2 and 3). Also, the long-ranging species *Hedbergella delrioensis* (Carsey), *H. simplex* (Morrow), *H. planispira* (Tappan), *Whiteinella brittonensis* (Loeblich & Tappan) are found. *Hedbergella hoelzli* (Hagn & Zeil) is very rare in the Turonian samples. The content of *Heterohelix globulosa* (Ehrenberg) and *H. moremani* (Cushman) is very variable. Sometimes these species represent up to 70–80% of all specimens in the sample.

The Middle and Upper Turonian planktonic foraminiferal assemblages show an increasing ratio of planktonic / benthic and keeled / non-keeled species. Keeled species like *Helvetoglobotruncana helvetica* (Bolli), *Dicarinella hagni* (Scheibnerova), *D. algeriana* (Caron), *Praeglobotruncana gibba* Klaus are characterized by inflated chambers.

Taxonomically, the Turonian foraminiferal assemblages are largely composed of planktonic species; nevertheless, benthic foraminifera are comparatively abundant and show a gradual increase in diversity too.

The Lower Turonian may be identified by the presence of *Gavelinella vesca* (Bykova). The Middle and Upper Turonian are recognized by occurrence of *G. ammonoides* (Reuss) and *G. moniliformis* (Reuss). The benthic foraminiferal complex from this stage is represented by the following calcareous forms: *Gavelinella vesca* (Bykova), *Cibicides gorbenkoi* Akimez, *C. polyrraphes* (Reuss), *Brotzenella belorussica* (Akimez), *B. berthelini* (Keller), *Globorotalites turonicus* Kaev., *Reussella turonica* Akimez, *Eponides* sp., *Stensioeina* sp. and by the agglutinate forms *Gaudryina frankei* Brotzen, *G. angustata* Akimez, *Spiroplectammina* sp., *Arenobulimina* sp., *Tritaxia* sp. (Grigyalis et al., 1961; Grigyalis, 1963, 1976; Grigyalis et al., 1980; Grigyalis, Gorbachik, 1980; Grigelis, 1994).

The Coniacian planktonic foraminiferal assemblage is rather similar to that of the Upper Turonian. The main Turonian foraminiferal genera persist in Coniacian foraminiferal

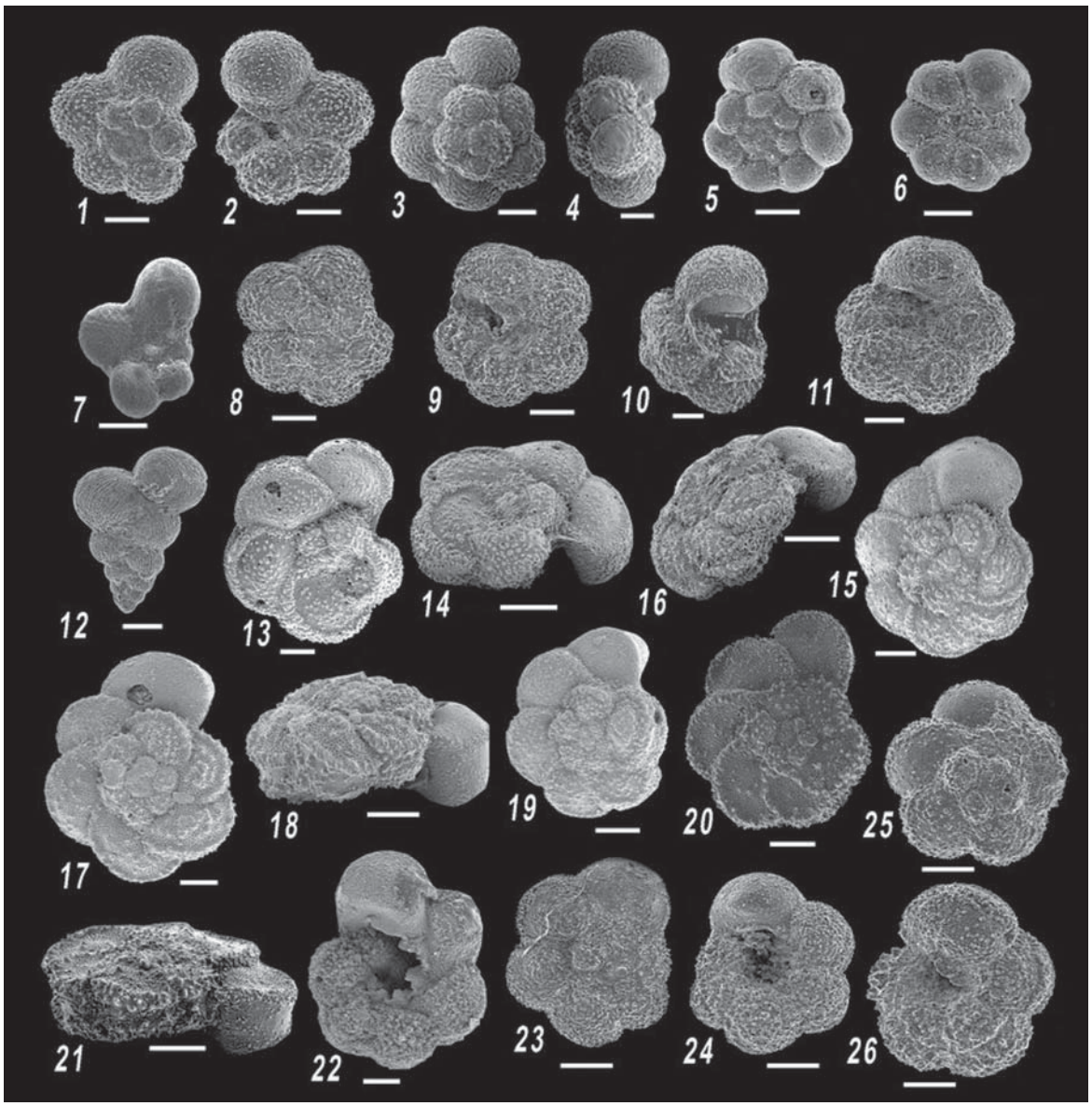

Fig. 3. SEM images of Upper Cretaceous planktonic foraminifera:
3 pav. Viršutinės kreidos planktoninių foraminiferų SEM nuotraukos:

1, 2 – Hedbergella delrioensis (Carsey) (Žalgiriai-1); *3, 4 – W. brittonensis* (Loeblich & Tappan) (Žalgiriai-1); *5 – H. planispira* (Tappan) (Žalgiriai-1); *6 – Globigerinelloides caseyi* (Bolli, Loeblich & Tappan) (Paikojai-10); *7 – H. simplex* (Morrow) (Paikojai-10); *8, 9 – Praeglobotruncana delrioensis* (Plummer) (Neravai-453); *10 – H. portsdownensis* (Williams-Mitchell) (Žalgiriai-1); *11 – W. baltica* (Douglas & Rankin) (Žalgiriai-1); *12 – Heterohelix globulosa* (Ehrenberg) (Varnupiai-445); *13, 14 – Dicarinella algeriana* (Caron) (Varnupiai-445); *15, 16 – D. imbricata* (Mornod) (Varnupiai-445); *17, 18 – Marginotruncana marginata* (Reuss) (Salapieraugis-451); *19 – M. coronata* (Bolli) (Varnupiai-445); *20, 21, 22 – M. renzi (*Gandolfi) (Varnupiai-445); *23, 24 – P. stephani* (Gandolfi) (Žalgiriai-1); *25, 26 – P. gibba* Klaus (Žalgiriai-1). Scale bar 100 µm

associations. The principal difference between these assemblages is an increased content of *Marginotruncana* sp. The Coniacian planktonic foraminiferal association is represented by *Dicarinella hagni* (Scheibnerova), *D. algeriana* (Caron), *D. imbricata* (Mornod), *D. asymetrica* (Sigal), *Marginotruncana coronata* (Bolli), *M. renzi* Gandolfi, *M. marginata* (Reuss), *M. schneegansi* (Sigal), *Archaeoglobigerina cretacea* (d'Orbigny) (Figs. 2 and 3).

The boundary between the Turonian and the Coniacian is poorly defined because the planktonic foraminiferal assemblages of the Turonian and Coniacian strata are represented by long-ranging species.

The same distribution is observed in the benthic foraminiferal complex. The assemblage is represented by a lot of species that occur in the Turonian age. The Lower Coniacian benthic foraminiferal association is composed of *Gavelinella kelleri* (Mjatliuk), *Reussella kelleri* Vassilenko, *Stensioeina emsherica* Bar., *Gaudryina frankei* Brotzen, *Spiroplectammina* sp., *Arenobulimina* sp., *Tritaxia* sp. The Upper Coniacian complex consists of the following species: *Gavelinella costulata* (Marie), *G. thalmanni* (Brotzen), *G. giedroyci* Grigelis, *Spiroplectammina embaensis* Mjatliuk, *Gaudryina frankei* Brotzen (Grigyalis et al., 1961; Grigyalis, 1963, 1976; Grigyalis et al., 1980; Grigyalis, Gorbachik, 1980; Grigelis, 1994).

DISCUSSION AND CONCLUSIONS

The marine basin invaded Lithuania in the Late Albian and lasted throughout the Late Cretaceous. It was part of a widespread European marine transgression developed from the southwest (Grigelis, 1994; 1996; 1998). The sea level changes were of great significance to the distribution and evolution of foraminifera. Compositional variations of planktonic foraminiferal associations allow to reconstruct palaeogeographical and palaeoecological conditions in the study area (Sliter, 1972; Hart, 1980).

The total abundance and diversity of planktic foraminifera vary from rare to high, and their preservation is poor to moderate due to the lithologic variation. The earliest planktonic foraminiferal association from the Cenomanian age is poor, monospecific and is represented by simple morphotypes such as the genus *Hedbergella*. Hedbergellids are widely distributed in space and time. They are common representatives of foraminiferal assemblages from Boreal and Tethys regions. These forms predominate in high latitudes and in upwelling areas, displaying an opportunistic life strategy (Gasinski, 1997; Alve, 2003).

Heterohelicids and whiteinelids appear in the Upper Cenomanian. Hedbergellids and heterohelicids are more abundant in samples from the western part of the study area where sedimentation was affected by a visible influx of terrigenous particles into a shallower basin and silty-marly deposits were accumulated. These species occupy shallower, near shore waters and unstable eutrophic environments (Eicher, Worstell, 1970; Hart, 1980; Gasinski, 1997).

Praeglobotruncannids are very rare in the studied Cenomanian samples. A deeper basin existed in Southern Lithuania where quiescent conditions of sedimentation prevailed. Whiteinellids and praeglobotruncanids are more abundant in samples from this area. These intermediate morphotypes are inhabitants of mesotrophic environments (Be, 1977; Hart, 1980; Gasinski, 1997).

The absence of the genus *Rotalipora* in the samples confirms the mentioned environmental conditions, because they are typical deep water dwelling planktonic foraminifera (Hart, 1980; Gasinski, 1997).

The presence of abundant hedbergellids and heterohelicids at the end of the Cenomanian stage indicates changes in water oxygenation. A discussion of the worldwide latest Cenomanian Oceanic Anoxic Event OAE2 (Bonarelli Event) is impossible, whereas there are no investigations of stable carbon and oxygen isotopes ($\delta^{13}C$, organic) in the Upper Cretaceous sediments from Lithuania.

A gradual deepening into open basin facies is documented by the increasing diversity of foraminifera in the overlying sediments of the Turonian age. The Lower Turonian foraminiferal fauna is diverse and quite similar to Boreal planktonic foraminiferal associations. Taxonomically, the assemblages are largely composed of the following genera: one-keeled *Helvetoglobotruncana*, *Praeglobotruncana* and two-keeled *Dicarinella, Marginotruncana*. The radiation of foraminifera in Lithuania was highest during the Middle-Late Turonian age. Marginotruncanids start to predominate in the Coniacian strata.

The Upper Cretaceous (Cenomanian–Coniacian) foraminiferal fauna is well preserved and comparatively abundant. Taxonomical differences between benthic foraminiferal assemblages allow to establish the biostratigraphical zones (Grigyalis, 1963). Investigation of planktonic foraminifera indicated that Upper Cretaceous (Cenomanian–Coniacian) assemblages have some specific peculiarities that evolved from particular environmental conditions.

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Agnė Aleksienė

CENOMANIO–KONJAKIO AUKŠTŲ (VIRŠUTINĖ KREIDA) FORAMINIFERŲ FAUNOS SUKCESIJA LIETUVOJE

S a n t r a u k a

Viršutinės kreidos nuosėdinės uolienos randamos Pietų ir Pietvakarių Lietuvoje. Vėlyvajame albyje iš Lenkijos transgresavus negiliam epikontinentiniam jūriniam baseinui į Lietuvos-Lenkijos įdubą, ėmė klostytis terigeninės ir karbonatinės nuosėdos. Viršutinės kreidos uolienose randamos gerai išlikusios fosilinės bentosinių bei planktoninių foraminiferų bendrijos.

Pagal būdingas bentosinių foraminiferų bendrijas viršutinė kreida suskirstyta į biozonas. Zonų ribos pagrįstos bendrijų taksonominiais skirtumais, kuriuos lėmė kintančios paleoaplinkos sąlygos bei rūšių evoliucija.

Lietuvos teritorijoje pirmosios planktoninių foraminiferų bendrijos atsirado cenomanyje, tuo tarpu bentosinių foraminiferų rūšių randama ir albio amžiaus uolienose. Planktoninių foraminiferų bendrijoje vyrauja seklių vandenų lengvai prisitaikančios, oportunistinės, rūšys, priklausančios hedbergelidams, heterohelicidams, globigerinelidams.

Tirtuose cenomanio mėginiuose daugiausia randama hedbergelidų (*Hedbergella*), pasižyminčių plačiu geografiniu ir stratigrafiniu paplitimu ir gausa tiek borealinių, tiek Tetijos regionų planktoninių foraminiferų bendrijose.

Planktoninių foraminiferų bendrijos sudėtis pradeda keistis nuo cenomanio vidurio. Joje atsiranda naujos rūšys: *Praeglobotruncana delrioensis* (Plummer), *P. stephani* (Gandolfi), *P. gibba* Klaus, *Whiteinella baltica* (Douglas & Rankin), *W. archaeocretacea* Pessagno, *Heterohelix globulosa* (Ehrenberg). Heterohelicidai yra seklių vandenų, priekrančių atstovai, prisitaikę prie nestabilios bei eutrofinės aplinkos. Jų gausu Vakarų Lietuvos cenomanio–konjakio amžiaus uolienose; čia paleobaseinas buvo seklesnis ir klostėsi molingos, vietomis aleuritingos-smėlingos karbonatinės nuogulos.

Praeglobotruncana ir *Whiteinellla* genčių atstovai yra mezotrofinės aplinkos indikatoriai. Daug jų randama Pietrytinės Lietuvos uolienuose; čia paleobaseinas cenomanio amžiuje laipsniškai gilėjo, klostėsi karbonatinės, pradžioje kiek smėlingos nuosėdos.

Foraminiferų faunos sukcesija yra susijusi su jūrinio baseino transgresijų ir regresijų ciklais. Turonio amžiuje jūros transgresijai pasiekus maksimumą, šioje dalyje susikaupė baltosios kreidos storymė. Pagilėjus paleobaseinui, planktoninių foraminiferų bendrijos taksonominė sudėtis pakito, atsirado ir jau vyravo giliavandenės, jautrios aplinkos sąlygų pokyčiams rūšys: *Helvetoglobotruncana helvetica* (Bolli), *Dicarinella hagni* (Scheibnerova), *D. algeriana* (Caron).

Turonio amžiuje planktoninių foraminiferų buvo daugiausia, taip pat didžiausia rūšinė jų įvairovė. Daugelis genčių, atsiradusių turonyje, egzistavo ir konjakio amžiuje. Pagrindinis skiriamasis konjakio planktoninių foraminiferų bendrijos bruožas – ryškus genties *Marginotruncana* vyravimas bei genties *Archaeoglobigerina* atsiradimas.

Raktažodžiai: faraminiferos, planktonas, bentosas, viršutinė kreida, biostratigrafija, paleoaplinka